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Government Revenue, Energy Intensity and Decarbonisation in Nigeria: Evidence from ARDL and FMOLS Estimates

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ABSTRACT
This paper examined the effect of government revenue on energy intensity and decarbonisation in Nigeria. The study is motivated by Nigeria's dual policy challenge: it needs larger and more predictable fiscal resources to finance development and energy access, yet the historical structure of public revenue remains closely connected to fossil-fuel production and consumption. Annual time-series data for 1990-2023 were analysed using the autoregressive distributed lag (ARDL) bounds-testing approach, with fully modified ordinary least squares (FMOLS) used as a robustness check. Government revenue is disaggregated into tax revenue and non-tax revenue to show whether the source of revenue matters for energy-efficiency and emissions outcomes. Energy intensity is modelled as the energy requirement of output, while carbon dioxide emissions are used as an inverse proxy for decarbonisation: lower emissions indicate stronger decarbonisation. The results show mixed fiscal-environmental effects. In the short run, tax and non-tax revenue increase energy intensity, although the contemporaneous effects are not generally significant. In the long run, both revenue streams reduce energy intensity, implying that revenue mobilisation can support energy efficiency when it is sustained and translated into productive investment. The decarbonisation results are less favourable. Tax revenue reduces emissions in the short run, but non-tax revenue increases emissions; in the long run, both tax and non-tax revenue are associated with higher carbon emissions. These findings indicate that Nigeria's fiscal system can improve energy efficiency but does not yet deliver sustained emissions reduction. The article recommends green taxation, reform of oil-linked non-tax revenue, climate-sensitive budgeting, and a dedicated energy-transition financing framework that earmarks part of fossil-fuel revenue for renewable energy, grid modernisation, clean cooking and energy-efficiency investment.
Keywords: Government revenue, tax revenue, non-tax revenue, energy intensity, decarbonisation, ARDL, FMOLS, Nigeria

1. INTRODUCTION

Climate change has become a central macroeconomic, fiscal and development risk. The World Meteorological Organization confirmed that 2024 was the warmest year in the 175-year observational record, with the global mean near-surface temperature about 1.55 degrees Celsius above the 1850-1900 average (World Meteorological Organization [WMO], 2025). The Intergovernmental Panel on Climate Change (IPCC, 2023) similarly shows that delayed mitigation raises the cost and difficulty of stabilising the climate system. Global carbon data reinforce the urgency of the problem: preliminary Global Carbon Budget estimates show fossil carbon dioxide emissions increasing again in 2024, while atmospheric carbon dioxide concentration reached roughly 52% above the pre-industrial level (Friedlingstein et al.,

2025). These trends make climate policy a fiscal issue, not only an environmental one, because governments must finance mitigation, adaptation, resilience and compensation while preserving macroeconomic stability.

Nigeria illustrates this tension strongly. It is a major African economy with substantial energy-access needs, large development financing requirements and a historically fossil-fuel-dependent public revenue structure. The World Bank's country data show that access to electricity was about 61.2% of the population in 2023 and carbon dioxide emissions excluding land-use change were about 0.6 tonnes per capita in 2024 (World Bank, 2026a). The updated Nigeria Energy Transition and Investment Plan reports that approximately 86 million people still lacked access to electricity and 161 million lacked clean cooking solutions, even as the country pursues net-zero emissions by 2060 (Sustainable Energy for All [SEforALL], 2024). The energy transition is therefore not only a decarbonisation project; it is also a development project that must expand reliable energy services, reduce energy poverty, improve productivity and diversify government revenue.

Nigeria has made important policy commitments. Its Energy Transition Plan sets out a national pathway for reducing emissions in power, cooking, oil and gas, transport and industry, and the 2024 update of the plan emphasises renewable energy and efficiency as key components of the net-zero future (Nigeria Energy Transition Office, 2024; SEforALL, 2024). Climate Action Tracker (2025) notes that Nigeria's Long-Term Low-Emissions Development Strategy confirms the 2060 net-zero target, but also stresses that only the renewable-energy scenario in the strategy reaches the target and that significant international support remains necessary. In practical terms, this means that fiscal policy must do more than raise revenue. It must shape how resources are allocated between carbon-intensive sectors and low-carbon investment.

Energy intensity is one important channel through which fiscal policy can influence sustainability. It measures the amount of energy required to produce a unit of output and is widely used as a proxy for energy efficiency (Adom, 2015; International Energy Agency [IEA], 2024a). Lower energy intensity implies that the economy produces more output from each unit of energy, thereby reducing pressure on energy supply and emissions. The IEA (2024a) argues that global efficiency progress remains too weak, with primary energy intensity improving by only about 1% in 2024, far below the level required to double annual efficiency progress by 2030. For developing economies, energy intensity is shaped not only by technology but also by industrial structure, infrastructure quality, energy prices, governance and access to finance (Zaidi et al., 2024).

Decarbonisation is the second outcome examined in this article. It refers to the reduction of carbon dioxide and other greenhouse gas emissions through cleaner energy supply, efficient demand, electrification, modal shifts, industrial upgrading and institutional reform (Akbar et al., 2022; Aba et al., 2023). Although Nigeria's per capita emissions are relatively low compared with advanced economies, total emissions are rising with population growth, urbanisation, industrial activity and continued use of fossil fuels in electricity, transport, backup generation and cooking. The policy challenge is therefore to prevent development from being locked into high-carbon infrastructure.

Fiscal revenue can influence both energy intensity and decarbonisation through several pathways. Revenue can finance public investment in grid infrastructure, renewable energy, mass transit, efficient public buildings, clean cooking and industrial upgrading. Tax policy can also alter relative prices by discouraging pollution and encouraging cleaner technologies. However, fiscal revenue can also reinforce carbon intensity when it is dominated by oil rents, petroleum-related royalties or taxes that are recycled into fuel-heavy public spending. This ambiguity makes the Nigerian case important. If higher government revenue is used mainly to finance conventional infrastructure and fossil-fuel-linked activities, emissions may rise. If it is used to finance energy efficiency, renewable energy and clean transport, energy intensity and emissions may decline.

This paper contributes to the literature in three ways. First, it focuses specifically on Nigeria, a resource-dependent developing economy whose fiscal and climate goals are closely intertwined. Second, it

disaggregates government revenue into tax revenue and non-tax revenue, recognising that oil royalties, rents and other non-tax receipts may affect emissions differently from broad-based tax revenue. Third, it estimates both short-run and long-run dynamics using ARDL and validates the long-run results with FMOLS. The core research question is: How does government revenue affect energy intensity and decarbonisation in Nigeria? The answer matters for designing fiscal rules, green taxes, budget frameworks and energy-transition financing strategies that are consistent with Nigeria's 2060 net-zero commitment.

2. Literature Review and Theoretical Foundation

The fiscal-policy literature provides two competing interpretations of the revenue-environment nexus. The first is a Keynesian fiscal-policy view. From this perspective, government revenue enables productive public expenditure and can stabilise the economy while financing long-term investment (Oshota, 2023). If fiscal revenue is channelled into modern infrastructure, green technologies, renewable power, clean cooking and efficient transport, it can reduce energy intensity while supporting growth. This argument is consistent with studies showing that well-designed environmental taxes and green fiscal incentives can improve energy efficiency and support low-carbon investment (Ahmed et al., 2022; Bashir et al., 2021; Fang et al., 2022).

The second perspective is the revenue-dominance view. Resource-dependent governments may prioritise revenue from oil, gas and energy-intensive sectors because these sectors provide foreign exchange, royalties and public budgets (Emmanuel et al., 2024). This creates a conflict between short-term fiscal stability and long-term decarbonisation. Governments may be reluctant to introduce policies that reduce fossil-fuel demand, accelerate electrification or restrict emissions if those policies threaten existing revenue bases. Black et al. (2024) show that global decarbonisation changes fiscal balances through rising carbon prices, erosion of fuel tax bases and potential revenue-sharing arrangements. For oil-dependent economies, the challenge is especially difficult because transition policies can reduce the very revenue streams that historically financed the state.

Empirical studies on fiscal policy and energy intensity are mixed. Bashir et al. (2021) found that environmental taxes reduced energy consumption and energy intensity in OECD economies. Ahmed et al. (2022) similarly reported that green taxes reduced energy intensity in Nordic countries. Fang et al. (2022) found that environmental taxation can promote renewable energy consumption among Belt and Road countries, while Aydin and Bozatli (2023) showed that environmental taxes and green innovation support renewable energy use in selected OECD economies. These studies suggest that the design of fiscal instruments matters. Revenue raised through taxes that penalise emissions can improve energy efficiency, but general revenue that is not tied to environmental goals may not generate the same effect.

Other studies suggest that fiscal decentralisation, fiscal imbalance and public debt may increase energy use or weaken efficiency. Elheddad et al. (2020) found a dynamic relationship between fiscal decentralisation and energy consumption in Chinese provinces. Liu and Zhang (2022) reported that fiscal imbalances increased energy intensity in China, while Ekesiobi et al. (2024) found that debt-related fiscal variables reduced energy efficiency in Nigeria. These findings imply that fiscal capacity alone is insufficient. Institutions, public investment quality and the structure of incentives determine whether fiscal resources produce cleaner or more energy-intensive growth.

The fiscal-decarbonisation literature is similarly nuanced. Environmental taxes and carbon pricing can reduce emissions by increasing the cost of carbon-intensive activities and creating incentives for cleaner technologies (Parry et al., 2015; Zhu et al., 2023). Inan et al. (2022) showed that carbon-tax simulations could reduce emissions in Nigeria's manufacturing sector. Kumbhakar et al. (2022) found that British Columbia's carbon tax improved aspects of economic and environmental efficiency in manufacturing. However, Lilliestam et al. (2020) cautioned that carbon pricing has not always delivered strong evidence of technological change or zero-carbon investment, particularly when prices are too low, exemptions are broad or complementary policies are weak.

Recent fiscal-transition studies emphasise that decarbonisation can create new fiscal risks. Fuel-tax revenue may decline as transport electrifies; governments may need to finance compensation for vulnerable households; and public spending on green infrastructure may rise (Black et al., 2024; De Mooij & Gaspar, 2023; Tol, 2023). Victor-Gallardo et al. (2024) showed that fiscal impacts from transport decarbonisation can be managed through tax adjustments, while Brizga et al. (2024) reported that environmental taxes can reduce transport emissions when supported by infrastructure and social innovation. These studies are relevant to Nigeria because they show that fiscal reform and decarbonisation must be designed together.

Within the Nigerian context, the gap is clear. Prior studies have examined energy consumption, carbon emissions, fiscal policy or oil revenue, but few have modelled tax and non-tax revenue separately in relation to energy intensity and emissions using recent data. Nigeria's policy setting makes this disaggregation essential. Tax revenue may provide a more flexible and potentially greener base for public finance, while non-tax revenue includes oil-linked rents and royalties that may reinforce fossil-fuel dependence. This article therefore tests whether the two revenue streams have different short-run and long-run effects on energy intensity and carbon emissions.

3. Methodology

3.1 Theoretical Framework

This study leans on the Keynesian fiscal policy theory. The theory argues that the government intervenes in the economy through fiscal responsibility to drive economic growth and wellbeing (Oshota, 2023). Fiscal revenue constitutes a critical component of the Keynesian fiscal policy theory and states that the government, through its accumulated revenue through tax and non-tax income (Akbar et al., 2022). Through this income, the theory argued that the government spends on capital infrastructures that support human welfare. Following this theoretical argument of Keynesian fiscal policy theory, governments can direct stimulus spending toward green technologies, renewable energy infrastructure, and energy efficiency projects. Such investments would boost economic demand and job creation and advance environmental sustainability (Ma & Wang, 2021; Zhu et al., 2023). Therefore, by balancing economic stimulus with sustainable energy investments through fiscal revenue, Keynesian policy can be crucial in reducing energy intensity and promoting decarbonisation. Based on the argument of the theory, the functional connection between fiscal revenue, energy intensity, and decarbonisation is presented as thus;

$$Y_t = f(FR_t) \quad \text{Eq(3.1)}$$

In Eq(3.2), Y represents energy intensity (EI) and decarbonisation (DC), while FR represents fiscal revenue. The equation indicates that energy intensity and decarbonisation is functions of fiscal revenue. This indicates that the government spends its revenue on modern energy across communities, it can impact energy intensity and control of CO2 emissions, leading to decarbonisation (Zhu et al., 2023).

3.2 Model Specification

The model to explore the interconnection between government revenue, energy intensity and decarbonisation in Nigeria is stated in this section, adapting the theoretical argument of the Keynesian fiscal policy theory and the empirical evidence of Lv et al. (2022) and Liu & Zhang (2022), the functional relationship between the variables based on the research objectives is presented thus; Specifically, for objective one, the functional linkage between government revenue and energy intensity is presented as thus;

$$EI_t = f(TX_t, NTX_t, INT_t, FD_t, RES_t, GEF_t) \quad \text{Eq (3.2)}$$

Following Eq(3.2), the functional relationship between government revenue and decarbonisation which captures objective two is presented thus;

$$DC_t = f(TX_t, NTX_t, INT_t, FD_t, RES_t, GEF_t) \quad \text{Eq (3.3)}$$

Based on Eq (2.3) and (3.3), the dependent variables are energy intensity (EI) and decarbonisation (DC). Moreso, on the left-hand side, government revenue variables are disaggregated into tax revenue (TX) and non-tax revenue (NTX) following the argument of Lv et al. (2022). The changes in TR and NTR can alter government investment in clean energy sources, which can impact EI and DC. The control variables in the model include Interest rate (INT), financial sector development (FD), national reserve (RES), and government effectiveness (GEF). These control variables can have several impact on EI and DC. For instance, high interest rates (INT) increase the cost of borrowing, which can discourage investments in energy-efficient technologies and renewable energy projects, thereby maintaining high energy intensity and slowing decarbonisation efforts (Robinson et al., 2019). Conversely, lower interest rates make financing cheaper, promote investment in cleaner technologies, reduce energy intensity, and accelerate decarbonisation. For financial sector development (FD), a well-developed financial sector provides better access to capital for energy-efficient projects and green technologies (Ekesiobi et al., 2024). This supports the reduction of energy intensity and facilitates decarbonisation by financing renewable energy ventures, promoting sustainable growth, and enabling investments in low-carbon infrastructure.In terms of reserve (RES), large national reserves give governments the financial capacity to invest in energy transition initiatives without compromising fiscal stability (Victor-Gallardo et al., 2023). This indicate that countries with ample reserves can allocate funds toward decarbonisation projects and energy efficiency improvements, reducing reliance on fossil fuels and lowering energy intensity over time. Lastly, effective governance (GE) ensures that policies aimed at reducing energy intensity and promoting decarbonisation are well-implemented and enforced. Governments that efficiently manage regulations, public spending, and project execution can drive the adoption of clean energy technologies, enforce environmental standards, and facilitate a faster shift toward decarbonisation (Ibekilo et al., 2023). Therefore, the functional relationship expressed in Eq (3.2) and (3.3) is expressed in econometrics estimation form as thus;

$$EI_t = \alpha_0 + \beta_1 TX_t + \beta_2 NTX_t + \beta_3 INT_t + \beta_4 FD_t + \beta_5 RES_t + \beta_6 GEF_t + \mu_1$$

Eq (3.4)

$$DC_t = \alpha_0 + \beta_1 TX_t + \beta_2 NTX_t + \beta_3 INT_t + \beta_4 FD_t + \beta_5 RES_t + \beta_6 GEF_t + \mu_1 \text{Eq (3.5)}$$

In Eq (3.4) and (3.5), all the variables remained as described earlier; however, α_0 indicate the regression intercept, β_{1-6} constitute the regression slope, μ represents the error term, and *t* indicates the time series factor.

The ARDL bounds-testing approach is appropriate for three reasons. First, it can be used when variables are integrated of order zero, I(0), order one, I(1), or a mixture of both, provided none is integrated of order two (Pesaran et al., 2001). Second, it performs well in small samples, which is important because the study uses 34 annual observations. Third, the unrestricted error-correction representation provides the speed at which short-run disequilibrium adjusts to the long-run equilibrium path. The analysis begins with Augmented Dickey-Fuller and Phillips-Perron unit-root tests, proceeds to bounds cointegration tests, estimates the short-run and long-run ARDL coefficients and then applies FMOLS as a robustness test (Phillips & Hansen, 1990).

A priori, tax revenue is expected to reduce energy intensity and emissions if it finances efficiency-enhancing investment or discourages carbon-intensive activity. Non-tax revenue can have either effect. It may finance low-carbon public investment, but if it is dominated by oil and mineral rents, it may increase emissions and delay decarbonisation. Interest rates are expected to increase energy intensity and emissions when higher borrowing costs reduce investment in clean technologies. Financial development,

reserves and government effectiveness are expected to support energy efficiency and decarbonisation when they improve access to finance, public investment capacity and policy implementation.

Table 1: Variable Measurement and Data Sources

Variable	Measurement	Source
Energy intensity (EI)	Energy requirement of output; lower values indicate greater energy efficiency.	Computed from energy and output data
Carbon emissions (DC)	CO2 emissions used as an inverse proxy for decarbonisation; lower emissions indicate stronger decarbonisation.	World Development Indicators
Tax revenue (TX)	Total tax revenue.	Central Bank of Nigeria Statistical Bulletin
Non-tax revenue (NTX)	Government revenue from non-tax sources, including oil-linked receipts.	Central Bank of Nigeria Statistical Bulletin
Interest rate (INT)	Bank lending rate.	World Development Indicators
Financial development (FD)	Domestic credit to private sector as percentage of GDP.	World Development Indicators
External reserves (LRES)	Log of external reserves.	Central Bank of Nigeria Statistical Bulletin
Government effectiveness (GE)	Government effectiveness estimate.	Worldwide Governance Indicators

Note. DC is interpreted as an inverse decarbonisation proxy because lower CO2 emissions indicate stronger decarbonisation. LRES denotes the logarithm of external reserves.

4. Results

The descriptive statistics show moderate variation in both environmental outcomes and fiscal variables. Energy intensity has a mean of 0.3764 and ranges from 0.2802 to 0.4841. The carbon-emissions proxy has a mean of 0.6875 and ranges from 0.5014 to 0.9109. Tax revenue and non-tax revenue exhibit greater dispersion than the environmental variables, reflecting the volatility of Nigeria's fiscal structure over the study period. Tax revenue is positively skewed and leptokurtic, suggesting that large revenue spikes occurred in selected years. This is consistent with Nigeria's exposure to oil-price cycles and revenue reforms.

The correlation matrix provides initial evidence of associations but does not establish causality. Energy intensity is strongly and positively correlated with the emissions proxy, which is expected because high energy requirements per unit of output are usually associated with higher carbon emissions in fossil-dependent economies. Tax and non-tax revenue are negatively correlated with energy intensity in the raw data, while external reserves are strongly negatively correlated with both energy intensity and emissions. However, the regression analysis is needed because correlations do not control for dynamic adjustment, cointegration or confounding variables.

Unit-root tests indicate that the variables are a mixture of I(0) and I(1), justifying the use of ARDL. Tax revenue and interest rate are stationary at level under both ADF and Phillips-Perron tests, while energy intensity, emissions, non-tax revenue, financial development and reserves become stationary after first differencing. Government effectiveness is stationary at level under the Phillips-Perron test and after first differencing under the ADF test. Since none of the variables is I(2), the ARDL bounds approach is appropriate.

The bounds tests confirm cointegration in both models. The F-statistic for the energy-intensity model is 4.71055 and exceeds the relevant upper bound, while the F-statistic for the emissions model is 7.470 and also exceeds the upper bound. This indicates the existence of long-run relationships between government revenue, the control variables and the two environmental outcomes. The long-run coefficients can

therefore be interpreted as equilibrium effects, while the error-correction terms describe the speed of adjustment after short-run shocks.

Table 2: **Descriptive Statistics**

Statistic	DC	EI	TX	NTX	INT	FD	RES	GE
Mean	0.6875	0.3764	2172.95	3319.30	18.604	10.047	23944.9	-0.7640
Median	0.6539	0.3601	1024.85	3592.44	17.690	9.3951	27929.9	-0.9920
Maximum	0.9109	0.4841	13587.5	8878.97	31.650	19.625	58472.8	0.0000
Minimum	0.5014	0.2802	18.325	71.887	11.483	0.0000	2157.9	-1.2131
Std. dev.	0.1106	0.0769	2920.22	2589.79	4.0188	3.8876	17122.6	0.4731
Skewness	0.3062	0.1906	2.2561	0.2570	1.0336	0.2000	0.0872	0.9554
Kurtosis	1.8461	1.3270	8.6100	1.9858	4.7946	3.7153	1.5552	2.0729
Jarque-Bera	2.4176	4.1709	73.430	1.8314	10.617	0.9516	3.0002	6.3908
Probability	0.2985	0.1242	0.0000	0.4002	0.0049	0.6213	0.2231	0.0609
Observations	34	34	34	34	34	34	34	34

Note. DC = carbon emissions proxy; EI = energy intensity; TX = tax revenue; NTX = non-tax revenue; INT = interest rate; FD = financial development; RES = external reserves; GE = government effectiveness.

Table 3: **ADF and Phillips-Perron Unit-Root Tests**

Variable	ADF level	ADF first diff.	PP level	PP first diff.	Status
DC	-2.8266	-5.8788***	-2.8266	-6.9956***	I(1)
EI	-1.6639	-4.7004***	-1.9331	-4.7004***	I(1)
TX	7.5562***	-	5.7155***	-	I(0)
NTX	-2.2940	-5.0249***	-2.3627	-6.2224***	I(1)
INT	-6.0864***	-	-4.0973**	-	I(0)
FD	-1.8527	-3.6431**	-0.7246	-3.0709**	I(1)
RES	-2.4920	-4.2995***	-1.7782	-4.1511***	I(1)
GE	-0.0981	-4.4878***	-6.2361***	-	Mixed/I(0)

Note. ** and *** denote significance at the 5% and 1% levels, respectively.

Table 4: **ARDL Bounds Cointegration Tests**

Model	F-statistic	Lower bound	Upper bound	Decision
Model 1: EI	4.71055***	2.26*	3.35*	Cointegration
Model 2: DC	7.470***	2.96**	4.18**	Cointegration

Note. Model 1 uses energy intensity as the dependent variable. Model 2 uses carbon emissions as the dependent variable. *, ** and *** denote the 10%, 5% and 1% bounds levels reported in the source output.

ARDL Results for Energy Intensity

The ARDL estimates for the energy-intensity model show that tax revenue and non-tax revenue increase energy intensity in the short run, although the contemporaneous coefficients are not statistically significant. The lagged change in tax revenue is positive and significant, suggesting that revenue mobilisation may initially expand energy-using activities before efficiency gains occur. This short-run effect is plausible in Nigeria because additional government revenue can raise public expenditure, construction activity, administration and energy demand in an economy where electricity supply, transport and backup generation remain fossil-fuel intensive.

The long-run coefficients tell a different story. Tax revenue has a negative but statistically insignificant effect on energy intensity, while non-tax revenue has a negative and statistically significant effect. The result implies that sustained fiscal revenue can reduce energy intensity when it is translated into infrastructure, technology, modernisation and productivity gains. External reserves and financial

development also have negative long-run signs, although they are not significant in the ARDL model. Government effectiveness has a negative and significant long-run coefficient, supporting the argument that institutions matter for converting fiscal capacity into efficient public outcomes.

The error-correction term for the energy-intensity model is -0.8398 and highly significant. This indicates that approximately 84% of disequilibrium is corrected within one year. The magnitude implies rapid adjustment back to the long-run path after shocks. In policy terms, the result suggests that energy intensity responds quickly to structural fiscal and macroeconomic conditions, which means that fiscal reforms can have measurable efficiency effects when they are sustained.

Table 5: **Short-Run and Long-Run ARDL Estimates for Energy Intensity**

Variable	Coefficient	Std. error	t-statistic	p-value
Short run				
D(EI(-1))	-0.2093	0.1920	-1.090	0.2909
D(TX)	0.0286	0.0200	1.4323	0.1702
D(TX(-1))	0.0815	0.0221	3.6773	0.0019
D(NTX)	0.0196	0.0141	1.3807	0.1852
INT	0.0172	0.0039	4.4102	0.0001
D(FD)	0.0006	0.0008	0.8298	0.4181
D(FD(-1))	-0.0016	0.0010	-1.5144	0.1483
D(LRES)	-0.0096	0.0129	-0.7412	0.4686
D(GE)	0.0106	0.0132	0.8061	0.4313
D(GE(-1))	0.0277	0.0126	2.1995	0.0420
ECM(-1)	-0.8398	0.0593	-16.798	0.0000
Long run				
TX	-0.0273	0.0403	-0.6776	0.5071
NTX	-0.2222	0.0845	-2.6285	0.0176
INT	-0.0227	0.0040	-5.6750	0.0000
FD	-0.0045	0.0037	-1.2200	0.2391
LRES	-0.0401	0.0509	-0.7872	0.4420
GE	-0.2445	0.1050	-2.3283	0.0325
C	1.1589	0.1771	6.5417	0.0000

Note. Dependent variable is EI. ECM(-1) is the error-correction term. LRES is the logarithm of external reserves.

ARDL Results for Carbon Emissions

The emissions model provides a more cautionary result. In the short run, tax revenue has a negative coefficient, implying that increases in tax revenue reduce emissions and promote decarbonisation, although the coefficient is not statistically significant at conventional levels. Non-tax revenue has a positive and significant short-run effect on emissions. This distinction is important. Tax revenue may be less directly tied to fossil-fuel extraction and may be used to finance broader public services, whereas non-tax revenue can contain royalties, rents and other receipts linked to carbon-intensive sectors. The short-run result therefore supports the view that the composition of revenue matters for decarbonisation.

In the long run, both tax and non-tax revenue are positively associated with emissions. Non-tax revenue is positive and statistically significant, and tax revenue is positive at the 10% level. The result implies that Nigeria's long-run revenue structure has not yet been aligned with a low-carbon development pathway. Higher revenue appears to support economic activity and infrastructure patterns that continue to increase emissions. This finding is consistent with the revenue-dominance argument: when fiscal systems are tied to fossil-fuel revenue and spending priorities are not climate-screened, revenue mobilisation can coexist with rising emissions.

The emissions model has an error-correction coefficient of -0.9675 and is statistically significant. This suggests that almost all short-run disequilibrium is corrected within a year. The speed of adjustment is

high, indicating a stable long-run relationship among fiscal revenue, controls and emissions. The long-run policy implication is serious: unless fiscal policy is redesigned, Nigeria may achieve efficiency gains without achieving sustained decarbonisation. Energy may be used more efficiently, but the total carbon content of growth can remain high.

Table 6: **Short-Run and Long-Run ARDL Estimates for Carbon Emissions**

Variable	Coefficient	Std. error	t-statistic	p-value
Short run				
D(DC(-1))	0.2481	0.1312	1.8899	0.0750
D(TX)	-0.0965	0.0723	-1.3354	0.1984
D(NTX)	0.0908	0.0342	2.6497	0.0163
D(INT)	0.0455	0.3321	0.1370	0.2254
D(FD)	0.0049	0.0022	2.1590	0.0446
D(LRES)	-0.1508	0.0463	-3.2516	0.0044
D(LRES(-1))	0.1095	0.0645	1.6957	0.1072
D(GE)	0.0277	0.0368	0.7544	0.4603
D(GE(-1))	-0.0545	0.0301	-1.8070	0.0875
ECM(-1)	-0.9675	0.2355	-4.1082	0.0000
Long run				
TX	0.0347	0.0198	1.7509	0.0970
NTX	0.0663	0.0290	2.2879	0.0345
INT	-0.0127	0.0026	-4.8846	0.0026
FD	-0.0007	0.0024	-0.2896	0.7754
LRES	-0.2862	0.0384	-7.4342	0.0000
GE	0.0990	0.0503	1.9670	0.0647
C	1.6622	0.1021	16.2675	0.0000

Note. Dependent variable is DC, a carbon-emissions proxy. A positive long-run coefficient means higher emissions and weaker decarbonisation.

Robustness and Diagnostic Checks

The FMOLS robustness estimates are broadly consistent with the ARDL long-run results. In the energy-intensity model, tax revenue and non-tax revenue have negative coefficients, while external reserves also reduce energy intensity. In the emissions model, tax revenue and non-tax revenue have positive coefficients, while external reserves reduce emissions. The consistency between ARDL and FMOLS supports the reliability of the central finding: government revenue is associated with lower energy intensity but higher long-run emissions in Nigeria.

Diagnostic tests also support the adequacy of the models. The Breusch-Godfrey serial-correlation tests are insignificant in both models, indicating that the residuals are not serially correlated. The Breusch-Pagan-Godfrey heteroskedasticity tests are also insignificant, suggesting constant error variance. The explanatory power of the models is high, with R-squared values of 0.9934 for the energy-intensity model and 0.9628 for the emissions model. Stability tests using CUSUM and CUSUM of squares remain within the 5% critical bounds, indicating stable model parameters over the sample period.

Table 7: **FMOLS Robustness Estimates**

Variable	Model 1 coef.	Model 1 SE	Model 2 coef.	Model 2 SE
TX	-0.0605	0.0271	0.0226	0.0253
NTX	-0.0771	0.0361	0.0624	0.0336
INT	-0.0028	0.0028	0.00003	0.0026
FD	-0.0007	0.0024	-0.0014	0.0022
LRES	-0.1517	0.0422	-0.2599	0.0393
GE	0.0254	0.0253	0.0160	0.0235
C	1.0110	0.1437	1.6707	0.1339

Note. Model 1 = energy intensity; Model 2 = carbon emissions. SE = standard error.

Table 8: **Post-Estimation Diagnostic Checks**

Test/statistic	Model 1	Model 2
Serial correlation BG test	0.4268 (p = .6603)	0.7536 (p = .4866)
Heteroskedasticity BPG test	1.3456 (p = .2774)	0.8476 (p = .6167)
R-squared	0.9934	0.9628
Adjusted R-squared	0.9880	0.9360
Stability	CUSUM and CUSUMSQ stable at 5%	CUSUM and CUSUMSQ stable at 5%

Note. Values in parentheses are p-values. The null hypothesis in the BG and BPG tests is no serial correlation and homoskedasticity, respectively.

DISCUSSION OF FINDINGS

The findings have two major interpretations. First, Nigeria's fiscal revenue can support energy efficiency in the long run. This is encouraging because reducing energy intensity is often the fastest and least costly way to improve energy security, reduce energy demand and lower the emissions intensity of growth (IEA, 2024a). The negative long-run effect of revenue on energy intensity suggests that larger fiscal capacity may be associated with better infrastructure, technology adoption and productivity improvements. This is consistent with the Keynesian argument that public revenue can finance development-enhancing investment when institutions are effective.

Second, energy efficiency does not automatically produce decarbonisation. The positive long-run effect of both tax and non-tax revenue on emissions shows that fiscal resources have not been consistently channelled into low-carbon development. This result reflects Nigeria's structural dependence on fossil fuels in electricity generation, transport, backup power and public revenue. It also reflects the possibility that revenue-financed infrastructure and industrial activity remain carbon-intensive. The result is consistent with Climate Action Tracker's (2025) warning that continued reliance on oil and gas can lock Nigeria into emissions-intensive assets and delay the energy transition.

The distinction between tax and non-tax revenue is central. Tax revenue reduces emissions in the short run, which suggests that a well-designed tax system can support cleaner production and consumption. This result aligns with the broader evidence that environmental taxes, carbon taxes and green fiscal incentives can reduce emissions and energy intensity when they alter relative prices and finance green investment (Ahmed et al., 2022; Bashir et al., 2021; Zhu et al., 2023). However, the long-run positive tax-revenue coefficient indicates that Nigeria's broader tax system is not yet sufficiently green. General tax revenue may simply finance conventional growth unless budget rules require climate-consistent spending.

Non-tax revenue is more problematic. Its positive effect on emissions in both the short and long run indicates that oil-linked fiscal receipts remain a barrier to decarbonisation. This does not mean that Nigeria should abruptly abandon all hydrocarbon revenue, because the country still faces serious energy-access and development challenges. It means that fossil-fuel revenue should be managed as a declining transition asset. A portion of oil and gas receipts should be earmarked transparently for renewable energy, electricity-grid expansion, clean cooking, energy-efficient public buildings, methane management and workforce transition. Without such a mechanism, non-tax revenue will continue to reinforce carbon-intensive development.

The findings also speak to the fiscal feasibility of Nigeria's energy transition. The 2024 Energy Transition and Investment Plan update estimates that net zero by 2060 requires about USD 500 billion in additional capital investment above business-as-usual levels, while generating large fuel savings over time (SEforALL, 2024). This scale of investment cannot be met by external finance alone. Domestic revenue mobilisation, public-private partnerships, development finance and climate finance must be combined. Yet domestic mobilisation will only support the transition if it is embedded in climate-sensitive budgeting and performance-based allocation.

Finally, institutional quality is important. Government effectiveness has a significant long-run negative effect on energy intensity in the ARDL model. This implies that the efficiency outcome of public revenue depends on governance. Revenue that is poorly planned, weakly monitored or diverted into recurrent expenditure will not reduce energy intensity or emissions. Revenue that is linked to transparent project selection, procurement quality, maintenance, monitoring and evaluation can improve energy efficiency. Fiscal reform must therefore be accompanied by public financial management reforms, project appraisal rules and environmental accountability.

Policy Implications

The first recommendation is to strengthen green taxation. Nigeria should gradually expand fiscal instruments that discourage carbon-intensive consumption and reward clean technologies. These can include differentiated excise taxes, vehicle taxes based on emissions, incentives for energy-efficient appliances, accelerated depreciation for clean technologies and carefully designed carbon-pricing pilots in sectors where monitoring is feasible. Revenue from such instruments should not disappear into the general budget. It should be reported and partly earmarked for renewable energy, clean cooking, grid reliability and energy-efficiency programmes. This would increase public trust and make the tax-environment link visible.

The second recommendation is to reform non-tax revenue. Oil royalties, mineral rents and other non-tax receipts should be treated as transition resources rather than permanent fiscal foundations. A dedicated energy-transition fund could allocate a fixed share of fossil-fuel revenue to low-carbon investment. The fund should have clear rules, independent reporting and parliamentary oversight. Priority projects should include solar mini-grids, transmission upgrades, efficient public lighting, mass transit, clean cooking, methane reduction, industrial energy audits and local manufacturing of renewable-energy components. Such a framework would convert part of Nigeria's fossil-fuel legacy into assets for a cleaner economy.

The third recommendation is climate-sensitive budgeting. Every major capital project should be screened for energy-efficiency and emissions implications. Budget circulars should require ministries, departments and agencies to identify whether proposed projects increase or reduce energy demand and emissions. A climate budget-tagging system would allow the Ministry of Finance to track how much public expenditure supports mitigation, adaptation and energy access. Over time, budget allocations should shift from carbon-intensive infrastructure toward low-carbon and climate-resilient assets.

The fourth recommendation is to integrate fiscal policy with Nigeria's 2060 energy-transition roadmap. The Energy Transition Plan already identifies priority sectors, including power, cooking, transport, industry and oil and gas (Nigeria Energy Transition Office, 2024). Fiscal policy should be mapped directly to these sectors. For example, tax incentives and concessional finance can accelerate solar deployment and battery storage; public procurement can create demand for efficient vehicles and appliances; and targeted support can help households move from biomass and kerosene to cleaner cooking solutions. The goal is not simply to raise revenue but to make every revenue instrument and expenditure allocation consistent with the transition pathway.

The fifth recommendation is to protect vulnerable households. Green fiscal reforms can be politically difficult if they increase living costs. Nigeria's experience with fuel-subsidy reform shows that price changes without adequate social protection can create hardship and resistance. Therefore, part of green revenue should finance targeted transfers, public transport, electricity access and clean cooking for low-income households. Compensation should be transparent, temporary and linked to measurable transition goals. This would make fiscal decarbonisation more equitable and politically sustainable.

CONCLUSION

This article converted a thesis-level empirical investigation into a journal-style analysis of government revenue, energy intensity and decarbonisation in Nigeria. Using annual data for 1990-2023, the ARDL and FMOLS results show that government revenue has mixed environmental effects. In the long run, tax

and non-tax revenue reduce energy intensity, implying that sustained fiscal capacity can support energy efficiency. However, both revenue streams increase long-run carbon emissions, suggesting that Nigeria's fiscal structure has not yet been aligned with deep decarbonisation. Short-run results are also mixed: tax revenue reduces emissions, whereas non-tax revenue increases emissions.

The central conclusion is that Nigeria does not face a simple choice between revenue mobilisation and climate action. It faces a design problem. Revenue can finance clean energy and efficiency, but it can also reinforce fossil-fuel dependence if spending and incentives remain carbon-intensive. The evidence supports a shift from revenue mobilisation alone to climate-aligned revenue mobilisation. Green taxation, reform of oil-linked non-tax revenue, climate budget tagging, transparent energy-transition funds and stronger public financial management are essential.

The study has limitations. Carbon emissions are used as an inverse proxy for decarbonisation, and the annual sample is limited to 34 observations. Future research can extend the analysis with sectoral emissions, state-level fiscal data, nonlinear models and explicit measures of green public expenditure. Nevertheless, the findings provide a policy-relevant message: Nigeria can use fiscal revenue to reduce energy intensity, but sustained decarbonisation will require deliberate fiscal rules that move revenue away from carbon lock-in and toward renewable energy, efficiency, clean cooking and low-carbon infrastructure.

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