



MODERATING EFFECT OF DIGITALISATION ON THE RELATIONSHIP BETWEEN TAX REVENUE AND BUDGET PERFORMANCE IN NIGERIA

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Abstract

Inspired by persistent fiscal imbalances, and tax revenue compelled an exploration of the significance of digitalisation in securing Nigeria's enduring budgetary sustainability. This study investigates the moderating effect of digitalisation on the relationship between tax revenue and budget performance in Nigeria, using annual data from 1981 to 2024. The study employed quantitative longitudinal research design. The Autoregressive Distributed Lag (ARDL) model was employed to analyze both short-run and long-run dynamics after unit root tests (Augmented Dickey-Fuller and Philip-Perron) confirmed a mix of stationary variables. The results revealed that total tax revenue showed a significant positive impact on budget performance. When disaggregated, direct taxes had a negative effect, while indirect taxes had a marginally positive effect in the short run. The interaction term with tax revenue was negative but statistically not significant. The consistently significant negative error correction terms across all models confirmed a long-run equilibrium relationship. The study concluded that digitalisation adoption in Nigeria does not significantly moderate the relationship between tax revenue and budget performance. The study recommends prioritizing structural reforms and digital modernization to curb expenditures and ensure sustainable budget performance. Furthermore, full implementation of the Nigeria Tax Act 2025 is advocated to digitalize tax revenue streams and enhance collection efficiency across federal agencies.

Keywords: Digitalisation, tax revenue, budget performance, ARDL Model.

1. Introduction

The proficient execution of budgetary performance is imperative for the effective financial governance and economic advancement of Nigeria (Olaoye & Orimogunje, 2022). Nonetheless, the process of revenue generation often leads to expenditures surpassing revenues, thereby culminating in fiscal deficits (Momodu & Monogbe, 2017). Consequently, the augmentation of revenue-generating competencies is imperative for the realization of macroeconomic equilibrium (Olaoye & Alabandan, 2024). Nigeria's fiscal deficits persistently exceeded the 3% limit, reaching 3.88% of GDP in 2024–2025 (Olusegun et al., 2024). Driven by expenditures doubling revenue, these deficits stemmed from poor tax compliance and narrow revenue bases (Felix & Elisha, 2023). Revenue underperformance consistently limited spending to 85% of targets (Amade & Oyigebe, 2024). Historically, outlays surpassed income since 1980, excluding 1995–1996 surpluses achieved through austerity (Adebisi & Oyeleke, 2020). Excessive deficits threatened stability (Chenge &

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Abel, 2023), fueled by fiscal indiscipline and inaccurate revenue projections (Olaoye & Akinola, 2019; Paolo & Chloe, 2020).

Nigeria's 7.3% revenue-to-GDP ratio ranked among the world's lowest, trailing Economic Community of West African States (ECOWAS) and Sub-Saharan Africa (SSA) averages (Jung, 2023). Strategic initiatives targeted a 15% ratio by 2027 to mitigate strains from declining petroleum income (Kolawole, 2021; Jung, 2023). Although taxes remained the most sustainable revenue source (Adeniyi & Adedapo, 2020), the tax-to-GDP ratio fell to 7.9% in 2022, missing the 15% World Bank threshold (Falohun & Babatunde, 2024). Consequently, authorities targeted an 18% ratio to ensure fiscal stability, leveraging digitalisation to enhance compliance (Bright, 2023; Ajetunmobi et al., 2022).

IPSAS 24 promoted transparency via budget-to-actual mandates, while Nigeria's adoption of ITAS and TSA aimed to boost revenue through improved compliance (Ater, 2023; Awogbade, 2023; Mohammed & Ibrahim, 2024). Although these technologies theoretically mitigated evasion and reduced deficits (Asomba et al., 2024; Värzaru et al., 2023), Nigeria lagged regional leaders due to infrastructure and literacy gaps (United Nations, 2022, 2024). Empirical contradictions persisted; Waleed (2020) found taxation insignificant in Jordan, whereas Anojan (2023) demonstrated substantial effects in Sri Lanka. In Nigeria, studies showed conflicting results regarding digitalisation's potential (Muhammad, 2025; Osadola et al., 2023), with disagreements over whether moderation was positive or negligible (Mohammed & Gemu, 2024; Ofurum et al., 2018; Ogbada et al., 2023). Methodological reliance on cross-sectional data further obscured long-term dynamics (Adefulu et al., 2024; Ejeh et al., 2025). Consequently, this study utilized ARDL modeling to investigate digitalisation's moderating role on the relationship between tax revenue and budget performance in Nigeria.

2. Literature Review

Conceptual Review

Budget Performance

Budgets were defined as financial plans detailing projected revenue and expenditure (Central Bank of Nigeria, 2017). Budget performance denoted how entities fulfilled aims regarding revenue, expenditure, and debt sustainability through economy, efficiency, and effectiveness (Akano & Salawu, 2024; Laili & Sari, 2022; Osadola et al., 2023). It served as a metric for a government's capacity to execute strategies and optimize resource allocation (Hadi Al Ghozali et al., 2024; Liu, 2024; Olaoye & Alababan, 2024). While deficits resulted from excessive spending or suboptimal collection (Balan, 2020), reforms like the Treasury Single Account were introduced to enhance transparency (Udoikah et al., 2024; Uwaleke et al., 2024). IPSAS 24 required juxtaposing budgeted and actual figures to enhance accountability (Dominic & Ubong, 2018; Ibrahim et al., 2021). While some studies used GDP or capital expenditure as proxies, this study utilized budget balances as a percentage of GDP to reflect fiscal discipline (Adeyemi et al., 2022; Arif & Arif, 2023; Okoye et al., 2021). Digitalisation supported IPSAS 24 by providing real-time data to track variances (Momodu & Monogbe, 2017). OECD metrics categorized performance via GDP ratios or expenditure growth (Ehizuelen & Basse, 2025). Digital systems streamlined cycles, addressing corruption to achieve better outcomes (Kadir et al., 2024; Obidike & Onuora, 2025; Ofoma, 2022). This research assessed performance using the budget balance-to-GDP ratio to evaluate national

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efficacy and debt viability (Hancer, 2024; Ogiji & Ajayi, 2020; Okwuokei, 2014; Olayide & Ikpi, 2010; Uwaleke et al., 2024).

Tax Revenue

Tax revenue was defined as a mandatory fiscal levy on individuals and entities to fund government initiatives, with evasion constituting a legal violation (Central Bank of Nigeria [CBN], 2017). These contributions remained vital for public finance, wealth redistribution, and stability (Kaka, 2020; Muhammad, 2025). Revenue generation involved systematic processes to increase resources through statutory enforcement (Dakhil et al., 2025). Taxation was categorized into direct and indirect forms. Direct taxes, including petroleum profit and company income taxes, were borne by the payer, while indirect taxes, such as VAT and customs duties, were transferred to consumers (CBN, 2017). In Nigeria, non-oil revenue targeted sectors outside crude oil, specifically commodities and services (Ajagun et al., 2025; Ibitoye et al., 2025). Regarding oil revenue, the FIRS (now Nigeria Revenue Service) collected hydrocarbon taxes, while the NUPRC oversaw royalties under the Petroleum Industry Act 2021 (CBN, 2017). Petroleum tax rates ranged from 30% to 85%, though recent reforms introduced a dual tax structure for new licenses (PwC, 2024). Digitalisation, including systems like VAT-Collect, aimed to bolster compliance and streamline audits (Folorunsho, 2023; Olasunkanmi & Adejuwon, 2024; Wole, 2020). Ultimately, digital integration strengthened the non-oil tax relationship by enhancing predictability and minimizing deficits (Ibitoye et al., 2025). This research disaggregated these components into direct and indirect taxes (Muhammad, 2025).

Digitalisation

Digitalisation in public finance is the integration of ICT to transform government operations and financial management. While digitization converted analog items into digital artifacts, digitalisation represented a broader socioeconomic transformation (Gradillas & Thomas, 2023). Gherghin (2025) defined it as the integration of technologies to enhance efficiency and transparency. It encompassed institutional and socio-political dimensions, utilizing the E-Government Development Index to foster collaborative governance (Gavrila, 2024; Setyawan et al., 2024). In tax administration, digitalisation optimized revenue collection and compliance (Ajaero et al., 2025). Adoption of electronic taxation boosted revenue while reducing costs, emphasizing transparency through real-time processing (Oloyede, 2022; Omotayo et al., 2025; Scannell & Tawiah, 2024). Nigeria's telecommunications sector evolved from a state-owned monopoly under Nigerian Telecommunications Limited (NITEL - 1980) to a liberalized market following the 1992 decree and the 2003 NCC Act (Anie, 2011; Eke et al., 2019). Progress was tracked through teledensity and mobile subscriptions (Ndam et al., 2023; World Bank, 2023). The government integrated platforms like the Treasury Single Account (2015), GIFMIS (2003), IPPIS (2007), and TaxPro-Max (2021) to automate budget execution and simplify compliance (Central Bank of Nigeria, 2017). The E-Government Development Index (EGDI), established by United Nations Department of Economic and Social Affairs (UNDESA) in 2001, measured digital governance through online services, infrastructure, and human capital indices (United Nations, 2022, 2024). Nigeria joined the EGDI framework in 2003, signifying a shift toward standardized global assessments (Ishola et al., 2020). This research utilized EGDI and telecommunication density (measuring phone connections per 100 residents and percentage of individuals using internet) to proxy digitalisation (DIG), evaluating infrastructure and inclusive access (Adams & Paul, 2023).

Ewuga, A., Shittu, I., Usman, A. B. & Garba, A. (2026). Moderating effect of digitalisation on the relationship between tax revenue and budget performance in Nigeria. *Malete Journal of Accounting and Finance*, 7 (1), 149 – 173

Theoretical Framework

Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM), developed by Davis (1989), served as the framework for understanding how digitalisation influenced Nigeria's fiscal landscape. Rooted in the Theory of Reasoned Action, TAM posited that perceived usefulness (PU) and perceived ease of use (PEOU) drove system adoption. In this study, PU reflected beliefs that tools like ASYCUDA enhanced collection efficiency, while PEOU denoted ease of navigation. Empirical evidence confirmed that high PU and PEOU significantly boosted taxpayer compliance and user intention (Kaliky et al., 2024; Sepasgozar et al., 2020). Widespread adoption reduced leakages and fostered transparency (Umar et al., 2023). Furthermore, digital utility encouraged fiscal discipline (Babatunde & Remilekun, 2024). TAM elucidated how digitalisation moderated the revenue-budget nexus, ensuring that technological acceptance optimized Nigeria's fiscal position.

Institutional Theory

Institutional Theory, pioneered by Meyer and Rowan (1977), examined how Nigeria's environments shaped fiscal outcomes. The framework suggested that institutions attained legitimacy through isomorphism, conforming to dominant norms (Meyer & Rowan, 1977). These pressures impacted performance as reality was socially constructed (Andriele et al., 2017; Lammers & Garcia, 2017). In Nigeria, governance quality and the Fiscal Responsibility Act (2007) determined efficiency, while inadequate frameworks led to deficits (Emelogu & Ozughalu, 2010; Kilishi, 2020). Consequently, transparency reforms were advocated (Emmanuel et al., 2024). Digitalisation acted as a catalyst for institutional change, reducing information asymmetry and rent-seeking behavior to optimize budget performance (Diamond, 2006; Jameel et al., 2019; Rivero-del-Paso et al., 2023).

Empirical Review

Muhammad (2025) found that while oil prices boosted revenue growth, tax revenue had marginal long-run impacts. Digitalisation was identified as essential for transparency, though infrastructure investments often coexisted with corruption (Osadola et al., 2023). Regarding deficits, effects ranged from stimulating short-run growth to increasing long-run borrowing costs (Emenike & Edirin, 2017; Kolawole, 2023; Umaru et al., 2021), while budget credibility remained a concern (Nwaorgu & Alozie, 2017). International evidence from Sri Lanka and Jordan remained inconclusive (Anojan, 2023; Waleed, 2020). In Nigeria, petroleum profit tax positively correlated with growth, whereas corporate and value-added taxes often exhibited negative impacts (Amadi & Amadi, 2023; Basha, 2022; Otekunrin et al., 2023). While some taxes boosted capital expenditure (Adeyemi et al., 2022; Duyile et al., 2024), implementation was hindered by corruption, fraud, and administrative inefficiencies (Audu et al., 2023; Owenvbiugie & Owenvbiugie, 2020).

The transformative role of digitalisation was highlighted by Oti-Akenteng et al. (2025), who found it enhanced revenue in Ghana. Ajaero et al. (2025) and Akinyosoye et al. (2025) confirmed that tax digitalisation altered Nigeria's revenue landscape, with online systems mitigating leakages. Asomba et al. (2024) and Oloyede (2022) argued e-governance augmented fiscal efficiency, while Mohammed and Gemu (2024) found technology positively moderated the non-oil revenue-growth relationship. However, empirical contradictions persisted; Okere et al. (2024) reported positive correlations between ICT and tax mobilization, whereas Ogbada et al. (2023) and Ofurum et al. (2018) found negligible effects. Ndam et al. (2023) highlighted long-run

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negative contributions from teledensity. Bate (2021) utilized GMM to show digitalisation positively affected African tax mobilization through education and industrial channels. Finally, Gomba et al. (2024) revealed that digital technologies significantly improved CIT and capital gains tax collection. This study addressed these gaps by utilizing an ARDL framework to test digitalisation as a moderator.

Ho₁ There is no significant relationship between tax revenue and budget performance in Nigeria.

Ho₂ Digitalisation does not significantly moderate the relationship between tax revenue and budget performance in Nigeria.

3. Methodology

The study employed a quantitative research method via a longitudinal research design to analyze time-series data, following the precedents set by Muhammad (2025), Okoroigwe et al. (2023), and Waleed (2020). Utilizing the approach of Oladejo (2024), the research utilized the entire population of Nigeria’s fiscal metrics from 1981 to 2024. Secondary data were sourced from the Central Bank of Nigeria, Federal Inland Revenue Service, World Bank Development indicators, and United Nations E-Government Development index. The 44-year analysis combined a pre-EGDI era (1981–2002), using telecommunication density as a proxy for technological preparedness (using overall average of telecommunication density, measure as number of telephones connections per 100 inhabitants both mobile and fixed line telephone subscribers and percentage of individuals using internet in Nigeria), and an EGDI era (2003–2024), measuring digital progress via overall average of online services, infrastructure, and human capital indices. Inferential analysis was conducted using EViews 12, employing Principal Component Analysis for tax revenue indices and the Autoregressive Distributed Lag (ARDL) approach to estimate short- and long-run relationships. Moderated multiple regression determined how digitalisation altered the link between revenue generation and budget performance, ensuring robust hypothesis validation.

Table 1
Summary of Variables, Acronyms, Measurements, and Sources

Variable	Symbol	Description & Measurement	Sourced
Budget Performance	BP	Measure as overall budget balance (deficit) expressed as percentage of Gross Domestic Product (GDP) annually.	Ehizuelen Bassy 2025
Tax Revenue	TR	Measure as absolute value of annual tax revenue for the period in Nigeria.	Choudhary et al., 2024
Direct Tax	DT	Measure as absolute value of direct tax revenue for the period in Nigeria	Basha, 2022
Indirect Tax	IDT	Measure as absolute value of indirect tax revenue for the period in Nigeria.	Ebaidalla, 2024.
Digitalisation	DIG	Measure as the E-Government Development index and World Development indicators Telecommunication Density period in Nigeria.	Kotenok et al 2020, & Usman & Mazadu, 2021
Government Expenditure	GE	Measure as log of government expenditure as percentage of GDP in Nigeria for the period.	Gombe et al., 2024

Ewuga, A., Shittu, I., Usman, A. B. & Garba, A. (2026). Moderating effect of digitalisation on the relationship between tax revenue and budget performance in Nigeria. *Malet Journal of Accounting and Finance*, 7 (1), 149 – 173

Public Debt Ratio PDR Measure as log of public debt ratio in Nigeria for the period
 Azu & Agbobu, 2023
 Source: Author's Compilation, 2026

Model Specifications

The study employed the ARDL multiple regression model to analyze the relationship between petroleum revenue and budget performance. ARDL provides valid estimation irrespective of mixed integration order up to I(1) (Umaru, Aliero & Abubakar, 2021) and allows for examining temporal effects using a contemporary framework (Aboudi, Allam & Bakkouchi, 2023). The generalized ARDL (p, q) model is specified as:

$$Y_t = g_{0i} + \sum_{i=1}^p d_i Y_{t-i} + \sum_{i=1}^q b'_i X_{t-i} + e_t \dots\dots\dots (1)$$

Where Y_t is a vector and the variable in (X'_t) are allowed to be purely I(0) or I(1) or cointegrated; d and b are the coefficients; γ is the constant; $i = 1..k$; p, q are optimal lag orders; ϵ_t is a vector of the error terms – unobserved zero mean white noise vector process (serial uncorrelated or independent. More precisely, the researcher delineates models based on objectives of the study and formed as aggregated and disaggregated, all specify using ARDL as employed by Muhammad (2025).

Model 1: The effect of tax revenue on budget performance in Nigeria.

$$BP_t = \beta_0 + \beta_1 TRI_t + \beta_2 \ln GE_t + \beta_3 \ln PDR_t + \epsilon_t \dots\dots\dots (2)$$

Where: BP = Budget performance proxied as Budget balances (% GDP)

β_0 = The constant term represents the expected value of the budget deficit when independent variables is zero.

TRI = Tax revenue index

$\ln GE$ = Log of government expenditure growth

$\ln PDR$ = Natural logarithm of public debt ratio

β_{1-3} , = The coefficients of direct relationship that represent the impact of each tax revenue and control variable on the budget performance

ϵ_t = Error term.

The ARDL model is specified as follows:

$$\Delta BP_t = \beta_0 + \sum_{t=1}^p \phi_i \Delta BP_{t-i} + \sum_{t=1}^q \alpha_1 \Delta TRI_{t-i} + \sum_{t=1}^q \alpha_2 \Delta \ln GE_{t-i} + \sum_{t=1}^q \alpha_3 \Delta \ln PDR_{t-i} + \beta_1 BP_{t-1} + \beta_2 TRI_{t-1} + \beta_3 \ln GE_{t-1} + \beta_4 \ln PDR_{t-1} + \epsilon_t \dots\dots\dots (3)$$

The Error Correction Model (ECM) model for BP_t is specified as follows:

$$\Delta BP_t = \beta_0 + \sum_{t=1}^p \phi_1 \Delta BP_{t-i} + \sum_{t=1}^q \alpha_1 \Delta TRI_{t-i} + \sum_{t=1}^q \alpha_2 \Delta \ln GE_{t-i} + \sum_{t=1}^q \alpha_3 \Delta \ln PDR_{t-i} + IECT_{t-1} + \epsilon_t \dots\dots\dots (4)$$

Where: All variables are as previously defined except:

$t=1$ = are the optimal lag orders.

$t-1$ = are the lag values.

ϕ, α = short term dynamics.

β = long term dynamics.

p = the maximum number of lags for independent variable in the study. It represents fiscal inertia. The parameter p tells us how many previous periods of Budget Performance ($BP_{t-1}, BP_{t-2}, \dots$) affect the current budget performance. This year's budget deficit is often a direct consequence of last year's commitments, debts, or surplus. If $p=1$, it means the budget performance from just one year ago is a significant predictor of today's balance

- q = The lag of the independent and control variables (TRI, GE and PDR). It represents the transmission delay (or time lag). The parameter q tells us how many previous periods of the tax revenue, expenditure growth and public debt ratio affect the current budget. The lag length for p , q , may not necessarily be the same.
- ε_t = Error term.
- Δ = is the difference operator (compute the difference between consecutive observations). Useful to transform non-stationary data into stationary data. Long run models do not have a difference operator, only the short run model.
- λ = $(1 - \sum_{i=1}^p d_i)$, speed of adjustment (speed limit of the recovery) parameter back to equilibrium, with a negative sign and statistically significant. Tells us how resilient the Nigerian fiscal system is in returning to normal after a crisis.
- ECT_{t-1} = $(BP_{t-1} - \theta X_t)$, the error correction term which is the extracted residuals from the regressions of the long-run equation. This is the most critical part of the model. It represents the gap or error from the previous period. The ECT calculates how much of that gap needs to be closed
- θ = $\frac{\sum_{i=0}^q b_i}{a}$, is the long-run parameters

Equation 4 aimed to determine the speed of adjustment at which the budget returned to its long run equilibrium after a shock. It reconciled short-term fiscal fluctuations with long-term structural trends, measuring how quickly previous errors or imbalances in tax revenue were corrected.

To examine specific items of tax revenue (TRI), TRI in equation 2 is further decomposed and disaggregated to linear form as specified in equation 5:

$$BP_t = \beta_0 + \beta_1 DTI_t + \beta_2 IDTI_t + \beta_3 \ln GE_t + \varepsilon_t \text{-----} (5)$$

Where: All variables are as previously defined except

- DTI = Direct taxes index.
- IDTI = Indirect taxes index.

Equation 5 identified which specific tax type, direct (DTI) or indirect (IDTI), more effectively stabilized the budget. By disaggregating the tax revenue, the parameters (β_1, β_2) measured the individual short-run and long-run contributions of income-based versus consumption-based taxes toward improving budget performance.

The ARDL model is specified as follows:

$$\Delta BP_t = \beta_0 + \sum_{i=1}^p \phi_i \Delta BP_{t-i} + \sum_{t=1}^q \alpha_1 \Delta DTI_{t-i} + \sum_{t=1}^q \alpha_2 \Delta IDTI_{t-i} + \sum_{t=1}^q \alpha_3 \Delta \ln GE_{t-i} + \beta_1 BP_{t-1} + \beta_2 DTI_{t-1} + \beta_3 IDTI_{t-1} + \beta_4 \ln GE_{t-1} + \varepsilon_t \text{-----} (6)$$

Where: All variables are as previously defined.

Equation 6 used an ARDL framework to simultaneously analyse the short-run shocks (α) and long-run relationships (β) of direct (DTI) and indirect (IDTI) taxes on the budget. It captured the time-lagged effects and structural dependencies of specific tax types on fiscal stability.

The ARDL (Short run model) specification is stated due to absence of cointegration:

$$\Delta BP_t = \beta_0 + \sum_{i=1}^p \phi_i \Delta BP_{t-i} + \sum_{t=1}^q \alpha_1 \Delta DTI_{t-i} + \sum_{t=1}^q \alpha_2 \Delta IDTI_{t-i} + \sum_{t=1}^q \alpha_3 \Delta \ln GE_{t-i} + \varepsilon_t \text{-----} (7)$$

Where: All variables are as previously defined.

Ewuga, A., Shittu, I., Usman, A. B. & Garba, A. (2026). Moderating effect of digitalisation on the relationship between tax revenue and budget performance in Nigeria. *Malete Journal of Accounting and Finance*, 7 (1), 149 – 173

The absence of cointegration in equation 6 was a major finding. It suggested that disaggregating tax revenue into direct and indirect tax in Nigeria might not have been structurally linked to budget performance at that time.

Model 2: The moderating effect of digitalisation on the relationship between tax revenue and budget performance in Nigeria.

$$BP_t = \beta_0 + \beta_1 TRI_t + \beta_2 DIG_t + \beta_3 TRI_t * DIG_t + \beta_4 \ln GE_t + \beta_5 \ln PDR_t + \varepsilon_t \text{ ----- (8) Where:}$$

All variables are as previously defined except

$$TRI * DIG = \text{Interaction between TRI and DIG}$$

Equation 8 used an interaction term (TRI*DIG) to test if digitalisation enhanced tax collection efficiency. It aimed to determine whether technology moderated the relationship between tax revenue and budget performance while controlling for spending and debt.

The ARDL model is specified as follows:

$$\Delta BP_t = \beta_0 + \sum_{t=1}^p \phi_i \Delta BP_{t-i} + \sum_{t=1}^q \alpha_1 \Delta TRI_{t-i} + \sum_{t=1}^q \alpha_2 \Delta DIG_{t-i} + \sum_{t=1}^q \alpha_3 \Delta TRI_{t-i} * DIG_{t-i} + \sum_{t=1}^q \alpha_4 \Delta \ln GE_{t-i} + \sum_{t=1}^q \alpha_5 \Delta \ln PDR_{t-i} + \beta_1 BP_{t-1} + \beta_2 TRI_{t-1} + \beta_3 DIG_{t-1} + \beta_4 TRI_t * DIG_{t-1} + \beta_5 \ln GE_{t-1} + \beta_6 \ln PDR_{t-1} + \varepsilon_t \text{ ----- (9)}$$

Where: All variables are as previously defined.

The Error Correction Model (ECM) model for BP_t is estimated as:

$$\Delta BP_t = \beta_0 + \sum_{t=1}^p \phi_i \Delta BP_{t-i} + \sum_{t=1}^q \alpha_1 \Delta TRI_{t-i} + \sum_{t=1}^q \alpha_2 \Delta DIG_{t-i} + \sum_{t=1}^q \alpha_3 \Delta TRI_{t-i} * DIG_{t-i} + \sum_{t=1}^q \alpha_4 \Delta \ln GE_{t-i} + \sum_{t=1}^q \alpha_5 \Delta \ln PDR_{t-i} + IECT_{t-1} + \varepsilon_t \text{ ----- (10)}$$

Where: All variables are as previously defined.

Equation 10 utilized an ECM to capture how digitalisation and driven tax improvements corrected fiscal imbalances. It aimed to measure the speed of adjustment (I) toward long-run budget stability while accounting for short-run shocks in taxation, technology, spending, and debt.

To examined specific items of tax revenue (TR), TR in equation 8 is further decomposed and disaggregated to form model 10 as:

$$BP_t = \beta_0 + \beta_1 DTI_t + \beta_2 IDTI_t + \beta_3 DIG_t + \beta_4 DTI_t * DIG_t + \beta_5 IDTI_t * DIG_t + \beta_6 \ln GE_t + \varepsilon_t \text{ -----(11)}$$

Where: All variables are as previously defined except:

$$DTI * DIG = \text{Interaction between DTI and DIG}$$

$$IDTI * DIG = \text{Interaction between IDTI and DIG}$$

The ARDL model is specified as follows:

$$\Delta BP_t = \beta_0 + \sum_{t=1}^p \phi_i \Delta BP_{t-i} + \sum_{t=1}^q \alpha_1 \Delta IDTI_{t-i} + \sum_{t=1}^q \alpha_2 \Delta IDTI_{t-i} + \sum_{t=1}^q \alpha_3 \Delta DIG_{t-i} + \sum_{t=1}^q \alpha_4 \Delta IDTI_{t-i} * DIG_{t-i} + \sum_{t=1}^q \alpha_5 \Delta IDTI_{t-i} * DIG_{t-i} + \sum_{t=1}^q \alpha_6 \Delta \ln GE_{t-i} + \beta_1 BP_{t-1} + \beta_2 DTI_{t-1} + \beta_3 IDTI_{t-1} + \beta_4 DIG_{t-1} + \beta_5 DTI_t * DIG_{t-1} + \beta_6 IDTI_t * DIG_{t-1} + \beta_7 \ln GE_{t-1} + \varepsilon_t \text{ -----(12)}$$

Where: All variables are as previously defined

The ARDL short-run model is specified as follows:

$$\Delta BP_t = \beta_0 + \sum_{t=1}^p \phi_i \Delta BP_{t-i} + \sum_{t=1}^q \alpha_1 \Delta IDTI_{t-i} + \sum_{t=1}^q \alpha_2 \Delta IDTI_{t-i} + \sum_{t=1}^q \alpha_3 \Delta DIG_{t-i} + \sum_{t=1}^q \alpha_4 \Delta IDTI_{t-i} * DIG_{t-i} + \sum_{t=1}^q \alpha_5 \Delta IDTI_{t-i} * DIG_{t-i} + \sum_{t=1}^q \alpha_6 \Delta \ln GE_{t-i} + \beta_1 BP_{t-1} + \varepsilon_t \text{ ----- (13)}$$

Where: All variables are as previously defined.

Equation 13 analyzed short-run shocks from digitalized direct and indirect taxation. It intended to measure immediate interactive impacts on the budget and the persistence of fiscal performance (lags) when no long-term structural equilibrium was established.

Ewuga, A., Shittu, I., Usman, A. B. & Garba, A. (2026). Moderating effect of digitalisation on the relationship between tax revenue and budget performance in Nigeria. *Malet Journal of Accounting and Finance*, 7 (1), 149 – 173

4. Results and Discussions

Descriptive Statistics

Raw data was utilized for descriptive statistics to ensure precision, identify outliers, and establish a rigorous foundation for modeling (Asuquo, 2021; Montgomery & Runger, 2018).

Table 2

Descriptive Statistics

Variable	Mean	Median	Max	Min	Std. D	Skew	Kurtosis	Jarque - B	Prob.	Obs.
BP	2.7098	2.6136	8.5696	0.0322	1.8733	0.7844	3.7576	5.5646	0.0618	44
TR	2931.9	1062.3	17184	6.2924	3842.7	1.6886	5.9844	37.241	0.0000	44
DT	2010.0	753.08	10462	4.3084	2455.2	1.2903	4.4163	15.888	0.0000	44
IDT	921.83	322.60	6721.3	1.6160	1496.7	2.4861	9.1182	113.95	0.0000	44
DIG	0.2567	0.1250	0.6864	0.0979	0.1369	2.1158	10.133	126.11	0.0000	44
GE	8.3114	8.0117	17.286	5.0893	2.4816	1.5935	6.1894	37.273	0.0000	44
PDR	31.346	24.249	79.713	7.1170	22.343	0.8065	2.3410	5.5665	0.0618	44

Source: *Researcher Computation Using Eviews12 Output, 2026*

Nigeria’s mean budget performance (proxied by budget balance as percentage of GDP) of 2.71% remained within the 3% statutory limit, despite periods of severe non-compliance (maximum value of 8.5%). Tax revenue exhibited strong positive skewness, particularly for indirect taxes (2.4861), indicating collections often trailed averages. Digitalisation showed a leptokurtic, non-normal distribution (Kurtosis: 10.133), reflecting sporadic technological progress. Coupled with surging expenditures and variable debt, these erratic dynamics posed significant challenges for sustainable fiscal planning (Asuquo, 2021; Montgomery & Runger, 2018).

Principal Component Analysis

PCA was employed to construct composite indices for tax revenue, addressing multicollinearity and proxy inconsistencies (Adedokun & Ukafor, 2024; Otekunrin et al., 2023). By transforming interrelated variables into orthogonal components, the study captured maximum variance while reducing dimensionality (Ramesh et al., 2025). Results revealed high commonality, with first components for total tax, direct tax, and indirect tax explaining 83.29%, 83.34%, and 91.33% of variance, respectively. These primary components captured significant co-movement among revenue categories, providing a more reliable and concise representation of overall performance than isolated variables.

Table 3

Principal Component Analysis of Tax Revenue

Component	Eigenvalues	Difference	Proportion	Cumulative Value	Cumul. Prop
Tax Revenue					
PPTR	3.332727	2.867447	0.8329	3.332727	0.8329

Ewuga, A., Shittu, I., Usman, A. B. & Garba, A. (2026). Moderating effect of digitalisation on the relationship between tax revenue and budget performance in Nigeria. *Malet Journal of Accounting and Finance*, 7 (1), 149 – 173

Component	Eigenvalues	Difference	Proportion	Cumulative Value	Cumul. Prop
CIT	0.464280	0.273710	0.1161	3.796007	0.9490
CED	0.190570	0.177147	0.0476	3.986577	0.9966
VAT	0.013423	-----	0.0034	4.000000	1.0000
Direct Tax Revenue					
PPTR	1.666789	1.333578	0.8334	1.666789	0.8334
CIT	0.333211	-----	0.1666	2.000000	1.0000
Indirect Tax Revenue					
CED	1.826656	1.653311	0.9133	1.826656	0.9133
VAT	0.174433	-----	0.0867	2.000000	1.0000

Source: Researcher Computation Using Eviews12 Output, 2026.

Correlation Analysis

The pairwise correlation matrix confirmed the absence of multicollinearity, ensuring model reliability (Kyriazos & Poga, 2023; Usman et al., 2016). A strong positive correlation between the public debt ratio and budget performance ($r=0.527$) suggested heavy reliance on borrowing, while the link between expenditure and performance ($r=0.400$) supported the spend-and-revenue hypothesis (Efuntade, 2020; Kaka, 2020). Conversely, tax revenue showed a weak link to budget performance ($r=0.150$), and digitalisation exhibited a negligible correlation ($r=-0.02$), indicating that technological initiatives had not yet mitigated deficits (Waleed, 2020). These results aligned with findings regarding infrastructural hurdles and institutional challenges (Central Bank of Nigeria, 2017; Umaru et al., 2021). Multicollinearity remained non-problematic as highly correlated revenue components were evaluated in separate models (Usman et al., 2016).

Table 4

Correlation Analysis of Government Revenue Components and Budget Performance in Nigeria

Variable	BP	TRI	DTI	IDTI	DIG	lnGE	lnPDR
BP	1.000						
TRI	0.150	1.000					
DTI	0.053	0.979	1.000				
IDTI	0.262	0.969	0.901	1.000			
DIG	-0.020	0.551	0.550	0.520	1.000		
lnGE	0.400	-0.470	-0.490	-0.420	-0.220	1.000	
lnPDR	0.527	-0.310	-0.400	-0.200	-0.180	0.688	1.000

Source: Researcher Computation Using Eviews12 Output, 2026.

Pre-test Analysis of the Data

In analysis involving time series data, it is imperative to examine this property of series. The assumption such as stationarity, nonstationary, optimal lag length selection, and cointegration are often tested to ensure unbiased regression analysis. The following subsections discuss the application of these tests in this study.

Stationarity Test

Stationarity was evaluated using Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests to address single-testing limitations (Adedokun & Ukafor, 2024).

Table 5
Stationarity test using Augmented Dickey-Fuller (ADF) and Philip Perron (PP) Unit Root Test:

Variables	Augmented Dickey-Fuller (ADF)					
	Level			First Difference		
	t-statistic	Critical Value	I(d)	t-statistic	Critical Value	I(d)
BP	-3.285 ^a	-2.931 ^{**}	I(0)	-----	-----	-----
TRI	-----	-----	-----	-4.693 ^b	-4.262 ^{***}	I(1)
DTI	-----	-----	-----	-4.527 ^b	-4.262 ^{***}	I(1)
IDTI	-----	-----	-----	-----	-----	-----
DIG	-5.654 ^a	-4.186 ^{***}	I(0)	-----	-----	-----
lnGE	-----	-----	-----	-9.375 ^b	-4.192 ^{***}	I(1)
lnPDR	-----	-----	-----	-4.000 ^b	-3.520 ^{**}	I(1)
Philip Perron (PP)						
BP	-3.273 ^a	-2.931 ^{**}	I(0)	-----	-----	-----
TRI	-----	-----	-----	-----	-----	-----
DTI	-----	-----	-----	-5.510 ^b	-4.192 ^{***}	I(1)
IDTI	-----	-----	-----	-6.215 ^b	-4.192 ^{***}	I(1)
DIG	-5.654 ^a	-4.186 ^{***}	I(0)	-----	-----	-----
lnGE	-----	-----	-----	-9.367 ^b	-4.192 ^{***}	I(1)
lnPDR	-----	-----	-----	-3.964 ^b	-3.520 ^{**}	I(1)

Note: The ^a indicates constant without deterministic trend; ^b is the model with constant and deterministic trend as exogenous lags are selected based on Schwarz info criteria. *, **, *** imply that the series is stationary at 10%, 5%, and 1% respectively. ADF and PP denote Augmented Dickey-Fuller and Phillip-Perron Unit Root tests. Source: Researcher Computation Using Eviews12 Output, 2026.

ADF results indicated that budget performance and digitalisation were stationary at level I(0), whereas tax revenue and government expenditure achieved stationarity at first difference I(1). While the ADF test failed for indirect tax, the PP test confirmed it's I(1) status. The series exhibited a mixed order of integration of I(0) and I(1) without I(2) variables. This satisfied the prerequisites for the ARDL Bounds Testing approach, facilitating the analysis of short-run and long-run fiscal dynamics.

Optimal Lag Length Selection

Lag values were included to capture how past revenue influenced current budget balances, addressing autocorrelation to establish accurate functional representations. An unrestricted Vector Autoregression (VAR) was utilized, assuming variables were not cointegrated. The Akaike Information Criterion (AIC) determined the optimal lag structure by evaluating goodness

Ewuga, A., Shittu, I., Usman, A. B. & Garba, A. (2026). Moderating effect of digitalisation on the relationship between tax revenue and budget performance in Nigeria. *Malet Journal of Accounting and Finance*, 7 (1), 149 – 173

of fit while penalizing parameter over-inclusion. Following the guideline of selecting minimal values an automatic selection process identified lag length 1 for disaggregated models and lag zero for aggregated models. This approach ensured the best model fit, consistency, and robust statistical results while avoiding bias in the lag selection process.

Table 6

Optimal Lag Length Selection Criteria using Standard Vector Autoregression (VAR) estimates

Models	Model 1		Model 2	
	Agg	Disagg	Agg	Disagg
Inf. Criteria	AIC	AIC	AIC	AIC
Lag length	0	1	0	1

Source: Researcher Computation Using Eviews12 Output, 2026.

4.4.3 ARDL Bounds Test

The Auto-Regressive Distributed Lag (ARDL) bounds testing methodology was employed to ascertain long-run relationships among variables (Oladipupo, 2023; Pesaran et al., 2001; Pesaran

Table 1.7

ARDL Bounds Cointegration Test Results

Model	F-Stat.	Aggregated Models				Remark	F-Stat.	Disaggregated Models			
		Lower Bound	Upper Bound	Cointegration	Remark			Lower Bound	Upper Bound	Cointegration	Remark
1	6.29	4.69***	4.69***	Yes	ECM	2.87	2.37*	3.2*	No	ARDL	
2	4.58	4.69**	4.69**	Yes	ECM	1.64	1.99*	2.94**	No	ARDL	

Note: *, ** and *** imply cointegration at 10%, 5% and 1* level of significance, respectively.

& Shin, 1998). Cointegration indicated that variables converged toward equilibrium despite short-term divergences. Results for aggregated models surpassed the $I(1)$ critical threshold at the 5% level, confirming a long-run relationship. Conversely, disaggregated models fell below $I(0)$ critical values, indicating no long-run connection. Consequently, the study analyzed both short-run and long-run dynamics for aggregated models using the Error Correction Model (ECM), while disaggregated models were restricted to short-run analysis via ARDL.

ARDL analysis

This section presents the ARDL analyses of the variables used in the regression analyses. Specifically, this section analyses the different models based on the objectives of the study.

Effect of Tax Revenue on Budget Performance in Nigeria

Long-run estimates from the aggregated ARDL model revealed that total tax revenue had a statistically significant positive impact on budget performance (0.498), suggesting that enhanced collection promoted fiscal health (Ogiji & Ajayi, 2020; Umaru et al., 2021). Highly significant negative error correction terms confirmed a stable equilibrium, with aggregated models exhibiting faster adjustment speeds (Adeyemi et al., 2022; Ebieri, 2022). Disaggregated results showed a negative impact from direct tax (-1.457) but a positive influence from indirect tax (0.690), while rising expenditure significantly increased imbalances (Alade, 2025; Uzor, 2025). Diagnostic tests, including Durbin-Watson and F-statistics, confirmed the absence of serial

correlation and heteroskedasticity. Adjusted R-squared values indicated moderate fit, suggesting that unobserved institutional factors accounted for remaining variance. With VIF scores below 10, multicollinearity was absent. The ARDL Eviews syntax $Z = Z(-1) + D(Z)$ in table 1.8 represents a dynamic variable where current values are estimated by combining previous levels with current changes to isolate short-term impacts from long-run trends. Consequently, the null hypothesis was rejected, affirming that tax revenue significantly affected Nigeria's budget performance.

Table 8

Regression analysis: Estimated ARDL long run and short run results for Model 1: $BP=F(TRI, lnGE, lnPDR)$ - (1,0,0,0) and Model 2: $BP=F(lnDT, lnIDT, lnGE,)$ - (1,1,0,1).

Variable	Aggregated Model 2 ARDL Long Run Results				Disaggregated Model 2 ARDL Long Run Results					
	Coeff. (β)	Std. Error	t-Stat	P-v	Coeff. (β)	Std. Error	t-Stat.	P-v		
TRI	0.498	0.188	2.650	0.011	-----	-----	-----	-----		
lnGE	3.286	2.130	1.542	0.131	-----	-----	-----	-----		
lnPDR	0.839	0.686	1.223	0.228	-----	-----	-----	-----		
Variable	Short Run Results					Short Run Results				
	Coeff. (β)	Std. Error	t-Stat	P-v	VIF	Coeff. (β)	Std. Error	t-Stat	P-v	VIF
Constant	-4.824	1.920	-2.511	0.016	NA	-2.865	2.094	-1.368	0.179	NA
BP(-1)*	-0.706	0.178	-3.955	0.000	2.36	-0.412	0.133	-3.093	0.003	1.87
TRI**	0.352	0.146	2.406	0.021	1.59	-----	-----	-----	-----	-----
DTI(-1)	-----	-----	-----	-----	-----	-0.193	0.429	-0.450	0.654	9.43
IDTI**	-----	-----	-----	-----	-----	0.690	0.350	1.972	0.056	7.12
lnGE**	2.322	1.241	1.870	0.069	2.43	-----	-----	-----	-----	-----
lnGE(-1)	-----	-----	-----	-----	-----	2.002	1.066	1.876	0.068	3.01
lnPDR**	0.593	0.579	1.024	0.312	3.96	-----	-----	-----	-----	-----
D(DTI)	-----	-----	-----	-----	-----	-1.457	0.430	-3.388	0.001	9.75
D(lnGE)	-----	-----	-----	-----	-----	5.231	1.047	4.993	0.000	2.45
CointEq(-1)	-0.706711	0.135	-5.214	0.000	NA	-----	-----	-----	-----	-----
Mean VIF					3.66					6.35
R-squared		0.492				0.660				
Adjusted R-squared		0.438				0.604				
Durbin Watson Stat		1.678				2.154				
F-Statistic		9.206				11.68				
Prob(F-statistic)		0.000				0.000				
Tests	Diagnostics tests			Diagnostics tests						
	F-Stat.	P-value	Decision (H_0)	F-Stat.	P-value	Decision (H_0)				
B-G LM test	1.318	0.258	Accept	1.404	0.244	Accept				
B.P.G Test	2.018	0.111	Accept	1.279	0.291	Accept				
ARCH test	0.688	0.411	Accept	1.082	0.304	Accept				
J-B test	0.487	0.783	Accept	0.222	0.894	Accept				
RESET test	0.699	0.408	Accept	1.444	0.237	Accept				
CUSUMSQ	-----	-----	Stable	-----	-----	Stable				

Ewuga, A., Shittu, I., Usman, A. B. & Garba, A. (2026). Moderating effect of digitalisation on the relationship between tax revenue and budget performance in Nigeria. *Malet Journal of Accounting and Finance*, 7 (1), 149 – 173

Note: The test includes only constant are at 5% level of significance. * *p*-value incompatible with *t*-bounds distribution. ** variables interpret as $Z = Z(-1) + D(Z)$ – this indicates a dynamic regressor with an optimal lag of zero, as such Eviews does not include lags and difference of such variables but estimates them contemporaneously. Source: Researcher Computation Using Eviews12 Output, 2026.

Moderating Effect of Digitalisation on the Relationship between Tax Revenue and Budget Performance in Nigeria.

Long-run estimates from the aggregated model showed no statistically significant independent impact from tax revenue or its interaction with digitalisation, reflecting weak fiscal links and structural limitations (Ogiji & Ajayi, 2020). However, short-run dynamics demonstrated a robust adjustment process, with 71.55% of previous disequilibria corrected within one period. Government expenditure significantly exacerbated deficits, while tax revenue and its digital interaction remained insignificant, suggesting that gains were offset by escalating spending (Yusau & Okwechime, 2025).

Table 9

Regression analysis: Estimated ARDL long run and short run results for Model 2 Aggregated: $BP=F(TRI, DIG, TRI_DIG, lnGE, lnPDR) - (1,0,0,0,0)$; Disaggregated: $BP=F(DTI, IDTI, DIG, DTI_DIG, IDTI_DIG, lnGE) - (1,0,0,0,1,0,1)$

Variable	Aggregated Model 5 ARDL Long Run Results				Disaggregated Model 5 ARDL Long Run Results			
	Coeff. (β)	Std. Error	t-Stat	P-v	Coeff. (β)	Std. Error	t-Stat.	P-v
Constant	-----	-----	-----	-----	-----	-----	-----	-----
TRI	2.708	1.020	-1.673	0.102	-----	-----	-----	-----
DIG	-4.960	3.618	-1.370	0.178	-----	-----	-----	-----
TRI*DIG	-2.635	3.313	-1.139	0.262	-----	-----	-----	-----
lnGE	3.611	2.165	1.667	0.104	-----	-----	-----	-----
lnPDR	1.097	0.686	1.599	0.118	-----	-----	-----	-----
Variable	Short Run Results				Short Run Results			
	Coeff. (β)	Std. Error	t-Stat	P-v	Coeff. (β)	Std. Error	t-Stat	P-v
Constant	-4.797	1.967	-2.437	0.019	-2.899	2.345	-1.236	0.225
BP(-1)*	-0.715	0.179	-3.982	0.000	-0.398	0.150	-2.655	0.012
TRI**	1.222	0.684	1.786	0.082	-----	-----	-----	-----
DTI**	-----	-----	-----	-----	-1.766	3.392	-0.520	0.606
IDTI**	-----	-----	-----	-----	2.391	3.844	0.622	0.538
DIG**	-3.549	2.487	-1.426	0.162	-0.215	2.490	-0.086	0.931
TRI*DIG**	-1.886	1.566	-1.203	0.236	-----	-----	-----	-----
DTI*DIG(-1)	-----	-----	-----	-----	5.629	11.08	0.507	0.615
IDTI*DIG**	-----	-----	-----	-----	-5.427	11.57	-0.468	0.642
lnGE**	2.584	1.251	2.064	0.046	-----	-----	-----	-----
lnGE(-1)	-----	-----	-----	-----	2.021	1.164	1.736	0.091
lnPDR**	0.785	0.599	1.309	0.198	-----	-----	-----	-----

Ewuga, A., Shittu, I., Usman, A. B. & Garba, A. (2026). Moderating effect of digitalisation on the relationship between tax revenue and budget performance in Nigeria. *Malet Journal of Accounting and Finance*, 7 (1), 149 – 173

D(DTI*DIG)	-----	-----	-----	-----	2.395	10.57	0.226	0.822
D(lnGE)	-----	-----	-----	-----	5.568	1.095	5.085	0.000
CointEq(-1)	-0.715597	0.127	-5.594	0.000	-----	-----	-----	-----

R-squared	0.520	0.695
Adjusted R-squared	0.441	0.611
Durbin Watson Stat	1.690	2.304
F-Statistic	6.526	8.355
Prob(F-statistic)	0.000	0.000

Tests	Diagnostics tests			F-Stat.	Diagnostics tests		
	F-Stat.	P-value	Decision (H ₀)		F-Stat.	P-value	Decision (H ₀)
B-G LM test	1.127	0.295	Accept	3.253	0.080	Accept	
B.P.G Test	1.221	0.318	Accept	0.954	0.493	Accept	
ARCH test	1.520	0.224	Accept	0.613	0.437	Accept	
J-B test	0.245	0.884	Accept	0.959	0.618	Accept	
RESET test	0.523	0.474	Accept	0.761	0.389	Accept	
CUSUMSQ	-----	-----	Stable	-----	-----	Stable	

Note: The test includes only constant and are at 5% level of significance. * *p*-value incompatible with *t*-bounds distribution. ** variables interpret as $Z = Z(-1) + D(Z)$ - this indicates a dynamic regressor with an optimal lag of zero, as such Eviews does not include lags and difference of such variables but estimates them contemporaneously. Source: Researcher Computation Using Eviews12 Output, 2026.

Disaggregated results confirmed that neither direct nor indirect tax interactions with digitalisation significantly reduced budget imbalance, aligning with findings on implementation gaps and administrative inefficiencies (Ajetunmobi et al., 2022; Ashafoke & Obaretin, 2023; Ogbada et al., 2023; Umaru et al., 2021). Diagnostic tests confirmed the absence of serial correlation and functional misspecification, while CUSUMSQ tests validated temporal stability. Adjusted R-squared values indicated moderate fits, with remaining variances likely explained by institutional corruption and informal economy leakage. Consequently, the study failed to reject the null hypothesis, concluding that digitalisation did not significantly moderate the relationship between tax revenue and budget performance in Nigeria.

Discussion of Findings

Effect of Tax Revenue and Budget Performance in Nigeria.

Tax revenue significantly improved budget performance in both the long and short run (Anojan, 2023; Joseph & Omodero, 2020). While government expenditure and debt showed insignificant long-run effects, short-run analysis revealed that increased expenditure significantly worsened budget performance (Mose et al., 2024). Furthermore, direct taxes negatively impacted performance initially, as compliance costs and reduced disposable income constrained private investment. However, the highly significant error correction term confirmed a stable long-run equilibrium. These findings indicated that while total tax revenue remained a vital fiscal tool, controlled spending was essential alongside revenue mobilization to ensure improved budget performance.

Ewuga, A., Shittu, I., Usman, A. B. & Garba, A. (2026). Moderating effect of digitalisation on the relationship between tax revenue and budget performance in Nigeria. *Malet Journal of Accounting and Finance*, 7 (1), 149 – 173

Discussion on the Moderating Effect of Digitalisation on the Relationship between Tax Revenue and Budget Performance in Nigeria.

Digitalisation (DIG) and its interactions showed statistically insignificant effects on budget performance, suggesting digital tools alone have not yet transformed fiscal outcomes. However, the positive interaction with direct taxes aligns with Nose et al. (2025) and Lambon (2023), who found that digital synergy fosters revenue growth when paired with institutional reforms. While Nigerian evidence (Olaoye et al., 2022; Ater, 2023; Tivde, 2024) confirms e-filing boosts compliance, the insignificant results here reflect challenges identified by Seungho (2024) and Ashafoke and Obaretin (2023). This indicates that digitalisation's benefits primarily materialize when supported by strong administrative capacity and robust governance, reconciling the mixed empirical evidence observed in literature. Institutional resistance and low perceived utility and poor infrastructural hindered digital adoption, necessitating strong capacity to ensure effectiveness.

5. Conclusion and Recommendations

This study demonstrated that aggregated tax revenue significantly improved Nigeria's budget performance, affirming its role in fiscal sustainability. Conversely, disaggregated and interaction models revealed that digitalization lacked a significant moderating effect, as structural inefficiencies and escalating expenditures offset potential digital gains. These findings highlighted the necessity of institutional reforms to mature digital implementation under the Nigeria Tax Act 2025. Although the research provided critical empirical evidence, it omitted robust institutional quality metrics and key macroeconomic variables, which warranted further investigation.

The study recommended that policymakers prioritize controlled government expenditure alongside aggressive tax revenue mobilization to stabilize fiscal health. While total tax revenue significantly improved budget performance, direct taxes required careful management to mitigate short-run compliance burdens. Furthermore, because digitalisation showed limited fiscal impact, the government should strengthen institutional administrative capacity and infrastructure to realize the benefits of e-taxation. Aligning with Institutional Theory and the Technology Acceptance Model, these findings suggested that digital tools only effectively enhanced performance when supported by robust governance and high perceived utility, necessitating comprehensive structural reforms over mere technological adoption.

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