Tax Smoothing Hypothesis In Nigeria: *Does It Hold?*

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Abstract

Tax Smoothing (TS), is the adjustment of tax rates to minimize welfare losses or excess burden from tax by spreading the burden of increasing distortionary taxes overtime, for a given path of government expenditure. The TS is often occasioned by unsustainable Fiscal Policy (FP), which invariably leads to debt accumulation and a burden on the future generation if not well managed and productively used. Previous studies on FP in Nigeria focused on the direct effect of its sustainability or vulnerability on economic growth with little attention paid to TS. This study, therefore, was designed to test for the validity of TS hypothesis in Nigeria from 1971 to 2023. The Barro's Tax Smoothing Theory provided the framework and secondary data on Government Revenue (GR), Government Expenditure (GE) and Gross Domestic Product (GDP) were sourced from the Central Bank of Nigeria's Statistical Bulletin and the World Bank Development Indicators. All estimates were validated at ñd" 0.05. The TS hypothesis was confirmed as "GR was predicted by "GE (X^2 = 6.11) and "GDP (growth rate of output (X^2 = 4.09)). This implies that government sets the budget surplus equal to expected "GE and "GDP over time; if expenditure was expected to increase, the government ran a budget surplus but if expenditure was expected to decline, the government ran a budget deficit. The Tax Smoothing hypothesis was valid for Nigeria from 1971 to 2023. Government revenues largely drove government expenditures. Therefore, there is need for government to improve revenue generation and block leakages, embrace fiscal discipline and prioritize public expenditure.

Keywords: *Tax smoothing; Fiscal policy sustainability; Fiscal discipline.*

Introduction

Fundamentally, fiscal policy is the use of government borrowing, spending, and revenue-generating actions, along with the resulting effects, to deliberately affect the economic performance and direction toward a desired trajectory and measurable, objective goals. These objectives frequently involve, among other things; promote macroeconomic stability, effective resource allocation, and equitable income distribution. Changes in tax, tax structure, and/or the amount and makeup of government spending are therefore all part of fiscal policy adjustments. Automatic stabilization or discretionary fiscal budgetary actions are the means by which these changes take place. Therefore, it is expected of a government to act responsibly at all times in order to create and implement the best possible fiscal policy and maintain its sustainability.

Indeed, fiscal sustainability is a key issue in public finance. This is because an unsustainable fiscal policy could harm the welfare of the state through large fiscal deficits and excessive public debt stocks, thereby generating an inefficient allocation of resources; excessive public debt stock that could affect future generations, and increase in the inflation rate as well as its volatility (Agnello & Sousa, 2009, Pradhan, 2019 and Begum & Flath, 2020). More succinctly, Buiter (2004) identified and listed the potential consequences of the absence of fiscal sustainability by a government. These include that: (i) public spending could be higher and tax revenues could be lower than originally planned; (ii) the inflation rate could be higher than expected; and (iii) public debt could be defaulted on. In these ways, unsustainable fiscal policies could hinder and exacerbate the macroeconomic conditions and aggravate any economy's vulnerability to exogenous shocks.

In the light of the foregoing, concerns and questions about fiscal sustainability have featured prominently in academic and policy debates. Undoubtedly, an unsustainable fiscal policy as manifested by huge amount of government debts or fiscal deficits has generated widespread public interest and political debate in many countries. Instructively, there is the common belief (though sometime uninformed) among people that government debt is one of the main reasons for inflation, unemployment and economic recession. Fiscal policy strategy can be considered sustainable if it meets the intertemporal budget constraint (Bohn, 1998; Alesina & Campante, 2008; Saibu, 2018; and MocPhee, Bergeron, Busby, & Nicol, 2021). Thus, the current debt level should be equal to or greater than the present value of future primary surpluses. If otherwise, it is unsustainable.

Fiscal sustainability is theoretically and generally believed to be rooted in optimal taxation and/or tax smoothing practices by the government. Arising from this, a reduction in government revenue combined with her wish to raise spending will result in debt accumulation, which, ordinarily, should not be a burden to the future generation if adequately utilized to spur growth. With this scenario, there is a dire need for government to smoothen taxes.

Tax smoothing allows the government to adjust tax rates to minimize welfare losses or excess burden from taxation by spreading the burden of increasing distortionary taxes over time for a given path of government expenditure. This situation will then result in budget deficit or surplus with temporary changes in government expenditure and output, as well as using public debt to reduce the burden of temporary changes in the tax rates. In other words, government reduces tax distortions by smoothing tax rates rather than adjusting them based on the budget requirements. Therefore, the main idea is to use budget deficits or surpluses to keep tax rates relatively stable (Henri, 2017). Consequently, using debt instruments become the best way to smoothen taxes and shape taxation policies. In fact, during permanent increases in predictable government spending, changes cannot occur in the tax rate (Turan, Mesut, & Halit, 2014).

The main cause of Nigeria's severe drop in government revenue and deteriorating financial situation, which has resulted in massive public debt acquisition, is the country's declining oil prices since 1985. Lean external reserves, pressure in the foreign exchange market, and reduced Federation Account and Allocation Committee (FAAC) distribution are further signs of the nation's budgetary issues (Tule, Okafor, Ogiji, Okoro, Laniyan & Ajayi, 2017). This experience has illustrated the challenges of enacting a fiscal policy when oil revenue is more volatile (Baunsgard, 2003, Tule et al., 2017 and Jaillet & Pfister, 2022).

In the last couple of years (1971-2024), the country has witnessed a considerable increase in government's indebtedness in spite of the windfall from crude oil. Poor fiscal policies and excessive government expenditure, which are demonstrated by the on-going pressure on state governments to receive their part of the excess crude account (ECA), may be linked to her incapacity to conserve windfalls. As a testimony and aside a budget surplus of ¦ 0.99 billion recorded in 1995, deficits between the neighbourhood of ¦ 2 billion in 1980 and ¦ 7 trillion in 2024 were also recorded. According to Owolabi (2011), Odetayo & Adeyemi (2017), and Fagbemi (2019), the reasons behind these budget deficits include; the implementation of the Structural Adjustment Program in the mid-1980s; the monetization of the fringe benefits of public officers and political office holders; the reduction in revenue generation due to decline in oil prices caused by oil glut in 1975, 1982, 1996, 2015 and 2020. Furthermore, the country's debt stock has expanded dramatically once more after the debt relief in 2005. It gradually increased both the debt service and the debt to GDP ratio, rising from ¦ 4.2 billion in 2006 to ¦ 32.2 trillion from 2019. Between 2020 and 2024, the total debt stock had increased from ¦ 39.62 trillion. The implication of this is that government spending has been largely financed by debt.

However, there is still a recurrent and persistent fiscal imbalance that leads to high levels of government debt, sovereign debt rollover, and eventual indebtedness, even after a number of economic reforms have been introduced, such as the privatization and commercialization of some government parastatals, passage of a few Acts like the Debt Management Act 2007, the Fiscal Responsibility Act 2007, the Public Procurement Act 2007, the full implementation of the Single Treasury Account (TSA) in 2015, the implementation of the 2022–2024 Medium Term Expenditure Framework (MTEF) and the newly conceived Tax Reform Bill 2024. With the accompanying loss of economic activities, the 2020 Corona Virus pandemic still has its foot prints and further aggravated the condition.

In view of the above, this article examines whether the government follows a tax smoothing pattern to spread tax burden in Nigeria, given that deficits are cyclical and tax creates an excess burden. In doing this, the research question raised is, does tax smoothing hypothesis holds in Nigeria? The main objective of this paper is to test for the validity of tax smoothing hypothesis having established that there is dearth of this study in Nigeria. Also, with regard to methodology, this paper uses Vector Auto-Regression (VAR) conditioned on pre-test results as against the Threshold and Engel Granger Causality used by previous studies such as Kurniawan (2016), Atuma & Eze (2017) and Bonzu (2022). The use of VAR helped to reveal the dynamic interaction among the variables (tax rates, government expenditure and output) via variance decomposition and the impulse response. Aside the introduction, other parts of the paper include: Stylized facts, Literature review, Model specification, Data and estimation techniques, Results and discussion as well as Conclusion and recommendations.

2. Stylized facts

Table 1: The Fiscal Stance in Nigeria, 1971-2023

YEAR	TR (₦'B)	TGE (₦'B)	FB (₦'B)	TD (₦'B)	TR % GDP	TGE% GDP	FB%GDP	TD%GDP	GROWTH RATE
1971-1975	2.86	2.53	0.329	1.51	22.17	19.6	2.22	11.71	5.79
1976-1980	8.8	9.41	-1.045	6,18	21.25	22.72	-2.94	14.92	4.05
1981-1985	12.31	11.13	-3.81	31.18	11.07	10.01	-3.56	28.03	-0.75
1986-1990	43.51	33.47	-12.71	211.72	16.71	12.85	-4.90	81.31	5.42
1991-1995	229.21	152.05	-41.94	864.98	16.81	11.15	-4.41	63.44	2.49
1996-2000	884.95	580.29	-99.04	2139.33	18.75	12.29	-2.06	45.32	3.08
2001-2005	3219.36	1313.94	-211.84	5116.34	31.8	12.98	-2.35	50.53	6.19
2006-2010	6358.29	2928.66	-436.29	3343.42	22.31	10.27	-1.32	11.73	6.76
2011-2015	9702.55	4924.24	-136.23	8612.16	12.16	6.17	-1.43	10.8	4.8
2016-2023	8818.19	12657.01	-4684.2	14326.9	6.48	9.24	-3.43	10.46	4.60

Source: Author's Computation 2024

In the 1970s, Nigeria remarkably benefited from the world oil boom. The windfalls were the proceeds from oil exports and taxes paid by the foreign oil companies operating in the country. This greatly increased the domestic (non-aid) revenues and savings of the government. With this, the government was able to commit a larger proportion of its savings to finance development projects rather than rely on foreign aid. Hence, the growth in oil revenues, unfortunately, lessen the urgent efforts to collect non-oil domestic revenues like income and sales taxes. Analytically, Table 1 shows the trend of the fiscal stance in Nigeria from 1971 to 2023 on a 5-year average.

1. Literature Review

This paper reviewed literatures relevant to this research. The review is organized into three sub-sections. The theoretical review comes first, followed by the methodological and empirical reviews.

Theoretical Literature

The relevant theoretical foundations to this study include Barro's Tax Smoothing Theory and the Ricardian Equivalence Theory. These theories are, in turn discussed accordingly:

Barro Tax Smoothing Theory

Barro's Tax Smoothing Theory (BTST) (1979, 1981) is essentially a theory of optimal financing that explains the factors that determine a choice between debt and taxes. The theory postulates that in a deterministic context, optimal tax rates are constant, but in the case of a stochastic economy with incomplete financial markets, tax rates follow a more random pattern generated by a martingale process. In other words, the hypothesis that tax rate, if optimally smoothed, will follow a random walk since an optimally set tax rate would only change upon the arrival of new information and/or shocks. The implication is that it is plausible to expect that tax distortions or excess burdens of taxation may increase more than proportional with tax rates. A major critique of the theory is that it is basically cast in a partial equilibrium context and prescribe that tax rate should smoothen over time.

The Ricardian Equivalence Theory

This is an economic theory developed by British 19th Century political economist David Ricardo (1772-1823) that argues that attempts to stimulate an economy by increasing debt-financed government spending are doomed to failure because demand remains unchanged. The theory posits that consumers will save any money received to pay for the future tax increases they expect to be levied in order to pay off the debt. Thus, the recipients of a government's windfall see it as a bonus but not a long-term increase in income because it may be clawed back in the form of higher taxes in the future.

In summary, the primary tenet of the Ricardian Equivalence Theory (RET) is that demand remains the same regardless of how a government decides to raise spending, whether it does so by raising taxes or borrowing more money. This hypothesis has, nevertheless, drawn a lot of criticism. First, it was claimed that the theory is predicated on irrational presumptions that individuals will save money in anticipation of a fictitious tax hike in the future. Additionally, it also assumes that while it will not be necessary to use the windfall, the financial markets, the economy as a whole, and even individual earnings will remain unchanged for the foreseeable future.

Empirical Review

The literature on tax smoothing has two strands; the first strand examines the random walk behaviour and whether tax rate is unpredictable by its own lagged value or lagged values of other variables, as shown in the works of Barro (1981), Kingston (1984), Kingston and Layton (1986), Kingston (1991) and Strazicich (1996, 1997, 2002), among others. The second strand examines the relationship between budget balance and government expenditure. The implication in this case is that during bad times, the government is expected to run budget deficit, either through an increase in spending or a cut in tax, and in good times, the government is expected run budget surplus. Thus, this approach of tax smoothing is counter-cyclical in nature as demonstrated in the works of Huang and Lin (1993), Olekalns (1997) and Cashin, Haque and Olekalns (1999)

Karakas, Turan and Yanikkaya (2014) assessed if tax smoothing existed in Turkey's situation using data spanning from 1923 to 2011. Data on tax rates, government expenditures and real output for the period were analyzed. To determine whether the tax smoothing hypothesis holds or not, they employ the Augmented Dickey Fuller (ADF) test, Dickey Fuller test with Generalized Least Squares (DF-GLS), Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) test, Elliot, Rothenberg, and Stock Point Optimal (ERS) test, and Philips-Perron (PP) test to check the presence of unit root in the tax rate sequence. An auto-regression and Vector autoregressive model were estimated. The overall findings suggested that Turkey does not fit the tax smoothing theory and this implied that distortionary eûects of taxation were minimized over the study period. Still on Turkey, Bolatoglu (2003) employs relatively simple techniques to examine the hypothesis and reported evidence for the existence of tax smoothing behaviour in the Turkish economy.

Belguith, Gabsi, and Mtibaa (2018) used yearly data covering the years 1972–2015 to test the tax smoothing hypothesis in Tunisia. The researchers ran unit root and co-integration tests on the data to investigate the null hypotheses of non-stationarity of the tax rates and no co-integration between future tax rate and current permanent government expenditure rate. This is because tax smoothing implies that the tax rate behaves as a random walk and changes in the tax rate are nearly unpredictable. The results showed that the null hypothesis of the unit root cannot be rejected, indicating that the tax rate is non-stationary and, thus, it follows a random walk. The co-integration test indicated that the future tax rate is co-integrated with the current permanent government expenditure rate. These results taking together suggest the existence of tax smoothing's weak form.

Using the tax smoothing hypothesis, Bonzu's (2022) study employed a tri-variate VAR technique to investigate and evaluate the best taxation and fiscal policies in Sierra Leone from 1980 to 2016. The fact that tax changes cannot be predicted by their lag values indicates that the tax rate is unpredictable, according to the research. As a result, the budget deficit is compatible with the best tax policy during the sampling period, so supporting the existence of the tax smoothing hypothesis.

1. Theoretical Framework and Model Specification

The theoretical foundation of this study rests on the Barro, R.J,(1979, 1981) tax smoothing theory (BTST). Using BTST, we consider a two-period domestic economy with no time preference where (y_t) is the output and labour (n_t) is the only factor of production. The production function is:

$$y_t = \theta_t n_t \qquad (1)$$

Where θ_t is exogenous variable with $0 < \theta_0 \neq \theta_1$, and t = 0,1. This implies that a period is a doom while the other is a boom. The production function in (4.1) has constant returns to labour with real wage equals the marginal and average products of labour, denoted by θ_t. Thus, output is exhausted by the wage bill [$\theta_t n_t$], which is the labour income. In this economy, if factor income [$\theta_t n_t$] is taxed, we have;

$$T_t = \tau_t y_t - h_t \qquad (2)$$; $h_t \geq 0$; $\tau_t \leq ½$. Where T_t , h_t , and τ_t

are respectively tax payments, exogenously determined government transfers and the marginal income tax rate. The revenue-maximizing tax rate turns out to be 1/2, therefore, the restriction $\tau_t \leq {}^1/_2$.

The representative agent has an instantaneous utility function of linear quadratic form $C_t - \frac{1}{2} n_t^2$, where C_t denotes domestic private consumption, of domestic and /or imported products. If domestic private asset holding is a_t where t = 0,1, 2. At the initial period (a_0) is predetermined, current asset a_1 is a decision variable, and terminal assets a_2 are zero. The assets are claims on the domestic government and/or on foreign entities with real interest rate of r_t

The representative private domestic agent chooses values of c_t , n_t (t = 0,1) and a_1 that maximize welfare subject to resource constraint as follows:

$$\text{Max} \sum_{i=0}^{n} \left(C_t - \frac{1}{2} n_t^2 \right) \qquad (3)$$

Subject to:

$$h_t + (1 - \tau_t)\, \theta_t n_t + (1 + r_t)\, a_t - (C_t + a_{t+1}) = 0$$

Using λ_t (t = 0, 1) as the multiplier for the constraints, the first-order-necessary conditions for an interior optimum are:

$$\lambda_t = 1 \qquad (4)$$

$$n_t = \theta_t (1 - \tau_t) \qquad (5)$$

$$\tau_t = 0 \qquad (6)$$

Equation (6) is consistent with the assumption of a world of zero time preference. Equation (1) and (5) suggest that output is positively related to productivity and negatively to taxes, such that

$$y_t = \theta_t^2 (1 - \tau_t) \qquad (7)$$

Lifetime private consumption is given by inherited assets *plus* lifetime disposable income:

$$\sum_{t=0}^{1} C_t = a_0 + \sum_{t=0}^{1}(\theta_t^{\,2}(1-\tau_t)^2 + h_t) \qquad (8)$$

The government seeks benevolent (welfare maximizing) finance of its exogenous purchases of goods and service, g_t, plus exogenous transfers h_t. Although debt finance is available, lump-sum taxation is not, so that tax policy must settle for second best. Public debt (b_t), is such that initial debt, b_0 , is predetermined and terminal debt, b_2 is zero.
The government's problem is to choose values of τ_t and b_1 that solve the following problem:

$$\text{Max } \{ a_0 + \sum_{t=0}^{1}(1/2\theta_t^{\,2}(1-\tau_t)^2 + h_t)\} \qquad (9)$$

Subject to:

$\tau_t\theta_t^2(1-\tau_t) + b_{t+1} - (b_t + g_t + h_t) = 0$

According to equation (9), the government's objective function is the agent's indirect life time utility function, or "value function".

Let μ_t be the multipliers to the constraints in (9). The first-order necessary conditions for an interior optimum are

$$\mu_t = 1 + \frac{\tau_t}{1-2\tau_t} \qquad (10)$$

$$\mu_0 = \mu_1 \qquad (11)$$

Equation (10) is the shadow price. μ_t can be interpreted as one plus the one-period marginal efficiency cost of income taxation; the Envelope theorem implies that μ_t also measures the life time domestic cost of an exogenous unit increase in foreign-held public debt. Hence, the case of domestic debt is such that the shadow price is the lesser amount in:

$$\frac{\tau_t}{(1-2\tau_t)}$$

Equations (10) and (11) then imply that: $\tau_0 = \tau_1 \ [= \tau^*]$ (12)

According to equation (12), the optimal tax rate will be *ex ante* (or expectedly) constant over time and that the current tax rate is an unbiased predictor of future tax rates.
Moving from perfect foresight to explicit uncertainty, equation (12) can be expressed as follows:

$$E(\tau_{t+1} \mid \Omega_t) = \tau_t \qquad (13)$$

where Ω_t is the information relevant to tax smoothing available at time *t*.
Equation (13) suggests that for fiscal policy to be optimal, the tax rate τ_t should be a martingale.
Accordingly, if Ω_t built on the past history of τ_t then

$$E(\tau_{t+1} \mid \tau_t, \tau_{t-1}, \dots ,) = \tau_t \qquad (14)$$

or, equivalently

$$E(\tau_{t+1} - \tau_t \mid \tau_t , \tau_{t+1} ,\dots\dots) = 0 \qquad (15)$$

The martingale property applies to a random walk since all changes of a variable following a random walk without drift have zero mean.
A random walk is a stochastic process where the changes of level are given by the addition of a random variable which exhibits a zero mean and a constant variance, and where there is zero correlation between observations. This is given formally as:

$$\tau_t = \tau_{t-1} + \varepsilon_t \qquad (16a)$$

$$\Delta\tau_t = \varepsilon_t \qquad (16b)$$

where ε_t is a term that is independent and identically distributed with mean 0 and variance σ^2 , or $\varepsilon_t \sim i.i.d\,(0, \sigma^2)$. The random walk model (16a) implies that τ_t is non-stationary with a unit root and that the coefficient on τ_{t-1} is equal to one.
Equation (16b) implies that changes in the t

Equation (16b) implies that changes in the tax rate variable will be statistically independent to lagged information. However, from this, changes in government spending and output could individually, or in combination, cause the tax rate to behave as an unpredictable random walk.

Therefore, adapting Kurniawan (2016) and incorporating the ratio of government expenditure to output as well as the growth rate of real GDP in equation 16b to achieve the existence of tax smoothing in Nigeria using Vector Autoregressive model (VAR), we have the model in equation 17:

$$\Delta\tau_t = \beta_0 + \beta_1\Delta\tau_{t-1} + \beta_2\Delta\tau_{t-2} + \beta_3\Delta GE_{t-1} + \beta_4\Delta GE_{t-2} + \beta_3\Delta GDP_{t-1} + \beta_4\Delta GDP_{t-2} \qquad (17)$$

Where $\Delta\tau$ is the change in tax rate, ΔGE is change in government spending, ΔGDP is change in output, β_1.......β_4 are the lag coefficients of $\Delta\tau_{t,}$ ΔGE_t and ΔGDP_t.

The Unit Root Tests

If a series is non-stationary in a regression, then all the regression results suffer from spurious regression problem (see Bai &Perron 1998; 2003). To avoid this problem, the study begins the analysis with prior determination of unvaried properties of the time series. Thus, the data set used in this analysis would be subjected to the standard Augmented Dickey-Fuller (ADF) and Philip Perron (PP) tests.

The Augmented Dickey-Fuller (ADF) Test

The Augmented Dickey-Fuller (ADF) test is a test for a unit root in a large set of time series sample of a model. The ADF takes the form:

$$\Delta X_t = \beta_1 + \beta_2 t + \alpha_1 X_{t-1} + \sum_{i=1}^{k} \alpha_2 \Delta X_{t-1} + \eta_t \qquad (18)$$

Where Δ is the first difference operator; t is the time trend; k denotes the number of lags used and η is the error term; β_s and $\alpha_s$are parameters. The null hypothesis that series X_t is non-stationary can be rejected if α_1 is statistically significant with a negative sign.

The Phillips-Perron (PP) Test

The PP test differs from the ADF tests mainly in how they deal with serial correlation and heteroskedasticity in the errors. In particular, where the ADF tests use a parametric auto- regression to approximate the autoregressive moving average structure of the errors in the test regression, the PP tests ignore any serial correlation in the test regression. The PP tests are specified as;

$$\Delta X_t = \beta_1 + \beta_2 t + \alpha_1 X_{t-1} + \eta_t \qquad (19)$$

Where Δ is the first difference operator; t is the time trend; and $\eta$is the error term; β_s and α_s are parameters. The null hypothesis that series X_t is non-stationary can be rejected if α_1 is statistically significant with a negative sign.

Unit Root with Trend Cases

When testing for unit roots, it is crucial to specify the null and alternative hypotheses appropriately to characterize the trend properties of the data. The two most common trend cases are summarized below:

Case I: Constant Only

The test regression is given as;

$$y_t = c + \phi y_{t-1} + \varepsilon_t \qquad (20)$$

this includes a constant to capture the non-zero mean under the alternative.
The hypotheses to be tested are:
$H_0: \phi = 1 \Rightarrow y_t \sim I(1)$without drift
$H_1: |\phi| < 1 \Rightarrow y_t \sim I(0)$with non-zero mean

Case II: Constant and Time Trend

The test regression is given as;

$$y_t = c + \delta t + \phi y_{t-1} + \varepsilon_t \qquad (21)$$

and this includes a constant and deterministic time trend to capture the deterministic trend under the alternative. The hypotheses to be tested are:
$H_0: \phi = 1 \Rightarrow y_t \sim I(1)$with drift
$H_1: |\phi| < 1 \Rightarrow y_t \sim I(0)$with deterministic time trend

Unit Root with Structural Breaks

The commonly used methods to test for the presence of unit root are the Augmented Dickey-Fuller (1979 and 1981), and it is of the view that current shocks only have a temporary effect and that the long-run movement in the series is unaltered by such shock. However, Perron (1989) showed that failure to allow for an existing break leads to a bias that reduces the ability to reject a false unit root null hypothesis. To overcome this problem, Perron proposed allowing for a known or exogenous structural break in Augmented Dickey-Fuller (ADF) tests. Following this development, many authors including, Zivot and Andrews (1992) and Perron (1997) proposed determining the break point 'endogenously' from the data. Lumsdaine and Papell (1997) extended the Zivot and Andrews (1992) model to accommodate two structural breaks. However, these endogenous tests were criticized for their treatment of breaks under the null hypothesis. Given the breaks were absent under the null hypothesis of unit root there may be tendency for these tests to suggest evidence of stationarity with breaks (Lee and Strazicich, 2003). Lee and Strazicich (2003) propose a two break minimum Lagrange Multiplier (LM) unit root test in which the alternative hypothesis unambiguously implies the series is trend stationary.

The minimum Lagrange Multiplier (LM) unit root test proposed by Lee and Strazicich (2003) not only endogenously determines structural breaks but also avoids the problems of bias and spurious rejections which other tests are subjected to. To avoid problems of bias and spurious rejections, we utilize the endogenous two breaks LM unit root test derived in Lee and Strazicich (2003). The two-break minimum LM unit root can be described as follows. According to the LM (score) principle, a unit root test statistics can be obtained from the following regression:

$$\Delta y_t = d' \Delta Z_t + \phi \tilde{S}_{t-1} + \Sigma \gamma_i \Delta \tilde{S}_{t-i} + \varepsilon_t \qquad (22)$$

where$\tilde{S}_t$ is a de-trended series such that $\tilde{S}_t = y_t - \tilde{\psi}_x Z_t \tilde{\delta}, t = 2, \ldots,$ T. $\tilde{\delta}$ is a vector of coefficients in the regression of Δy_t on ΔZ_t and $\tilde{\psi}_x = y_1 - Z_1 \tilde{\delta}$, where Z_t is defined below: y_1 and Z_1 are the first observation of y_t and $Z_{t,}$ respectively, and Δ is the difference operator. $\varepsilon_t$is the contemporaneous error term and is assumed independent and identically distributed with zero mean and finite variance. $\Delta \tilde{S}_{t-i,}$ I = 1,…, k, terms are included as necessary to correct for serial correlation. Z_t is a vector of exogenous variables defined by the data generating process. Corresponding to the two-break equivalent of Perron's (1989) Model C, with two changes in level and trend, Z_t is described by $(1, t, D_{1t}, D_{2t}, DT^*_{1t}, DT^*_{2t},)'$, where $D_{jt} = 1$ for t $\geq T_{BJ} + 1, J = 1, 2$, and zero otherwise, DT^*_{jt} = t for t $\geq T_{BJ} + 1, J = 1, 2$, and zero otherwise, and T_{BJ} stands for the time period of the breaks. The LM unit root tests statistics is given by: τ = t-statistics for testing the null of a unit root ($\phi = 0$). To endogenously determine the location of two breaks ($\lambda_j = \frac{T_{BJ}}{T}, j = 1,2$), the minimum LM unit root for selecting all plausible break points for the minimum statistics is as follows;

$$LM_\tau = \text{Inf}_\lambda \tilde{\tau}(\lambda) \qquad (23)$$

Since the critical values for Model C depend on the location of breaks (λ_j). Therefore, we utilize critical values that correspond to the location of the breaks. To implement our test, we first need to determine the number of augmentation terms $\Delta \tilde{S}_{t-i,}$ I = 1,…, k, that correct for serial correlation. At each combination of break points $\lambda = (\lambda_1, \lambda_2)'$ in the time interval [0.1T, 0.9T] (to eliminate end points), where T is the sample size, we determine k by following a ''general to specific'' procedure.

The advantages of the two-break minimum LM unit root test over other tests are; first, the break points are endogenously determined from the data. Second, the test is not subject to spurious rejections in the presence of a unit root with break(s). Third, when the alternative hypothesis is true and spurious rejections are absent, Lee and Strazicich (2003) demonstrate that the two-break minimum LM test has greater or comparable power to the LP test.

Predictability of Tax Rate Changes

In this sub-section, the tax smoothing will be examined using the univariate autoregression to predict whether tax rate changes. $D\tau_t$ is predictable by its own lagged values by estimating the following AR model:

$$\Delta\tau_t = \beta_0 + \sum_{i=1}^{k} \beta_i \, \Delta\tau_{t-1} + u_t \qquad (24)$$

Based on equation (4.40), the test is carried out by employing the *F* test under the null hypothesis that $\beta_1 = \beta_2 = \ldots = \beta_k = 0$, that is $\Delta\tau_t$ is unpredictable by its own lagged values. The *F*-statistics is given by:

$$\frac{R^2/(k-1)}{1 - R^2/(n-k)}$$

where *n* is the number of observations and *k* is the number of estimated parameters and R^2 is the coefficient of determination of the estimated model. If the *F*-statistics is less than the critical values, it implies that tax rate changes are not predicted by its own previous values.

Vector Autoregression (VAR)

Additionally, to examine whether or not tax rate changes are predictable, this study will also perform the VAR analysis. It is important to note that the interest is not to use the impulse response function to capture the dynamic interactions among variables of interest, but to use the *F* test and block exogeneity Wald test.

In this case, changes in tax rates, government expenditure and output were all assumed to be endogenous and they are written as a linear function of its own previous values. The VAR system is represented below:

$$Y_t = C + \sum_{i=1}^{p} A_i \, Y_{t-1} + \varepsilon_{it} \qquad (25)$$

Where Y_t denotes the (3x1) vector of the three endogenous variables given by $Y_t = [\Delta\tau_t, \Delta GE_t, \Delta GDP_t,]'$, c, is a (3x1) vector of intercept terms, A_i is the matrix of autoregressive coefficients of order i, and the vector of random disturbances $\varepsilon_t \equiv [\varepsilon_t{}^{\Delta\tau}, \varepsilon_t{}^{\Delta GE}, \varepsilon_t{}^{\Delta GDP}]'$contains the reduced-form ordinary least squares residuals. The lag length of the endogenous variables, *p*, will be determined by using the information criteria.

By imposing a set of restrictions, it is possible to identify orthogonal shocks, η, for each of the variables and to compute these orthogonal innovations through the random disturbances:

$$\eta_t = B\varepsilon_t \qquad (26)$$

The estimation of allows $Cov(\varepsilon)$ to be determined. Therefore, with the orthogonal restrictions and by means of an adequate normalisation

$$Cov(\eta) = I$$

where *I* (3 x3) identity matrix, therefore:

$$Cov(\eta_t) = Cov(B\varepsilon_t) = BCov(\varepsilon_t)B' \qquad (27)$$

$$I = BCov(\varepsilon_t)B' \qquad (28)$$

Since *B* is a square (n x n) matrix, which has three dimensions, B then has 9 parameters that need to be identified. By imposing orthogonality, only 6 parameters can be determined, essentially from the 2 variances and the 4 covariances. For the complete identification of the model, 3 more restrictions are needed. The use of a Choleski decomposition of the matrix of covariances of the residuals, which requires all elements above the principal diagonal to be zero, provides the necessary additional 3 restrictions, and the system is then exactly identified.

A lower triangular structure to B^{-1} is then imposed,

$$B^{-1} = D = \begin{bmatrix} d_{11} & 0 & 0 \\ d_{21} & d_{22} & 0 \\ d_{31} & d_{32} & d_{33} \end{bmatrix} \quad (29)$$

The residuals ε_{it} are written as a function of the orthogonal shocks in each of the variables which gives:

$$\varepsilon_{it} = D\eta_{it} \quad (30)$$

The basic identification scheme uses a recursive VAR model (proposed by Sims (1980) in which the ordering of the variables is $[\Delta\tau_t, \Delta GE_t, \Delta GDP_t]$, where the contemporaneously exogenous variables are ordered first. The variable in the VAR is thus ordered from the most exogenous to the least exogenous one.

Based on the estimated VAR, predictability of variables in the system is examined by applying the *F* test and block exogeneity Wald test. The *F* test is a joint test that is used for testing the null hypothesis that none of the explanatory lagged variables in a particular equation in the VAR system has significant influence on the dependent variable; all coefficients are simultaneously zero (Greene, 2011; Wooldridge, 2008).

Thus, the tax rate changes equation with p order is given as:

$$\Delta\tau_t = \beta_0 + \sum_{i=1}^{p} \beta_i \, \Delta\tau_{t-1} + \sum_{i=1}^{p} \delta_i \, \Delta GE_{t-1} + \sum_{i=1}^{p} \gamma_i \, \Delta GDP_{t-1} + u_t \quad (31)$$

the null hypothesis to be tested is:

$$H_0 : \sum_{i=1}^{p} \beta_i = \sum_{i=1}^{p} \delta_i = \sum_{i=1}^{p} \gamma_i = 0 \quad (32)$$

If the null hypothesis cannot be rejected, then there is no evidence that any of the explanatory lagged variables have significant influence on changes in the tax rate, hence, changes in tax rate is unpredictable.

A block-exogeneity Wald test is used for testing whether each block of lagged variables in each equation in the VAR system can, either individually or jointly, significantly influence each of the dependent variables. This is done by restricting all the coefficients in each block of lagged variables to zero. The null hypothesis for individual block exogeneity test is given as:

$$H_0 : \sum_{i=1}^{p} \beta_i = 0 \; or \; \sum_{i=1}^{p} \delta_i = 0 \quad (33)$$

1. Results and Discussion

Empirical Results

Descriptive Statistics and Correlation Matrix

The descriptive statistics in Table 2 (Panel A) below shows that Tax Revenue (TR), Government Expenditure (GE) and Gross Domestic Product (GDP) are all the indicators of tax smoothing. The values of the mean were between 0.107 and 0.231. The maximum and minimum values are quite instructive as they show the highest and lowest that have ever been recorded in the series within the period under study. The low standard deviation also reported the extent in which TR, GE and GDP have deviated from their averages with GDP having the highest deviation upon 53 observations.

Table 2 (Panel B) below shows that GE and GDP are positively correlated with TR while GE is negatively correlated to GDP. This reveals the counter cyclical nature of government expenditure in Nigeria. Thus, when the economy is booming, the Nigerian government reduces her expenditure and when it is in recession, it increases her expenditure.

Table 2: Descriptive Statistics and Correlation Matrix

Panel A: Descriptive Statistics for Government Expenditure, Revenue and Growth

Variables	Mean	Max	Min	Std. Dev.	Obs
TR	0.149	0.303	0.056	0.068	53
GE	0.107	0.299	0.051	0.060	53
GDP	0.231	1.772	0.019	0.266	53

Panel B: Correlation Matrix for Government Expenditure, Revenue and Growth

Variables	TR	GE	GDP
TR	1.000		
GE	0.665	1.000	
GDP	0.108	-0.015	1.000

Source: Author's Compilation 2024

Unit Root Tests Results (With and Without Structural Breaks)

Augmented Dickey-Fuller and Phillips-Perron Unit Root Tests

The stationary tests employed were the Augmented Dickey-Fuller (ADF) and the Phillips-Perron (PP) unit root tests as in Table 3 below. The unit root tests for both ADF and PP results indicate that TR, GE and GDP were not stationary at levels. Thus, the null hypothesis of a unit root was not rejected because the critical values of -3.50 at 5% level is more negative than the calculated values of ADF and PP for the three variables (TR, GE and GDP).

Table 3: Unit Root Tests (1971-2023)

Variables	ADF	PP	Remarks
TR	-3.029	-3.098	
ΔTR	-7.436**	-7.703**	I(1)
GE	-2.847	-2.823	
ΔGE	-10.083**	-10.083**	I(1)
GDP	-2.810	-2.315	
ΔGDP	-6.986**	-36.616**	I(1)

Source: Author's Computation 2024

Lee-Strazicich LM Unit Root Test with Structural Breaks

Following the evidence from the traditional unit root tests of ADF and PP characterized with low unit root power, the Lee-Strazicich LM unit root test as in Table 3 below accounts for the structural breaks in null and alternative hypotheses. The result shows that all the series were not stationary at level because the calculated t-statistics for TR, GE and GDP were less negative than the critical value of -6.185 at 5 per cent level of significance.

In sharp contrast to the results at levels, the Lee-Strazicich t-statistics values were more negative at the first difference of TR, GE and GDP. Thus, TR, GE and GDP were first difference stationary.

Table 4: Lee- Strazicich LM Unit Root Tests with Structural Breaks (1971-2023)

Variables	Statistic	Break Dates	Remarks
TR	-5.140	1981, 2006	
ΔTR	-7.647**	1986, 1990	I(1)
GE	-3.913	1985, 1992	
ΔGE	-10.752**	1981, 1985	I(1)
GDP	-5.528	1985, 1992	
ΔGDP	-7.209**	1997, 2006	I(1)

Source: Author's Computation 2024

Notes: The critical values are -7.004, -6.185 and -5.828 at 1, 5 and 10% levels of significance, respectively. ** denote significance at 5% level.

Predictability of Changes in Tax Rate Autoregression Results

Reiterating from the earlier discussion on tax smoothing, tax rate may behave in an unpredictable random walk. Table 5 below shows the results of autoregression of tax rate ($\Delta\tau_t$) changes which provide information on whether or not changes in tax rate are predictable by their own lagged values. Thus, the autoregression model is estimated using lag order 1, 2, 3 and 4. The Alkaike Information Criterion (AIC) statistics was used to determine the appropriate lag length and lag 1 gives the best specification because it has the lowest value. However, lags 2, 3 and 4 were also considered to provide further information on the predictability of tax rate changes.

In addition, the F-statistics obtained from all the 2, 3 and 4 lag lengths were not significantly different from zero at the 5 per cent level. At the 1, 2, 3 and 4 lag lengths, the F-Statistics values were 0.298, 1.445, 1.146 and 0.979.

Arising from the above, the null hypothesis of zero coefficients for the lag values of tax rate changes cannot be rejected, hence changes in the tax rate cannot be predicted by its own lag values for the sample period considered. This, however, implies that tax rate changes in Nigeria exhibits random walk.

Table 5: Tax Rate Autoregression

	Autoregression Lags			
Coefficient	Lag 1	Lag 2	Lag 3	Lag 4
β_0	-0.001	-0.002	-0.004	-0.005
	(-0.195)	(-0.264)	(-0.563)	(-0.654)
β_1	-0.079	-0.099	-0.114	-0.141
	(-0.541)	(-0.681)	(-0.783)	(-0.907)
β_2		-0.232	-0.248	-0.273
		(-1.603)	(-1.737)	(-1.829)
β_3			-0.019	-0.038
			(-0.133)	(-0.252)
β_4				-0.085
				(-0.574)
F-stat	0.298	1.445	1.146	0.979
Prob	0.591	0.248	0.343	0.434

Source: Author's Computation 2024

Lag Order Selection Criteria and Vector Autoregression (VAR) Estimates

Table 6 gives the summary of the lag order selection criteria (Panel A) and Vector Autoregression (VAR) estimates (Panel B) premised on variables such as the changes in tax rate ($\Delta\tau_t$) can only be predicted by its own lagged values as well as by the changes in government expenditure (ΔGE_t) and the real growth rate of gross domestic product (ΔGDP_t). Similarly, ΔGE_t and ΔGDP_t cannot be predicted by their lagged values only but also by changes in other variables alike in the model.

From Table 6 below, the changes of tax rate provides evidence on the predictability of ΔGE_t and ΔGDP_t via determining the lag length of the VAR models by choosing a lag length of 1 exhibited by the FPE, AIC and HQ from a maximum lag length of 6 (as shown in Panel A). However, for robustness about the predictability of ΔGE_t, $\Delta\tau_t$ and ΔGDP_t, lags 1-4 were considered.

In Panel B, the results of the VAR estimation for changes in tax rate equation, ($\Delta\tau_t$) as the dependent variable suggests that the null hypothesis of zero coefficient for lags 1,3 and 4 cannot be rejected since the F-statistics of 2.380, 1.570 and 1.977 (with p-values of 0.083, 0.164 and 0.063) were not significant at 5 per cent. However, lag order 2 which is significant at 5 per cent with F-statistics of 2.584 (p-value=0.033). It can be concluded that changes in tax rate in Nigeria are not predictable by lag order 1, 3 and 4 variables but predictable by lag order 2.

For changes in government expenditure (ΔGE_t) equation in Nigeria, the results suggest that lag order 2, 3 and 4 do not have predictive power because their F-statistics of 2.053, 1.339 and 1.247 (with p-values = 0.082, 0.255 and 0.303) respectively were not significant at 5 per cent. Thus, for lag order 1, the F-statistics of 4.466 (with p-value = 0.009) indicated that it has a predictive power at 5 level of significance.

The results for the GDP growth rate (ΔGDP_t) equation, also suggest that lag order 2, 3 and 4 have no predictive power because they are not significant at 5 per cent since they exhibit F-statistics of 2.295, 1.720 and 1.424 (with p-values = 0.053, 0.121 and 0.207) respectively. Conversely, the F-statistics of 4.324 for VAR with lag order 1 was significant and predictive at 5 per cent (with p-values = 0.009).

Table 6: Vector Autoregression Results

Panel A: VAR Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	159.2234	NA	0.0000	-7.1012	-6.9796*	-7.0561
1	174.7376	28.2081	0.0000*	-7.3974*	-6.9108	-7.2169*
2	181.3365	11.0985	0.0000	-7.2882	-6.4370	-6.9726
3	183.8623	3.9038	0.0000	-6.9939	-5.7776	-6.5430
4	189.9808	8.6215	0.0000	-6.8634	-5.2817	-6.2768
5	195.1463	6.5747	0.0000	-6.6889	-4.7425	-5.9670
6	210.7480	17.7295*	0.0000	-6.9889	-4.6774	-6.1319

Panel B: Vector Autoregression

Dependent Variables	Lag Order in VAR	R^2	F-Stat	DW
$\Delta\tau_t$	1	0.139	2.380*	1.841
	2	0.274	2.582**	1.983
	3	0.276	1.570	2.018
	4	0.418	1.977*	1.995
ΔGE_t	1	0.231	4.464**	1.979
	2	0.234	2.053*	1.998
	3	0.246	1.339	1.864
	4	0.313	1.247	2.245
ΔGDP_t	1	0.225	4.324**	1.931
	2	0.254	2.295*	1.895
	3	0.296	1.720	1.881
	4	0.344	1.425	2.071

Source: Author's Computation 2024
Notes: ** denotes significance at 5% level.

Granger Causality Results

Table 7 presents the results of block exogeneity Wald test based on VAR with lag order of 1 being the best specification as earlier mentioned. The results are on 4 rows and 5 columns. The second row reports the results of testing by excluding the block lags of ΔGE_t and ΔGDP_t from changes in the $\Delta\boldsymbol{\tau}_t$ equation jointly and separately. In the same vein, row 3 reports the results of testing $\Delta GE_t$by excluding $\Delta\boldsymbol{\tau}_t$and ΔGDP_t while row 4 reports the results of $\Delta GDP_t$by excluding $\Delta\boldsymbol{\tau}_t$ and ΔGE_t. The second column has a list of independent variables as well as a joint statistics excluded from the equations. The third, fourth and fifth columns were the values of the chi-square, degree of freedom (DF) and probability, respectively.

The results in row 2 suggest that the null hypothesis of excluding ΔGE_t and ΔGDP_t as well as the joint variables from the $\Delta\tau_t$ can be rejected either jointly or separately following the Chi-square values of 6.108, 4.091 and 6.814 with the probability values being 0.014, 0.044 and 0.035, respectively at 5 per cent level of significance. The implication is that all the variables have significant explanatory power of predicting $\Delta\tau_t$ in Nigeria.

In row 3, the block of lags of ΔGDP_t and joint variables can jointly be excluded from ΔGE_t equation since the chi-square test of 0.743 (with probability = 0.391) and chi-square of 5.731 (with probability = 0.059) are not significant at 5 per cent. For $\Delta\tau_t$, the result suggests that the null hypothesis should be rejected because the chi-square value was 4.455 (with probability = 0.036) significant at 5 per cent. This implies that $\Delta\tau_t$ has a significant explanatory power of predicting ΔGE_t in Nigeria.

In the last row, the results suggest the null hypothesis of excluding the block of lags of $\Delta GE_t$and joint variables from output growth (ΔGDP_t) equation should be rejected following the chi-square values of 11.154 and 12.942 (with probability values = 0.001 and 0.002), respectively while the null hypothesis of $\Delta\tau_t$ with chi-square of 0.004 (with probability = 0.958) cannot be rejected because the variable have no predictive power in ΔGDP_t.

In summary, there is evidence that GE_t and GDP_t Granger cause τ_t, τ_t Granger causes GE_t and GE_t Granger causes GDP_t. Thus, there is evidence of bidirectional causality between GE_t and τ_t and unidirectional causality from GE_t to GDP_t in Nigeria.

Table 7: Block Exogeneity Wald Test

	Column 1	**Column 2**	**Column 3**	**Column 4**	**Column 5**
Row 1	Dependent Variables	Excluded Variables	Chi-Sq	Df	P-value
Row 2	$\Delta\boldsymbol{\tau}_t$	ΔGE_t	6.108	1	0.014
		ΔGDP_t	4.091	1	0.044
		All	6.814	2	0.035
Row 3	ΔGE_t	$\Delta\boldsymbol{\tau}_t$	4.455	1	0.036
		ΔGDP_t	0.743	1	0.391
		All	5.731	2	0.059
Row 4	ΔGDP_t	$\Delta\boldsymbol{\tau}_t$	0.004	1	0.958
		ΔGE_t	11.154	1	0.001
		All	12.942	2	0.002

Source: Author's Computation 2024

Notes: Table 7 reports block exogeneity test for changes in tax rate ($\Delta\tau_t$), government expenditure (ΔGE_t) and gross domestic product (ΔGDP_t).

1. Conclusion and Recommendations

In the battery of the unit root tests, tax rate was non-stationary because the null cannot be rejected and this is consistent with a random walk.

The predictability of tax rate was anchored on regressing changes in the tax rate on its own lagged values as well as lagged changes in tax rate on changes in government expenditure as a ratio of GDP ("GE_t) and the growth rate of output ("GDP_t).

In the final analysis, it was discovered that the tax smoothing hypothesis was consistent and displayed random walk but the lagged changes in tax rate was significantly predicted by changes in government expenditure (") and growth rate of output (") in Nigeria. In support of this, Barro (1979, 1981), Adler (2006), Karaka, Taner & Yanikkaya (2014) and Bonzu (2022) established that in a deterministic situation, optimal tax rates are constant, but in a stochastic economy with new information or shocks, tax rates follow a more random pattern generated by a martingale process. This paper recommends that; government should improve revenue generation and block leakages; embrace fiscal discipline; broaden tax base and simplify tax system to encourage voluntary compliance and reduce cost; and prioritize public expenditure.

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