

Electricity Power Constraints and Trade Integration: Assessing the Drivers of Nigeria's Non-Oil Economic Diversification

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ABSTRACT

It has become essential to diversify the Nigerian economy through the growth of its nonoil sector in order to reduce the country's dependence on oil exports. So, identifying the factors that promote the nonoil sector's economic expansion and their efficacy is crucial. This study examines the relationship between electricity transmission and distribution losses, nonoil trade openness and nonoil gross domestic product in Nigeria using the autoregressive distributed lag (ARDL) bounds test approach to cointegration in order to ascertain both the short run and long run association among the variables. The findings establish the existence of a long run relationship among our variables. It also revealed that electricity transmission and distribution losses has a significant and negative relationship with nonoil gross domestic product in the long run. However, in the short run, the relationship is positive and significant, suggesting that firms in the nonoil sector temporarily adapt to the electricity constraints by using alternative power sources which boosts nonoil gross domestic product before the long-run negative consequence sets in. Furthermore, the result shows that nonoil trade openness and nonoil gross domestic product's relationship is positive and significant in the short run, while in the long run, the link is negative and significant. This indicates that the benefits of trade integration in the short run may be weakened by Nigeria's dependence on high imports and insufficient domestic productive capacity moving forward. Therefore, government's reforms in the power and trade sectors should be coordinated to enhance productivity, reduce import dependence and support the sustained growth of Nigeria's nonoil economy.

Keywords: Nonoil gross domestic product, electricity transmission and distribution losses, nonoil trade openness, ARDL model, Nigeria.

INTRODUCTION

Nigeria being one of the largest economies in Africa has a tremendous growth and diversification potential beyond its oil-reliant economic system. Non-oil sectors, such as agriculture, manufacturing, telecommunications and services are fundamental to economic resilience and sustainable development. To realize its diversification goal, adequate electricity infrastructure is required. Electric power is an essential component of economic activities because it enhances rapid and sustained industrial growth, technological progress and job creation (Lawal et. al, 2020). Unfortunately, Nigeria's electricity sector is consistently described as rich in resources with abundant renewable and nonrenewable resources that remain underutilized (Aiyetan et al., 2021). Approximately half of Nigerian's population don't have electricity access, with rural areas considerably more underserved than urban areas due to persistent electricity access deficits (Adoghe et. al., 2023). Installed or nominal capacity is repeatedly shown to exceed delivered supply, indicating that generation shortfalls are compounded by poor evacuation, transmission, and distribution performance (Henry et al., 2021).

Notably, electricity shortfalls are further linked to wider development outcomes, including reduced trade competitiveness, weaker manufacturing performance, firm closures, and difficulty attracting or retaining investment (Gold et al., 2024). In addition, Gold and Tregenna (2024) argued that electricity policy should

be integrated with industrial, trade, and investment strategy, not treated as a standalone infrastructure problem. To Jóźwik et al (2025), trade openness accelerates growth through resource accumulation and technology transfer, which in turn raises energy demand. They explicitly stated that export demand stimulates production growth, economies of scale thereby increasing electricity consumption and that advanced energy efficient technologies move from developed to developing countries through trade, affecting both economic activity and energy use. Furthermore, Kim (2022) asserted that renewable electricity expansion and trade openness jointly reduce CO₂ emissions in OECD countries while supporting growth. Meanwhile in Brazil, Hdom and Fuinhas (2020) affirmed that GDP, hydropower and renewables negatively affect CO₂ emissions while trade openness positively affects the growth model.

In spite of the power reforms and privatization embarked on by the government, rising system inefficiencies and losses has been a hindrance and the core bottleneck to effective electricity delivery and use in Nigeria (Aleshinloye, 2026). This anomaly can be attributed to the gap between ambitious policy frameworks and weak implementation. This implementation gap is further ascribed to institutional weakness, inadequate investment, poor technical capacity, policy discordance, and an unconducive investment climate (Nwozor et al., 2021). Nigeria's significant supply-demand gap means generation levels may be too low to register causal effects on growth in some specifications (Akan et al., 2023). However, multiple studies confirm that electricity generation and consumption increases economic growth (Nathaniel & Bekun, 2020; Apinran et al., 2020; Adewale et al., 2024; Balogun et al., 2024; Gold and Tregenna 2024; Tabash et al., 2024), supporting the electricity-led growth hypothesis. In detail, Chitedze et al. (2021) suggests that bidirectional causality runs between electricity consumption and manufacturing sector output. In support, Joseph et al. (2026) advocate that government needs to boost electricity supply for better industrial productivity.

Conversely, not all studies find electricity generation causes growth, contradicting the broader consensus. Some extant literature submit that electricity generation and supply has a negative effect on economic growth (Xiong and Xu, 2021; Ogbeide-Osaretin and Orhewere, 2022; Edobor et al., 2023; Adelowo and Fadare, 2023; Adediran and Adekoya, 2025). This might be attributed to the energy sources employed, electricity policies or insufficiencies. Nwagu et al. (2025) insists that an increase in funds allocated to electricity subsidies probably affects economic growth adversely. Accordingly, Onabote et al. (2020) asserts that both alternative and nuclear energy and electricity production from hydroelectric sources contribute adversely to economic growth in Nigeria due to inadequate number of hydro-electric plants, poor maintenance and inability to upgrade such facilities. In alliance, Iroh et al. (2022) is of the view that power outage and electricity pricing negatively affects factor productivity in Nigeria. Yusuff (2024) notes that the wide disparity between generated power and distributed power has adversely affected the advance of all sectors of the Nigerian economy. Evidence from sectoral literature, like Asalaye et al. (2021) agree that electricity consumption in Nigeria has not enhanced the performance of the manufacturing sector. Also, Edet et al. (2022) stress that electricity supply has adversely, though insignificant, affected manufacturing output. Furthermore, sectorial evidence for agriculture and services is markedly weaker. According to Henry et al. (2021) electric power transmission and distribution losses decrease agricultural output in the long run but have no significant short-run effect. Similarly, electricity consumption displays a little and insignificant impact on agriculture and service sector outputs (Chitedze et al., 2021). Likewise, Samuel et al. (2021) insist that there is non-causal relationship between the service and agricultural sectors regarding electricity. However, some studies have varied conclusions, for example, Nchege and Okpalaoka (2023) affirm that nuclear and alternative energy increases gross domestic product over time but hydroelectric power generation substantially reduces long term economic growth, thereby making a case for adoption of nuclear and alternative renewable energy sources. On the other hand, Ologunla (2025) submits that improved access to electricity enhances productivity but electric power consumption has been detrimental to industrial growth due to grid inefficiencies and high costs offset potential benefits.

Related to the studies on electricity and economic growth, previous researches on trade openness and economic growth have yielded mixed results. Therefore, the impact of trade openness on economic growth is subject to debate due to inconclusive evidence. Some studies assert that trade openness has adversative impacts on economic growth (Duru and Ezenwe, 2020; Rakshit, 2022; Ogudu et al., 2023; Abdulkarim, 2023). Specifically, Adekunle (2025) concludes that both non-oil imports and oil imports impede the

economic growth of Nigeria, reflecting challenges related to overdependence on foreign goods and services. On the contrary, Sunde et al. (2023), indicate a beneficial relationship between trade openness and economic growth. Relatively, Kong et al. (2021), Esaku (2021), Islam (2021) and Islam et al. (2022) identify a positive link between trade openness and economic growth in various countries. However, Malefane and Odhiambo (2021) suggest an insignificant trade openness and economic growth nexus.

Consequently, such contradictory arguments conceal vital policy insights on the electricity power, trade policy and economic growth nexus. More so, some of these studies predominantly measured economic growth with overall gross domestic product and trade integration with trade openness, while others focused on the sectoral gross domestic product like agriculture, manufacturing, industry and service sectors. However, studies that included nonoil gross domestic product and non-oil trade openness in the electricity power, trade policy and economic growth relationship, especially in oil reliant countries like Nigeria is limited. Hence, to bridge the gap, this study specifically probes the simultaneous relationship between electricity power transmission and distribution losses (% of output), non-oil trade openness and non-oil gross domestic product in Nigeria. By exploring these dimensions, the study seeks to provide a comprehensive understanding of how electricity infrastructure constraints and trade influences Nigeria's nonoil economic diversification efforts. Therefore, this study suggests vital relevant strategies and offer actionable insights for policymakers, private sector stakeholders, and international partners to address this critical barrier to sustainable development. The study also employed the autoregressive distributed lag (ARDL) bounds test approach to cointegration developed by Pesaran and Shin (1995) which offers broad insights into long-run and short-run effects and contribute to a deeper understanding of Nigeria's non-oil economy.

The study comprises of five sections which include the introduction section, literature review and research methodology respectively. The fourth section discusses and compares the outcome of the study's empirical results and analysis with extant literature. The final and fifth section presents a succinct conclusion preceded by policy recommendations and a deliberation of the study's limitations and future researches.

LITERATURE REVIEW

The relationship between electricity power constraints, trade integration and the growth of the economy is reviewed with extant literature in this section. The theoretical foundation and empirical overview are incorporated in this section with the aim of providing an in depth understanding of this study and its contribution to extant literature.

Theoretical Literature

The interactions between electricity infrastructure and the development of the non-oil sector may be explained in terms of a number of theoretical models, including the Infrastructure-Led Growth Theory and the neoclassical growth model theory. According to Agénor (2010), public infrastructure which includes electricity is the engine of economic growth in an economy. He submitted that economic development entails the presence of a strong infrastructure, which increases the productivity and lowers the cost of operations and attracts investment. In Nigeria, this potential is compromised by the lack of proper electricity infrastructure because businesses are forced to pay a high price due to the use of alternative energy sources, and this makes them less competitive on the international market (Gold & Tregenna, 2024). Also, Stern (2004), represents a neoclassical model of the relationship between energy and economic growth. The Stern model assumed the neoclassical idea of the Cobb-Douglas production function to investigate the forces that may weaken or strengthen the connection between energy consumption and economic activity over time and used the description that there has been decoupling of economic output and resources which means the constraints to growth are not limiting as before. Stern model can simply be translated into output (GDP) as a function of capital, labour, holding energy inputs and technological change constant. The model suggests that substitution between energy and other inputs, technological change, a change in the composition of the energy input, and a change in the composition of output may then influence the relationship between energy and an aggregate of output like gross domestic product. And the relationship between energy and output

may vary when the composition of the other inputs changes especially in a capital-intensive economy rather than a labor-intensive economy. Furthermore, in the case of trade integration and economic growth, the Neo-classicalist through Heckscher-Ohlin model support the importance of trade openness for economic development. They proposed that countries concentration should be on areas with greater factor endowment, strong technical capacity to produce exports at a lower cost advantage to accelerate economic growth. This assertion lends credence to the export-led growth hypothesis which states that increasing exports boosts productivity and market access, leading to economic growth (Gold & Rasiah, 2022). However, most developing countries that lack abundant resources and technology, with low degree of openness experience unfavorable trade balances which impedes growth (Sriyana & Afandi, 2020). All these theories emphasize the fact that the lack of electricity infrastructure is linked to weaker manufacturing performance and trade competitiveness which constraints the process of economic diversification.

Empirical Literature

The deliberation on the nature of the relationship between energy and economic growth remains unresolved with contradicting views on the direction of the relationship. This might be due to the sources or classification of energy, the context and differences in the methodologies employed. As highlighted earlier on, most prior studies have reiterated the importance of electricity generation and consumption to the growth and competitiveness of the economy in Nigeria. Some of these studies concentrated on the effect of electricity generation and consumption on the aggregate measure of gross domestic product for economic growth. For instance, Nathaniel and Bekun (2020) explored the link between electricity consumption, urbanization, and economic growth in Nigeria from 1971 to 2014. The bounds test cointegration result affirmed a long run relationship, while electricity consumption increases economic growth in both time periods, the impact of urbanization appears to inhibit growth. Additionally, Apinran et al. (2022) examined the role of electricity consumption on economic growth, while controlling for labor, capital, and carbon emissions, using the autoregressive distributed lag (ARDL) and the dynamic nonlinear autoregressive distributed lag (NARDL) models over the periods 1981 and 2019. The empirical results showed that electricity consumption, capital, and labor exert positive inelastic impacts, while carbon emissions exert negative inelastic significant impact on economic growth within the period under investigation.

For Pakistan, Qazi et al. (2021) estimated the long-run relationship between foreign direct investment, electricity consumption and GDP for the period of 1971 to 2017, using ARDL bounds testing, FMOLS and Canonicals cointegration regression. The cointegration results of all the approaches reveal that there exists long-run relationship, while the impact of electricity consumption on economic growth is very strong as compared to foreign direct investment. For studies on sub-Saharan African economies, Lawal et al. (2020) analyzed the correlation between economic growth and electricity use in the period of 1971-2017. It employed the System Generalized Methods-of-Moments (System GMM) procedures in order to resolve the problems of endogeneity of the data generating process and dynamic panel threshold regression model to determine the extent of the threshold level of energy intensity and the possibility of threshold asymmetric effect of energy consumption on the economic growth. The study found substantial positive correlation between electricity use and growth with a critical threshold of energy intensity that was 0.48%. This implies that the rate of energy consumption exceeding 0.48 percent will decelerate growth whereas below the rate will cause growth.

Furthermore, some studies investigated the impact of electricity generation and consumption on sectoral gross domestic product growth. Notably, Samuel et al. (2021) explored the co-integrating and causal link between energy consumption and economic growth in three economic sectors of agriculture, manufacturing, and service sectors in Nigeria from 2000Q1 to 2018Q4 using the autoregressive distributed lag (ARDL) bounds test approach, error correction model and the Clemente-Montanes-Reyes unit root approach for structural breaks in the series. The findings revealed that sufficient energy distribution and consumption stir economic growth through value additions in the agricultural, manufacturing, and service sectors. Also, Henry et al. (2021) employed the Autoregressive Distributed Lag (ARDL) and time series data between 1981 and 2017 to test how electric power transmission and distribution losses affect the agricultural and industrial RGDP. The obtained result indicated that the increase in the loss of electric power transmission

and distribution by 1 percent will reduce agricultural output by 3 percent in the long term but insignificant in the short term and losses in transmission and distribution of electric power do not impact much on the industrial output. Accordingly, Quadri & Bukola (2022) explored the impact of electricity consumption on manufacturing output in Nigeria from 1980 to 2021 using the ARDL model and the study identified labour, capital, and electricity consumption as the primary factors influencing manufacturing output in Nigeria. Corroboratively, Gold et al. (2024) studied the impact of electricity production, consumption on Nigeria's industrial output, employing time series data from 1985 to 2018 and the autoregressive distributed lag (ARDL) bounds testing technique for cointegration. Findings of their study reveal short and long-term manufacturing sector output benefits from electricity. However, the statistically significant effect is established over time. On the contrary, certain studies had varying assertions, including Ekeocha et al. (2020) study on the relationship between energy consumption and economic growth in Nigeria over the period 1999Q1-2016Q4 using a nonlinear (or asymmetric) ARDL model and an ARDL-ECM. The estimated result suggests that energy consumption has a negligible impact on economic growth, while the granger causality tests revealed a unidirectional causality moving from energy consumption to economic growth, suggesting that Nigeria can attain high levels of sustainable growth with improved and stable energy supply. Likewise, Aiyetan et al (2021) study on the dynamic effects of electricity production on industrial and agricultural output growth in Nigeria, disaggregated electricity production into renewable and non-renewable and employed a Structural Vector Autoregressive (SVAR) and other time series econometrics analysis. Thus, their study found that electricity production from the two sources had a trivial impact on the growth of the industrial and agricultural sectors in Nigerian. Besides, Chitedze et al. (2021) examined the extent at which electricity consumption has contributed to real sector performance using the vector autoregressive and vector error correction models for estimation. This study finds that electricity consumption displays a little and insignificant impact on manufacturing sector output, as well as agriculture and service outputs. Moreover, Edet et al. (2022) study which examined the relationship between Nigeria's manufacturing production and electrical supply from 1980 to 2022 using the ARDL model, revealed that power availability alone did not significantly increase manufacturing output in Nigeria, while technology improves manufacturing output.

More varying claims from Asaleye et al. (2021) study on electricity consumption and manufacturing sector performance using canonical ordinary least squares (OLS) suggest that credit to the manufacturing sector and electricity consumption exerts a negative impact on manufacturing sector output in Nigeria. Similarly, Edet et al. (2022) investigated the impact of electricity supply on manufacturing output in Nigeria using data from 1980 to 2019 using autoregressive distributed lag (ARDL) model and the result of the estimation revealed that electricity supply has a negative but insignificant relationship with the manufacturing sector output. Assertions from most recent studies have also shown inconsistencies, such as, Gold and Tregenna (2024) investigation of the nexus of trade openness, hydroelectric power production, and foreign direct investment (FDI) nexus on economic growth in Nigeria. The models used are the autoregressive distributed lag (ARDL) as a long-run and short-run model and the dynamic ordinary least squares (DOLS) as a robustness to tackle the possible endogeneity and serial correlation issues. The results show that trade openness positively influences the long run economic growth with DOLS estimates supporting this fact. Nonetheless, the FDI and hydroelectric power production influenced the economic performance of Nigeria differently. As well, Aleshinloye (2026) considered the link between Nigeria's economic growth and energy consumption from 1981 to 2024 using granger causality tests, impulse response functions, the vector error correction model (VECM), and Johansen cointegration. The findings indicate that increase in economic growth is mostly driven by crude oil consumption, with electricity having lag effects and coal contributing modestly. Meanwhile, Adediran and Adekoya (2025) investigated the dynamic interplay between the efficiency in the use of energy and economic growth in Nigeria towards achieving Sustainable Development Goal-7, while assessing the institutional mechanisms that influence this relationship using the Johansen co-integration approach, a vector error correction model and causality test. The empirical result demonstrated a co-integrated relationship, with the consumption of electricity exerting a negative influence on GDP. This finding suggests structural bottlenecks in the energy sector or inefficiencies in electricity usage, which may be impeding economic growth. The inconsistency is more pronounced in Ologunla (2025) study on the impact of energy equity on industrial sector growth in Nigeria, focusing on fossil fuel energy consumption, access to electricity, and electric power consumption, over the period 1999–2023 employing the fully

modified ordinary least squares (FMOLS) technique to estimate the long-run relationship. Findings showed that fossil fuel energy consumption had a positive and significant impact on industrial sector growth. Access to electricity also showed a positive and significant relationship with industrial output. However, electric power consumption exerted a negative and significant impact on industrial growth.

The extant literature also shows that trade openness increases economic growth, but this empirical evidence remains contested. For Nigeria, Nwadike et al. (2020) examined the nature of trade openness and economic growth from 1970–2011 using the ordinary least square (OLS) for estimation. The result obtained discovered that there exists long-run relationship among the variables used and trade Openness has a positive and significant impact on Nigeria's economic growth. However, Omoke and Okpuala (2021) study on the relationship between trade openness and economic growth in Nigeria incorporating the role of institutional quality showed mixed results. The study covers the period from 1984 to 2017 and employed three indicators of trade openness including total trade, import trade, and export trade. Cointegration among the variables is examined using the ARDL bounds testing approach. The estimated results suggest that export trade has a significant positive impact on economic growth while the effect of import trade on economic growth is negative and significant. The results also reveal that the negative long-run effects of import trade on economic growth in Nigeria decreases as institutional quality (quality of governance) progresses. Conversely, Malefame and Odihiambo (2021) tested the dynamic impact of trade openness on economic growth in Lesotho using the autoregressive distributed lag (ARDL) bound testing approach. The study used four indicators of trade openness, which include three trade-based proxies and an index of trade openness. The empirical results of this study indicated that trade openness has no significant impact on economic growth in both the short run and long run irrespective of which proxy of trade openness is used.

For Uganda, Esaku (2021) employed data covering the period from 1983 to 2019 and the autoregressive distributed lag (ARDL) bound testing approach to investigate the economic growth and trade openness relationship. The study's empirical results revealed the existence of a positive and statistically significant relationship between trade openness and economic growth in the short-run and long-run relationship. For Namibia, Sunde et al. (2023) tested the impact of exports, imports, and trade openness on Namibia's economic growth using the ARDL cointegration method. The results revealed a positive and significant interaction between exports, trade openness and economic growth, while a significant and negative relationship exists between imports and economic growth in Namibia in the long run. Moreover, the result suggests that short-term economic growth is led by exports, imports, and trade openness in Namibia. The diverged empirical evidences of these extant studies stresses the need for more investigations on the electricity, trade and economic growth nexus. Apart from the conflicting submissions, most results relied on gross domestic product and its components as a measure for economic growth. This is evident even in the resource reliant countries like Nigeria that are struggling to diversify their economy. Hence, as stated earlier, the study measures economic growth with nonoil gross domestic product and for its empirical analysis to provide insights on how electricity and trade affects the nonoil growth of Nigeria's economy.

DATA AND METHODOLOGY

For the study, annual time series data specifically from Central Bank of Nigeria statistical bulletin (CBN, 2023) and World Development Indicator (WDI) were sourced. The data of the variables employed ranged from 1990 -2023 (34 years).

Model Specification

To empirically investigate the impact of electricity infrastructure constraints and trade integration on non-oil sector growth in Nigeria, this study relied on the David Stern Model which implemented the neoclassical view of the Cobb-Douglas production function to observe the factors that could potentially reduce or strengthen the connection between energy utilization and economic activities overtime (Stern 2004). This adoption showed that there has been an uncoupling of economic output and resources. Accordingly, Ogbonna et al. (2016) and Henry et al. (2021) presented a general form of the David Stern's model in Eq. (1).

$$(Q_i, \dots, Q_m) = f(A, X_i, \dots, X_n, E_k, \dots, E_p) \quad (1)$$

Where Q_i are several outputs of different sectors of an economy like the agriculture and industrial sector, X_i are various factor inputs such as capital, labour etc. E_k represents the different energy inputs including gas, hydro, coal, oil etc., and A is the level of technological development as defined by the total factor productivity indicator. Thus, Ogbonna et al. (2016) restated the model as follows in Eq. (2).

$$RGDP = f(PGCKWH, GCF, UNEM) \quad (2)$$

Where; real GDP is expressed as a function of power generation capacity in kilowatts hour, gross capital formation, and unemployment. However, in this study, real gross domestic product (RGDP) is disaggregated into nonoil gross domestic product. This is important because it shows how electricity affect the nonoil economy and the diversification agenda of government. For this study, power generation capacity in kilowatts is replaced with electricity power transmission and distribution losses (% of output) for electric power constraints. This is because power generation capacity is assumed and not proportionate to the actual amount of electricity delivered to the final consumers. In line with empirical literature like Gold and Tregenna (2024), the study's model is modified with the inclusion of drivers of growth such as Gross fixed capital formation as proxy for capital while unemployment rate is used as a proxy for labour. Nonoil trade openness is also introduced to the model as a measure for technological progress. Thus, the model that guided this study is shown in Eq. (3).

$$NGDP = f(ETDL, GFCF, UNEMP, NTOP) \quad (3)$$

Eq. (3) is transformed into a stochastic form in Eq. (4) below.

$$\ln NGDP_t = \beta_0 + \beta_1 ETDL_t + \beta_2 \ln GFCF_t + \beta_3 UNEMP_t + \beta_4 NTOP_t + \varepsilon_t \quad (4)$$

Where, the dependent model $\ln NGDP_t$ is the log of nonoil gross domestic product at time t , the explanatory variables $ETDL_t$ is electricity power transmission and distribution losses (% of output) at time t and $NTOP_t$ is nonoil trade openness. The control variables $\ln GFCF_t$ is log of gross fixed capital formation at time t and $UNEMP_t$ is unemployment rate at time t . β_0 to β_4 are parameters to be estimated, while ε_t is the error term at time t .

Method of Data Analysis

To investigate the impact of Nigeria's electricity power constraint and trade integration on the non-oil economic growth, the study employed the Autoregressive Distributed Lag (ARDL) bounds test approach to cointegration developed by Pesaran and Shin (1995) and further elaborated by Pesaran et al. (2001). The ARDL has an edge over other time-series cointegration techniques when examining long-run relationships between variables, unlike Johansen's cointegration test, which is suited for multiple variables but requires all series to be integrated of the same order (e.g., first difference) and performs poorly in small samples, the ARDL framework is flexible. It accommodates variables with different integration orders $I(0)$, $I(1)$, or a mix of both after unit root tests and it is well suited for estimation using limited data. Additionally, ARDL model framework has the ability to estimate short-run and long-run parameters simultaneously. The general form of the Autoregressive Distributed Lag (ARDL) bounds testing model is presented as follow in Eq. (5):

$$\begin{aligned} \Delta \ln NGDP_t = & \beta_0 + \sum_{j=1}^b \beta_{1i} \Delta \ln NGDP_{t-j} + \sum_{j=0}^c \beta_{2i} \Delta ETDL_{t-j} + \sum_{j=0}^d \beta_{3i} \Delta NTOP_{t-j} + \sum_{j=0}^e \beta_{4i} \Delta \ln GFCF_{t-j} \\ & + \sum_{j=0}^f \beta_{5i} \Delta UNEMP_{t-j} + \delta_{1i} \ln NGDP_{t-1} + \delta_{2i} ETDL_{t-1} + \delta_{3i} NTOP_{t-1} + \delta_{4i} \ln GFCF_{t-1} \\ & + \delta_{5i} UNEMP_{t-1} + \varepsilon_t \end{aligned} \quad (5)$$

Also, the ARDL bounds test F- statistics tests the null hypothesis (H_0) against the alternative (H_1) for. It is expressed as $H_0: \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = 0$; $H_1: \beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq \beta_5 \neq 0$. Furthermore, the ARDL unrestricted error correction model (ECM) specified in Eq. (6) examines the short run estimates, while θECT_{t-1} illustrates the rate of adjustment back to their long-term equilibrium from any short-term disequilibrium, while Δ represents the difference operator.

$$\begin{aligned} \Delta \ln NGDP_t = & \beta_0 + \sum_{j=1}^b \beta_{1i} \Delta \ln NGDP_{t-j} + \sum_{j=0}^c \beta_{2i} \Delta ETDL_{t-j} + \sum_{j=0}^d \beta_{3i} \Delta NTOP_{t-j} \sum_{j=0}^e \beta_{4i} \Delta \ln GFCF_{t-j} \\ & + \sum_{j=0}^f \beta_{5i} \Delta UNEMP_{t-j} + \theta ECT_{t-1} \\ & + \varepsilon_t \end{aligned} \quad (6)$$

Description of Terms

The variables, terms and source for the study are explicitly described in table 1 below.

Table 1. Definition of Variables

Variable	Symbol	Measurement	Source
Electricity power transmission and distribution losses (% of output)	ETDL	The difference between the amount of electricity supplied to the grid and the amount of electricity delivered to the final consumers	World development indicator
Non-oil trade openness	NTOP	Non-oil Total trade to Non-oil GDP ratio	CBN Statistical Bulletin (2023)
Non-oil gross domestic product	NGDP	A country's GDP minus crude petroleum, natural gas and oil refining.	CBN Statistical Bulletin (2023)
Unemployment rate	UNEMP	The percentage of the labor force that is unemployed	World development indicator
Gross fixed capital formation	GFCF	Total value of a country's acquisition of new or existing fixed assets minus the disposal of those assets	CBN Statistical Bulletin (2023)

EMPIRICAL RESULTS AND DISCUSSION

Descriptive Statistics

The descriptive statistics for each of the variables used in the study is depicted in Table 2. The measures of central tendency are represented by the mean value, median value, maximum and minimum value and the maximum value of the variables shows positive numbers respectively. The summary test also shows that the

average electricity lost during delivery to the final consumers (ETDL) is 17.2% of electricity output in Nigeria. Furthermore, the maximum ETDL is 20%, while the minimum is 13% which are greater than the global benchmark of 5% to 7%. This can be attributed to outdated grid infrastructure, destruction and theft. The statistics also indicate that non-oil trade openness (NTOP) averaged 11% of GDP, oscillating between 7% and 20% of GDP during the years of study. This shows exceptionally low trade integration. The average non-oil (NGDP) is 52063.06 billion ₦ and the maximum is 216784 billion ₦. Unemployment in Nigeria averaged 4% with a maximum of 6% and minimum of 3%. The lowest described volatility is in the gross fixed capital formation (GFCF), while non-oil (NGDP) is the highest. Meanwhile, the result reveals that ETDL is skewed to the left, whereas NTOP, NGDP, GFCF and UNEMP are skewed to the right.

Table 2. Descriptive statistics

	UNEMP	ETDL	NGDP	GFCF	NTOP
Mean	4.125912	17.25804	52063.06	13918.70	11.51612
Median	3.906000	17.40894	27823.02	7266.445	10.75852
Maximum	6.012000	20.00000	216784.0	82889.22	20.27730
Minimum	3.074000	13.77063	430.9827	262.7656	7.182644
Std. Dev.	0.653932	2.769075	60190.19	20004.42	2.722300
Skewness	1.503477	-0.047666	1.187591	2.126970	0.970783
Kurtosis	4.532607	1.067463	3.426345	6.744470	4.400897
Jarque-Bera	16.13676	5.303698	8.249619	45.49917	8.120604
Probability	0.000313	0.070521	0.016167	0.000000	0.017244
Sum	140.2810	586.7735	1770144.	473235.8	391.5482
Sum Sq. Dev.	14.11168	253.0367	1.20E+11	1.32E+10	244.5603
Observations	34	34	34	34	34

Source: Authors compilation

Optimal Lag Selection Result

The lag length information criteria as presented in Table 3, selects the required optimal lag length.

Table 3. Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-843.5034	NA	4.09e+17	54.74216	54.97345	54.81755
1	-644.9130	320.3072	5.74e+12	43.54277	44.93050	43.99514
2	-604.1892	52.54675	2.39e+12	42.52834	45.07251	43.35767
3	-545.5397	56.75756*	4.01e+11*	40.35740*	44.05801*	41.56371*

* indicates lag order selected by the criterion

Source: Authors compilation

The result in Table 3 indicates that lag order of 3 is the optimal lag length on the basis of Akaike information criterion (AIC), Schwarz criterion (SC), final predictor error (FPE), Hannan-Quinn criterion and the likelihood ratio (LR) test.

Unit Root Test

As mentioned earlier, the unit root tests result determines the estimation method to apply in the study, which in this case is the Autoregressive Distributed Lag (ARDL). Table 4 shows the result of the augmented Dickey Fuller unit root tests (Fuller Dickey and Fuller, 1979) and Phillip Perron unit root tests (Phillips and Perron, 1988).

In the result, the ADF test specifically displays that NGDP and NTOP are stationary at 1(0) order of integration, while ETDL, GFCF and UNEMP are stationary at 1(1) order of integration. This result as shown in table 4, confirms the appropriateness of the study's chosen method in that the considered variables are stationary at 1(0) and 1(1) order of integration at 1% and 5% level of significance.

Table 4. Unit root result

Variables	ADF		PP	
	1(0)	1(1)	1(0)	1(1)
NGDP	-5.050883*	-2.643086	-4.330003*	-2.586856
ETDL	-0.784784	-5.652537*	-0.781335	-5.653437*
NTOP	-5.556892*	10.29379*	-5.575685*	-15.83741*
GFCF	-1.013157	-4.206601*	-0.918289	-4.346603*
UNEMP	-2.242333	-6.147529*	-3.604100**	-6.147529*

Note: * and ** show significance at the 1% and 5% level respectively

Source: Authors compilation

Bounds Test Cointegration

Subsequently, in order to estimate an Autoregressive Distributed Lag (ARDL) model analyzing the study, a cointegration test using the bound test cointegration is considered suitable to establish whether a long-run relationship exists between the variables (Pesaran and Smith, 2001).

The cointegration test results in Table 5 reveals that the F-value of 11.508862 is higher than the 1(0) and I(1) critical bounds, even at a 1%. 5% and 10% levels of significance which confirms the cointegration among the variables, suggesting a long run relationship.

Table 5. Bounds Test Cointegration Result

	Test Statistic		Critical Value Bounds					
			10%		5%		1%	
	Value	k	1(0)	1(1)	1(0)	1(1)	1(0)	1(1)
F-Statistics	11.508862	5	2.525	3.560	3.058	4.223	4.280	5.840

Source: Authors compilation

ARDL Short and Long-run estimates

As cointegration has been established, the autoregressive distributive lag (ARDL) bounds model is estimated to determine the short-run and long-run estimates. The result of the autoregressive distributive lag (ARDL) bounds model is presented in table 6.

Table 6. Autoregressive Distributed Lag (ARDL) results

Variables	Long-run estimates	Short-run estimates
	Coefficient	Coefficient
$\ln\text{NGDP}_{t-1}$	-0.353(-3.296)*	
ETDL_{t-1}	-0.030(-2.523)*	
NTOP_{t-1}	-0.0490(-2.852)**	
$\ln\text{GFCF}_{t-1}$	0.328(2.682)**	
UNEMP_{t-1}	-0.187(-3.088)**	
ΔETDL		0.009(0.832)
ΔETDL_{t-1}		0.056(4.200)*
ΔETDL_{t-2}		0.041(3.896)*
ΔNTOP		-0.002(-0.901)
ΔNTOP_{t-1}		0.032(5.498)*
ΔNTOP_{t-2}		0.010(3.016)*
$\Delta\ln\text{GFCF}$		0.323(3.966)*
$\Delta\ln\text{GFCF}_{t-1}$		-0.212(-2.113)*
ΔUNEMP		-0.131(-4.032)*
ΔUNEMP_{t-1}		0.218(5.605)*
C		2.700(4.698)*
ECT_{t-1}		-0.353(-9.595)*

Note: t-statistics are in parentheses; *, ** and *** show significance at the 1%, 5% and 10% level respectively.

Source: Authors compilation

The outcome of the estimation reveals that lag of the error correction term (ECT_{t-1}) has a negative and significant coefficient as expected. This implies that there is long-run equilibrium convergence of the model. Subsequently, the estimation result shows that electricity power transmission and distribution losses (ETDL) has a reducing and significant relationship with nonoil gross domestic product (NGDP) in the long run but a positive and significant correlation at lag 1 and 2 in the short run. This disclosure suggests that the relationship between electric power constraints and the performance of the nonoil economy is dynamic. The positive short run relationship should not be construed as evidence that electricity constraints promote economic growth, but might be as a result of firms relying on alternative power sources like solar micro grids, private generators due to unreliable electricity power. This resort to private power generation is likely to artificially boost short run nonoil gross domestic product. However, persistent electricity power transmission and distribution losses becomes detrimental to nonoil economic performance thereby constraining productivity and investment in the long run. Therefore, this evidence is consistent with Roy et al. (2023) and Afolabi et al. (2025) and underscores the need for improving the efficiency and reliability of

electricity supply in Nigeria if nonoil economic diversification is to be achieved. Next, the result exposed that nonoil trade openness (NTOP) as a measure for trade integration is negative and significantly correlated with nonoil gross domestic product (NGDP) in the long run. Conversely, the relationship was positive and significant in the short run. This insight suggests that the benefits of trade integration in Nigeria may be transitory. In the short run, increase in trade openness may stimulate nonoil economic activity through rise in imported capital and intermediate goods, technology, investments and competitive pressure which is in line with Zaria et al. (2025). Nevertheless, the negative long run relationship suggests that trade liberalization without a commensurate improvement in domestic productive capacity may be inimical to economic growth and diversification. Nigeria's high import dependence, competition from foreign producers may eventually eliminate the gains achieved in the short run. This perception of an adverse relationship corresponds with Ogudu et al. (2024).

In the case of the impact of gross fixed capital formation (GFCF) on nonoil gross domestic product (NGDP), evidence reveals a significant positive influence in the long run which is in tandem with Abdulkarim (2023). This result suggests that sustained investment in productive physical assets augments the productive capacity and development of Nigeria's nonoil sector. Contrariwise, the impact of gross fixed capital formation (GFCF) is significantly positive at level and significantly negative at lag 1 in the short run. The mixed effect suggests that investment creates an immediate incentive to nonoil economic activity through expansion of productive activities. But the subsequent negative effect indicates lack of sustained investment in that period. This may reflect inefficient resource allocation, temporary adjustment costs, delays in the completion and utilization of investment projects or lack of implementation of capital investments (Gold and Tregenna, 2024). Thus, the mixed effects suggests that nonoil sector in Nigeria may be subject to short run fluctuations before manifesting fully over time.

Accordingly, the finding emphasizes that increase in investment alone may not be sufficient in sustaining the growth of Nigeria's nonoil economy. Furthermore, the estimated result posits that unemployment has a negative and significant relationship with nonoil GDP (NGDP) in the long run, which is consistent with Edeme et al. (2024). This evidence implies that persistent unemployment may restrain the productive capacity and development of Nigeria's nonoil economy. The unemployment also reduces household incomes and aggregate demand thereby reducing productivity of the nonoil sector in the long run. On the other hand, the positive lagged short run correlation indicates a short run adjustment dynamics which should not imply that unemployment promotes growth, rather it suggests that the immediate adverse effect of unemployment on nonoil GDP may be partially offset in the following period. To Aderemi et al. (2022), the positive relationship in the short run implies that the Nigerian economy experienced jobless growth in the short run. Overall, the negative long-run relationship remains more important for policy interpretation, indicating that sustained reductions in unemployment are necessary to strengthen Nigeria's non-oil productive base and promote more employment-intensive economic growth.

Diagnostics Test

Additionally, Table 7 reveals the diagnostics test that substantiates the reliability and robustness of the empirical estimates. These included the heteroskedasticity, serial correlation, normality, and stability tests. The Breusch-Pagan-Godfrey heteroskedasticity test procedure, showed that the result is homoscedastic, with an F-statistic of 0.644 and p-value of 0.797. Meanwhile, the Breusch-Godfrey serial correlation test procedure recognized that the estimated result does not have a serial correlation problem given that the F-statistic has a value of 0.539 and a p-value of 0.595. Also, the Jarque-Bera normality test statistic value of 1.817 and its p-value of 0.403 indicate that the model residuals are normally distributed. Also, Ramsey's RESET test F-statistic value of 0.004 and p-value of 0.949 signify that the model was correctly specified. Furthermore, the recursive residuals (CUSUM and CUSUM of Squares) methods were used to examine the stability of the model (Pesaran & Pesaran, 1997). From the CUSUM and CUSUM of squares plots, it was established that the model is stable. Overall, the diagnostic tests indicate the plausibility of the reliability of the empirical estimates and its validity for forecasting.

Table 7. Diagnostic Test

Breusch-Godfrey Serial Correlation LM Test	
F-statistic	0.539
Prob.	0.595
Heteroskedasticity Test: Breusch-Pagan-Godfrey	
F-statistic	0.644
Prob.	0.797
Jarque-Bera Normality test	1.817
Prob.	0.403
Ramsey's RESET Stability test	
F-statistic	0.004
Prob.	0.949
Cusum	Stable
Cusum Square	Stable

Source: Authors compilation

CONCLUSION AND POLICY RECOMMENDATION

Conclusion

The analysis investigates the relationship between electricity power transmission and distribution losses, nonoil trade openness and nonoil gross domestic product in Nigeria, with gross fixed capital formation and unemployment as control variables. The study employed the autoregressive distributed lag (ARDL) bounds test approach to cointegration to estimate the short-run and long-run relationship. The analysis findings established the presence of a long run relationship among our variables and suggests that electricity power transmission and distribution losses (ETDL), nonoil trade openness (NTOP) and unemployment (UNEMP) are adversely correlated to Nigeria's nonoil economy measured by nonoil gross domestic product (NGDP) in the long run, while gross fixed capital formation contributes positively to nonoil gross domestic product (NGDP). Interestingly, the conflicting evidence from the short run results indicate a dynamic relationship between the variables that is subject to adjustment effects. Reliant on these results, this study has essential policy implications.

Recommendations

In order to achieve sustainable diversification and growth of the nonoil economy, the Nigerian government needs to improve electricity infrastructure. According to the Transmission Company of Nigeria (TCN), electricity transmission capacity has expanded by 8,700 MW through over \$1.4 billion in multilateral loans and new substation infrastructure. However, severe distribution bottlenecks forces distribution companies to under-procure available bulk power resulting in frequent system collapses. To resolve the electricity supply and power losses, Nigeria must recapitalize and modernize the transmission and distribution networks and deploy technology to balance the bulk power transmission with actual demand. Also, the findings of the study that persistent trade liberalization is detrimental to the nonoil sector in the long run implies that nonoil trade openness alone may be insufficient to promote sustainable nonoil economic growth, which is a huge hindrance to the diversification efforts of government. Although, the Nigerian government has implemented investment focused budgeting, expanded nonoil export financing and boosted tax revenue across the nonoil sector. Still, these efforts are constrained by critical infrastructure deficit, especially severe electricity shortages, high cost of capital, insecurity, heavy reliance on imported goods and foreign exchange

dependencies. Therefore, to ensure that the domestic firms in the nonoil sector can compete in international markets and convert trade opportunities into sustained domestic production and value chain for accelerated growth, these constraints must be addressed. In accordance with most extant literature, the result of this study reflects how important investment in the nonoil sector is in the diversification drive and growth of the Nigerian economy. The gross fixed capital formation coefficient recorded the highest effect, which is also positive and significant in the long run. But the short run result highlights the necessity of directing investment towards productive sectors of the nonoil economy. Effective monitoring and implementation are required to ensure investments enhance and sustain economic benefits. Finally, the adverse effect of unemployment in the long run should prompt the government towards reducing unemployment through policies that promote labour intensive industries, entrepreneurship, vocational training and private sector investment within the nonoil sector. An increase in employment will improve household incomes, aggregate demand and the productive capacity of the economy.

Limitations and Future Research

The study's empirical findings may not be applicable to other nations and regions because of its specific focus on Nigeria thereby restricting its generalizability. The method employed in the empirical analysis may also impact the study's findings and might differ when different methods are used. Therefore, future studies should expand the contextual and methodological scopes to accommodate more complex linearity and nonlinearities. This study focused on a select set of variables, thereby omitting other potential drivers of nonoil economic growth, such as exchange rate, institutional quality, electricity tariffs, import and export tariffs, environmental factors, global commodity prices and technology. Finally, comparative studies on the effect of electricity constraints and trade integration across different sectors of the nonoil economy crop production, transportation, health, education, communication and motor vehicles assembly could provide targeted policy insights.

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