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Research paper

Empirical Analysis of The Dynamic Interplay between Energy Consumption and Economic Growth in Nigeria

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Abstract

The study investigated energy consumption and economic growth in Nigeria using time series data for the period of 1986 to 2024. Energy consumption was measured by PMS consumption, electricity consumption, coal consumption, and labour consumption, while economic growth was measured by GDP per capita. The study used the Error Correction Model (ECM) to achieve its objectives. The Johansen cointegration test showed that there was no long-run relationship between the components of energy consumption and economic growth in Nigeria. In the short run, it was observed that while PMS consumption and electricity consumption had an insignificant effect on GDP per capita, coal consumption and labour consumption were significant to GDP per capita growth. The study therefore recommended that the government should make adequate provision to enhance electricity consumption towards boosting economic growth in the Nigerian economy. This could be achieved if the federal government improves on energy generation, energy transmission, and energy distribution to boost its consumption among economic agents such as households, firms, markets, and the government itself.

Keywords: *Energy; Energy Consumption; Economic Growth; Error Correction Model; Gross Domestic Product.*

1. Introduction

Energy is widely recognised as the backbone of every modern economy, which drives development and innovation and enhances the quality of life. In Nigeria, as a key economic player in West Africa with a population exceeding 220 million, energy consumption plays a pivotal role in shaping economic performance as well as enhancing social welfare (Goshit & Shido-Ikwu, 2022). Despite being richly endowed with various energy resources, Nigeria's economy over the years has continued to grapple with energy insecurity, with unreliable power supplies as well as an underdeveloped energy infrastructure (Adeleye, Gershon, Ogundipe, Owolabi, Ogunrinola, & Adediran, 2020). These challenges have persisted and constrained the nation's economic aspirations as well as its ability to foster sustainable development.

In Nigeria, energy plays an essential role in shaping the economic activities of the country, yet the country continues to grapple with energy poverty despite its vast natural resource endowments. Within the African continent, Nigeria is the largest producer of crude oil and has more natural gas (coal and renewable energy potential) reserves than other African countries (IEA, 2021). However, energy production, distribution, and consumption have been inefficient, thereby hindering the nation's economic progress. Electricity consumption is a major indicator of economic vitality, yet the power sector in Nigeria remains underdeveloped, resulting in an epileptic supply. The country generates less than 5,000 megawatts (MW) of electricity for its population of over 200 million. This leads to frequent power outages, and a greater majority of the country's population relies heavily on generators (World Bank, 2022). This electricity deficit increases the production cost of doing business in Nigeria, which stifles industrial development and discourages foreign investment inflows (Azebi & Lubo, 2025).

The Nigerian electricity sector has faced many years of challenges. Some of these include poor infrastructure, inadequate power generation capacity, power transmission losses, and inefficient and ineffective distribution networks (IEA, 2021). Despite the privatisation efforts of the Power Sector Reform Act of 2005, the power supply still remains highly unreliable, with many households and industries depending on alternative sources of energy such as diesel and petrol-powered generating sets (NERC, 2023). This heavy reliance on self-generated electricity power increases the cost of doing business in the country, thereby reducing competitiveness, and ultimately hampers economic growth and development (Adeleye et al., 2020). Again, the inefficient supply of stable electricity in rural areas exacerbates poverty and reduces growth opportunities for small and medium-scale enterprises (SMEs), which are vital drivers for employment, poverty reduction, and economic growth (Ogundipe & Adeleye, 2019). As of 2023, about 45% of the population, particularly in rural areas, lacked grid-connected electricity (Adebayo & Alimi, 2023). This energy deficit continues to hamper economic activities, worsen poverty, and stall progress toward sustainable development. The low level of investment in renewable energy infrastructure has thus become a significant constraint on Nigeria's quest for inclusive and sustainable economic development.

Obviously, Nigeria is yet to harness the full potential of its power sector to stimulate economic development, as the wide gap between electricity demand and supply continues to widen (Johnson & Mohammed, 2024). As a result, alternative energy sources have been promoted in Nigeria to overcome frequent energy shortages, reduce the high cost and environmental impact of using fossil fuels for generators, and meet international commitments to combat climate change. Nigeria has vast alternative energy resources, with significant untapped potential in solar, hydroelectric, wind, and biomass power. The government has implemented policies, such as the National Renewable Energy and Energy Efficiency Policy (NREEEP), to promote these resources. While solar energy and mini-grids are increasingly used to reach off-grid communities, challenges like high acquisition costs remain a barrier to widespread adoption. The high cost of alternative energy sources due to epileptic power supply imposes a high financial burden on households and businesses, thereby reducing disposable income and discouraging industrial growth and development (CBN, 2023).

Nigeria's post-2020 energy policy shifts focus to transitioning to a net-zero economy by 2060, driven by the Nigerian Energy Transition Plan (ETP) launched in 2022. Key policy shifts include a greater emphasis on renewable energy expansion through initiatives like Solar Power Naija and the National Renewable Energy and Energy Efficiency Policy (NREEEP), alongside the passage of the Climate Change Act of 2021. The country also adopted a mixed strategy for the power sector, positioning fossil gas as a "transition fuel" for centralized power while aiming to phase out decentralized fossil gas by 2050. Nigeria's major post-2020 energy policy shift was the full removal of fuel subsidies in May 2023, a decision aimed to improve fiscal stability and promote a competitive, market-driven petroleum sector, but resulted in a rapid increase in fuel prices and significant inflation, affecting household expenditure and the cost of living. The policy shift also raised concerns about transparency and governance, with calls for targeted social programs and infrastructure development to mitigate the adverse effects on vulnerable populations and small businesses.

Premium motor spirit (PMS), also known as petrol, is another essential energy source in Nigeria, but the country's dependence on imported refined petroleum products due to inefficient local refineries has led to high fuel costs and economic instability, leading to loss of jobs and increasing the poverty rate (NNPC, 2023). The recent removal of subsidies on premium motor spirit (PMS) has further increased the inflation rate and increased transportation, manufacturing, and household expenses (CBN, 2023). PMS plays a vital role in the landscape of the Nigerian economy, serving as the primary source of energy for transportation, power generation, and industrial activities (Adeniran & Sidiq, 2022). Nigeria, despite being West Africa's largest producer of crude oil, incongruously suffers from perennial petrol shortages and heavily relies on refined petroleum products imported from abroad, with no possible solution in sight due to inadequate domestic refining capacity (NNPC, 2023). This dependence on PMS imports has created significant fiscal burdens, thereby crowding out the economy, with fuel subsidy payments consuming approximately $9.6 billion USD between 2005 and 2021 (CBN, 2022). Unfortunately, the recent removal of fuel subsidies to curb petrol subsidy payments has further stiffened the economy, causing hyperinflationary trends and reducing the purchasing power of Nigerian citizens (NBS, 2023).

PMS consumption patterns in Nigeria reveal the complexity of the relationship between energy consumption and economic performance. The transportation sector accounts for more than 60% of PMS consumption in Nigeria, while the power sector utilises less than 30% through its backup generators (Energy Commission of Nigeria, 2022). This heavy dependence on PMS for electricity generation in Nigeria explains the failure of the national grid, with businesses, institutions, and households spending over $14 billion per year on fuel for local generation of power with their generating sets (World Bank, 2023). This has clear economic implications, because high PMS costs translate to increased production costs, which in turn reduce industrial competitiveness, as well as constrain economic development (Oyedepo, 2021).

Academic literature presents divergent perspectives on the relationship between the PMS and economic growth. While many researchers believe that petroleum consumption positively correlates with economic growth and development in economies that are oil-dependent, others suggest that excessive reliance on petroleum motor spirit as a major source of energy tends to create structural distortions and fiscal vulnerabilities (Amangwai & Amos, 2025). The case of Nigeria appears to be too complex due to the interplay of different subsidy regimes, smuggling activities, which are estimated at 15-20% of total national consumption, and frequent supply disruptions (NEITI, 2022). These factors jointly seemingly undermine the potential economic benefits of petroleum motor spirit consumption in Nigeria while amplifying its negative externalities, as well as the environmental degradation effect and public health implications (Ogundipe, Ogunrinola & Adeleye, 2020).

As a form of energy-related labor input, labor is directly influenced by access to reliable power and the availability of fuel. Access to reliable power and available fuel directly influences labour in Nigeria by affecting job creation and productivity. Energy supply Inefficiency reduces the nation's workforce productivity, especially in the manufacturing and agricultural sectors, which are vital to Nigeria's economic growth (Adeleye et al., 2020). On the other hand, coal, which was once a major source of energy in Nigeria, has been underutilised despite having great potential in diversifying the energy mix and supporting industrial growth (Emodi & Boo, 2015). The overheavy reliance on oil revenues in Nigeria has made the economy prone to shocks in global oil prices, necessitating a shift toward a more balanced energy portfolio for the nation.

In Nigeria, coal was once the backbone of the nation's industrial energy sector, and it presents a paradoxical energy solution in the nation's contemporary economic landscape if properly utilised (Emodi & Boo, 2015). The country possesses an estimate over 2 billion metric tonnes of coal reserves (Ministry of Mines and Steel Development, 2022), yet coal's contribution to the national energy mix still remains negligible at less than 1% of total energy consumption (Energy Commission of Nigeria, 2023). This under-utilisation continues to persist while the country battles with chronic electricity shortages and heavy reliance on the importation of refined petroleum products, which is raising critical questions about the diversification strategies of the country's sources of energy and their potential effects on the economy (Adeleke, 2021). But the discovery of crude oil in the 1950s resulted in a fast decline in coal utilisation as a source of energy, which led to the eventual collapse of the coal mining industry in the country (Sambo, 2020). Recently, due to global energy transitions to safer energy sources and Nigeria's persistent deficits of power (of about 4,500 MW for 200 million people), the country's interest in coal as a potential solution to base-load power has been renewed (World Bank, 2023). Also, the growing environmental concerns have given rise to the resurgence of interest in coal as a source of energy, particularly in accordance with Nigeria's commitments to the Paris Climate Agreement (Federal Ministry of Environment, 2022).

For emerging economies such as Nigeria, the relationship between energy consumption and economic development has been a major pillar of both economic theory and public policy. Access to affordable, reliable, and sustainable energy is crucial for the social advancement, economic industrialisation, and general growth of the economy. It is obvious that for Nigeria to achieve its ambition of achieving middle-income status and economic diversification, it is directly linked to its capacity to meet rapidly growing energy demands. For many decades now, fluctuations in electricity supply, petroleum products consumption, and gas consumption have mirrored the nation's varied phases of economic development. Despite the various government efforts and policies on energy generation and foreign investment inflow to the energy sector in Nigeria, the country is yet to attain the desired level of energy security, sufficiency, and efficiency essential for enhanced economic development. The major subject of ongoing debate among researchers, policymakers, and scholars is the question of how the energy sub-sectors impact economic growth and the direction of causality between energy consumption and economic progress in West Africa.

In light of these challenges, it becomes imperative to critically examine the role of energy consumption in Nigeria's sustainable economic growth. Understanding the constraints and opportunities for scaling up consumption in this sector is essential to crafting effective policies and attracting the necessary public and private capital required to transform the economy and improve the quality of life for citizens. The main objective of this study, therefore, is to examine the interplay between energy consumption and economic growth in Nigeria. The specific objectives of the study are to: examine the impact of PMS consumption on growth of GDP per capita in Nigeria; evaluate the effect of electricity consumption on the growth of GDP per capita in Nigeria; assess the influence of electricity consumption on GDP per capita in Nigeria; investigate the relationship between coal consumption and GDP per capita in Nigeria; ascertain the impact of labour consumption on GDP per capita. This research is aimed at providing recommendations for optimising energy use to foster sustainable economic growth by evaluating trends, inefficiencies, and policy gaps.

2. Literature Review

Nigeria's transition to renewable energy can drive economic growth and development by creating jobs, improving energy access in rural areas, and reducing energy costs. However, challenges like high upfront costs, limited financing, policy inconsistencies, and weak infrastructure hinder progress. To succeed, Nigeria needs significant private sector investment, clear and enforced policies, and improved grid infrastructure to support its goals of achieving energy access and net-zero emissions. Recent empirical literature on energy consumption and its effect on Nigeria's economy reveals significant, yet complex, relationships which may be influenced by the type of energy source, the methodology adopted, and the economic context.

With emphasis on the energy shift policy in Nigeria, Azebi and Lubo (2025) assessed the impact of renewable energy investment on sustainable economic development. Sustainable economic development was measured by the growth rate of gross domestic product, while renewable energy was proxied by solar, wind, and biomass. Data on these variables for the period 1990 to 2023 were analysed using the Johansen cointegration test and the Error Correction Model approach. The Johansen cointegration test revealed the presence of a long-run relationship among the variables. Findings from the ECM estimates showed that investment in solar energy had a considerable positive impact on the growth of Nigeria's gross domestic product, while investment in wind energy had an insignificant positive impact on the growth of Nigeria's gross domestic product. The study also disclosed that investment in biomass had a non-negligible positive influence on the growth of gross domestic product in Nigeria.

In a study, Amadi et al. (2025) explored the relationship between energy poverty and economic development in Nigeria from 1990 to 2022. Using the Auto-Regressive Distributed Lag (ARDL) model, the analysis ensured stationarity of variables and provided robust insights into their interactions. Data were sourced from the World Bank's World Development Indicators and the United Nations Development Programme. Empirical results revealed no long-run correlation between energy poverty and economic development, as indicated by the bounds test. Consequently, the analysis focused on short-term dynamics. The findings showed that access to electricity and renewable energy consumption positively and significantly influenced the HDI in the current period and the second-year lag, respectively. However, renewable energy output and electric power consumption, while positive, exhibited no significant impact on the HDI. The study concluded that energy poverty has a substantial impact on economic development in Nigeria, particularly in the short term.

Again, Okafor (2025) investigated the effect of energy consumption, renewable energy, and circular energy on Nigeria's economic growth from 2010 to 2023. The study employed various statistical tools, including Descriptive Statistics, Group Unit Root Test, Johansen Cointegration Test, and the Vector Error Correction Model (VECM), with post-analysis tests ensuring model validity. Findings revealed that primary energy consumption had an insignificant positive effect on economic growth due to inefficiencies, transmission losses, and over-reliance on fossil fuels. Total renewable energy capacity also showed a positive but insignificant impact, indicating its potential in driving economic expansion with adequate investment and policy support. However, circular energy exhibited a negative effect, highlighting Nigeria's underdeveloped recycling capacity and the need for technological advancements.

Similarly, Balogun and Adeyemi (2024) adopted a Bayesian Vector Autoregression (BVAR) model to explore the response of Nigeria's economic sustainability indicators—GDP per capita, employment rate, and environmental index—to renewable energy shocks. Using quarterly data from 2001 to 2023, the study found that positive shocks in renewable energy investment led to long-lasting improvements in economic sustainability. The authors proposed that policy prioritisation of decentralised renewable systems would cushion the effects of fossil fuel volatility on development.

Likewise, Johnson & Mohammed (2024) examined the impact of renewable energy consumption on economic growth in Nigeria from 1990 to 2022. The study of the Non-linear ARDL (NARDL) model. The NARDL Wald test result showed that an asymmetric relationship exists between renewable energy consumption and economic growth in the long run. The short-run and long-run results for the NARDL revealed that both the positive and negative changes in renewable energy consumption are significant at a 5% significance level. Still, the positive change exhibited a positive relationship between renewable energy consumption and economic growth, while the negative change exhibited a negative relationship. Also, the long-run results revealed that positive change was significant while negative change was not. It was observed that the impact of positive change is negative while that of negative change is positive, as shown in their respective coefficients of -0.526016 and 0.184204, respectively.

Again, Ogwuche et al. (2024) examined the impact fuel subsidy payments had on economic growth in Nigeria from 2005 to 2023. The long-run relationship among the variables was confirmed using the Johansen co-integration technique, while the Vector Error Correction Model (VECM) technique of analysis was adopted for estimation of the data. The study found that a significant negative relationship exists between fuel subsidy expenditure and economic growth in Nigeria within the period under study.

Using an ARDL model, Ashakah (2024), with data from 1990 to 2023, found that current-year electricity consumption negatively but insignificantly affected GDP, while electricity consumption lagged for a year and positively and significantly impacted economic growth. Natural gas consumption had positive but insignificant effects on economic growth, emphasising the delayed and mixed energy effect of consumption types on growth.

Also, Bank-Ola, Adediwura, Alao-Owunna, & Udofia (2024), using the Vector Error Correction Mechanism (VECM), found a long-run relationship existing between renewable energy and economic growth in Nigeria, and no causality exists between the variables. The work suggested investment in renewable energy as a solution to the energy crisis of the nation.
Evidence shows renewable energy consumption has a significant positive effect on Nigeria's economic growth. The labour force and gross fixed capital formation positively affected economic growth, underscoring the need for diversifying the energy sources and complementing energy use with productive inputs (Oluwatoyin, Huseyin, & Mehdi, 2023).
Evidence from the research by Buzugbe (2023) on energy consumption and economic growth in Nigeria using the ARDL technique revealed a long-run connection between energy consumption and economic growth in Nigeria.
Likewise, Ikpe & Oyedeji (2023) investigated energy consumption and economic growth, and their result revealed that electric power consumption, population, and lending interest rates significantly impacted Nigeria's GDP for the period 1971–2021.
Similarly, Okeoma, Nwachukwu, Ezeonye & Osatemple (2023), in their study on energy consumption and economic growth in Nigeria, revealed that capital formation, electricity consumption, and crude oil consumption have a significant positive effect on economic growth in Nigeria and a long-term relationship between energy consumption and economic growth.
From the literature, it is seen that energy consumption in Nigeria can drive economic development by creating jobs, improving energy access in rural areas, and reducing energy costs. However, challenges like high upfront costs, limited financing, policy inconsistencies, and weak infrastructure hinder progress. To succeed, Nigeria needs significant private sector investment, clear and enforced policies, and improved grid infrastructure to support its goals of achieving energy access and net-zero emissions. Most studies rely on data that ended by 2020; rapid policy shifts and energy transitions after these periods necessitate updated analyses to capture current dynamics and policy effects. Though some research on nonlinearities and asymmetries was identified, their economic policy implications and interpretations warrant further research for informed targeted interventions.

3. Methodology

The dataset for this study was obtained from the World Bank Development Indicator (WDI) Database (2024) within the period 1986 to 2024 to capture the post-2020 energy policy shifts in Nigeria, such as fuel subsidy removal in 2023. The variables of interest in the study are: Gross Domestic Product Per Capita (GDPPC) served as a proxy for economic development, being the dependent variable, while energy consumption, being the independent variable, will be disaggregated into premium motor spirit consumption (PMSC), electricity consumption (ELEC), coal consumption (COLC), and labour consumption (LABC).
The study employed the Error Correction Mechanism (ECM). Error Correction Mechanism (ECM) is a regression approach that involves the lag of both the endogenous variable and exogenous variables. In structuring the ECM model, the following model was adapted. The model utilized variables such as PMS consumption (PMSC), electricity consumption (ELEC), coal consumption (COLC), and labour consumption (LABC) as its independent variables, while gross domestic product per capita (GDPPC) was the dependent variable.
The functional model takes the form presented in Equation 1.

$$\mathrm{GDPPC} = \mathrm{f(PMSC, ELEC, COLC, LABC)}$$

The econometric form of equation 1 is expressed in equation 2.

$$\mathrm{GDPPC} = \beta_0 + \beta_1\mathrm{PMSC} + \beta_2\mathrm{ELEC} + \beta_3\mathrm{COLC} + \beta_4\mathrm{LABC} + \mu$$

To minimize the possibilities of outliers, the logarithmic transformation of the model was done as depicted in equation 3.

$$\mathrm{LOG(GDPPC)} = \beta_0 + \beta_1\mathrm{LOG(PMSC)} + \beta_2\mathrm{LOG(ELEC)} + \beta_3\mathrm{LOG(COLC)} + \beta_4\mathrm{LOG(LABC)} + \mu$$

Where,
β_0 = constant
$\beta_1 - \beta_4$ = coefficients
μ = error term
LOG = Logarithmic transformation

4. Results and Discussion

4.1. Descriptive statistics

The study's analysis started with descriptive statistics of the study variables. Descriptive statistics were deployed to ascertain the distributional properties of the raw dataset. The Jarque-Bera test, which combines measures of skewness and Kurtosis to analyze normality, was central to the descriptive analysis. The Jarque-Bera statistic gives information on the deviation of the series' skewness and Kurtosis from the normal distribution. If the probability value (i.e., p-value) of the Jarque-Bera test is less than 5% (0.05), the null hypothesis of normal distribution is rejected; otherwise, it is accepted (Thadewald & Büning, 2024). Table 1 presents the descriptive statistics.

Table 1: Descriptive Statistics

	GDPPC	PMSC	ELEC	COLC	LABC
Mean	1458.946	151488.0	127.0146	69.92365	83.01523
Median	1599.539	110367.3	121.8059	70.23129	82.58700
Maximum	3088.721	420000.0	219.2345	86.36610	88.73400
Minimum	465.4881	67800.00	79.18917	51.02076	80.98500
Std. Dev.	793.4656	95281.16	30.49258	10.75374	2.163875
Skewness	0.200834	1.449123	1.029147	-0.044674	1.756022
Kurtosis	1.766013	3.905356	4.246433	1.654500	5.359582
Jarque-Bera	2.736598	14.98168	9.409021	2.954824	29.09088

Probability	0.254540	0.000558	0.009054	0.228228	0.000000
Sum	56898.88	5908034.	4953.570	2727.022	3237.594
Sum Sq. Dev.	23924329	3.45E+11	35332.29	4394.431	177.9296
Observations	39	39	39	39	39

Source: Researcher's computation using EViews 10.0.

In the current case, all the p-values for GDPPC and coal consumption associated with the Jarque-Bera statistic exceed the 0.05 limit, indicating the distributions for GDP per capita and coal consumption are normally distributed. Furthermore, the descriptive statistics showed that PMSC, ELEC, and LABC have p-values that are less than the prescribed 0.05 limit, implying that the time series data associated with PMS consumption, electricity consumption, and labour consumption are not normally distributed as they are found to be significantly deviated from the mean values. The non-normal distribution of most of the variables implies that a logarithmic transformation of the data should be done to linearise the relationship among the variables under consideration.

4.2. Unit root tests

The unit root tests outcome based on the Augmented Dickey Fuller (ADF) test is presented in Table 2.

Table 2: Unit Root Test Results

	Critical values	@ level	Critical values	@ first difference	Decision
LOG(GDPPC)	-3.533083	-1.271492	-3.536601	-4.701742	I(1)
LOG(PMSC)	-3.533083	-3.271609	-3.536601	-7.104183	I(1)
LOG(ELEC)	-3.533083	-3.113088	-3.536601	-6.688103	I(1)
LOG(COLC)	-3.533083	-2.241599	-3.536601	-6.268397	I(1)
LOG(LABC)	-3.533083	-2.327236	-3.536601	-6.639032	I(1)

Source: Researcher's computation using EViews 10.0.

All other variables under consideration are integrated at I(1) as displayed in the unit root results in Table 2. Following the suggestions of Johansen and Juselius (1990) about the estimation of I(1) variables, the Johansen cointegration test is estimated and reported in Table 3.

4.3. Lag length selection criteria

Before the VECM procedure, the optimum lag length selection criteria were used to ascertain the number of lag(s) to be included in the model before the Johansson cointegration test. The optimum lag selection must be determined to avoid the problem of misspecification and autocorrelation. The result is presented in Table 3, which shows that all the selection criteria indicate that a maximum lag is to be included in the model.

Table 3: Optimal Lag Length Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	116.8784	NA	1.38e-09	-6.215468	-5.995534	-6.138705
1	210.0075	155.2151*	3.17e-11*	-10.00041*	-8.680816*	-9.539839*
2	223.8598	19.23941	6.42e-11	-9.381102	-6.961837	-8.536714
3	240.4051	18.38364	1.29e-10	-8.911396	-5.392465	-7.683194

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Source: Researcher's computation using EViews 10.0.

4.4. Johansen cointegration test

Co-integration analysis is needed to clarify the long-run relationships among integrated variables. Johansen's (1995) procedure is the maximum likelihood for the finite-order vector autoregressions (VARS), and it is calculated for such systems to be used in this study. The results are presented in Table 4:

Table 4: Johansen Co-Integration Test Result

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.561199	76.01481	79.34145	0.0868
At most 1	0.429301	46.36125	55.24578	0.2386
At most 2	0.366509	26.16907	35.01090	0.3182
At most 3	0.214563	9.734751	18.39771	0.5063
At most 4	0.028481	1.040201	3.841466	0.3078
Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.561199	29.65355	37.16359	0.2814
At most 1	0.429301	20.19218	30.81507	0.5352
At most 2	0.366509	16.43432	24.25202	0.3790
At most 3	0.214563	8.694550	17.14769	0.5276
At most 4	0.028481	1.040201	3.841466	0.3078

Source: Researcher's computation using EViews 10.0.

Table 4 shows that in both trace and max-eigen tests, test results did not accept the null hypothesis, under the 5% level, and no cointegrating equation exists. This means there are no stable and long-term equilibrium relationships among the variables. On the premise of no cointegration relationships, the short-run estimation was conducted.

4.5. Short-run coefficients

In the absence of a cointegrating relationship among the variables, the short-run estimation was conducted with results displayed in Table 5.

Table 5: Short-Run Estimation Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLOG(PMSC(-1))	-0.089039	0.204383	-0.435647	0.6658
DLOG(ELEC(-1))	0.505624	0.518815	0.974575	0.3367
DLOG(COLC(-1))	-1.593740	0.659193	-2.417714	0.0211
DLOG(LABC(-1))	-9.698354	4.131377	-2.347487	0.0249
C	55.32908	21.10233	2.621942	0.0130
R-squared	0.635308			
Adjusted R-squared	0.592403			
F-statistic	14.80733			
Prob(F-statistic)	0.000000			
Durbin-Watson stat	1.851805			
Diagnostic tests and probability value:				
Serial correlation	0.5228 > 0.05			
Heteroskedasticity	0.1215 > 0.05			
Jarque-Bera	0.6144 > 0.05			

Source: Researcher's computation using EViews 10.0.

From the short-run estimation, it can be seen that PMS consumption has a negative and statistically insignificant (prob. > 0.05) effect on GDP per capita. The short-run coefficient of PMSC implies that a percentage change in PMS consumption led to approximately a 0.09% marginal decrease in GDP per capita. Therefore, notwithstanding the government's claim of an increase in premium motor spirit consumption (PMSC), there was still a decline in economic development in Nigeria within the study period. Also, this could be attributed to the several policies, such as the era of petrol subsidy and periods of subsidy removal, witnessed over the years.

Electricity consumption (ELEC) turned out to have a positive and statistically insignificant (prob. > 0.05) effect on GDP per capita. The short-run coefficient of ELEC indicates that a 1% increase in electricity consumption led to approximately a 0.51% marginal increase in GDP per capita. This implies that a rise in electricity consumption resulted in a little increase in GDP per capita. This could be attributed to the epileptic power supply experienced in Nigeria over the years. The insignificant effect of electricity consumption hinders industrial production, disables technological advancements, and hampers productivity across various sectors. Furthermore, lack of access to electricity impedes social development, healthcare, education, and overall quality of life, which is requisite to economic development.

Coal consumption (COLC) was found to have a negative and statistically significant (prob. < 0.05) effect on GDP per capita. The negative coefficient of COLC indicates that a 1% increase in coal consumption resulted in approximately a 1.59% decrease in GDP per capita in the short run. This is despite huge deposits of coal in Nigeria, implying inefficient use of natural resources. If coal consumption rises but GDP growth falls, it suggests coal is not contributing productively to output in the short run. This may point to low energy efficiency, where industries using coal are not generating sufficient value-added or may face outdated technologies that waste energy. Another economic implication is that the costs of environmental degradation and healthcare may outweigh the benefits of coal-driven production, thus leading to depressed economic growth. A negative link also suggests that reallocating resources toward coal may crowd out more productive energy sources, leading to inefficiencies in the short run.

Again, this finding could be due to the health hazards associated with the use of coal; burning coal emits harmful pollutants, which can lead to health problems like respiratory illnesses, cardiovascular problems, and even cancer. As such, the inefficient use of coal generates a lower level of economic development in Nigeria.

Energy-related Labour consumption (LABC) exerted a negative and statistically significant (prob. < 0.05) effect on GDP per capita. The short-run coefficient shows that a percentage change in labour consumption led to approximately a 9.70% decrease in GDP per capita in Nigeria. This negative coefficient implies that more labour employed in energy-related activities is not translating into higher output per person. This implies that labour is being absorbed into low-productivity or inefficient segments of the energy sector, such as outdated coal mining, manual operations, or poorly mechanized production. This short-run finding may indicate that the sector has too many workers relative to capital and technology.

This could be due to the heightened labour unemployment in Nigeria. Also, the "negative effect of labour consumption" can refer to diverse situations, but generally implies a detrimental impact from labour usage, either on the worker or on the overall economy. This can manifest as reduced productivity, increased costs, or social problems like unemployment and inequality.

The Adjusted R-squared of 0.592403 shows that the explanatory variables collectively accounted for approximately 59% changes of the total variation in GDP per capita. The prob. F-statistic (prob. < 0.05), which indicates the overall significance level of the estimate, showed that the overall estimate is significant as the p-value is less than 5 per cent (0.05). The Durbin Watson statistic of 1.851805 is approximately 2, thus indicating the absence of first-order autocorrelation.

The diagnostic test results are shown in Table 5, and all tests reveal that the model is stable, has no problem with serial correlation, and has a constant variance and normal distribution. The CUSUM and CUSUM OF SQUARE tests are employed to check how stable each residual is in the model. The result is shown. The CUSUM and CUSUM of squares tests indicated that the model's residual errors are within the acceptable range, suggesting the model's reliability. This implies that the short-term coefficient is stable and consistent with the long-run relationship. Additionally, the CUSUM and CUSUM-of-squares statistics for the model remained within the 5% significance level, allowing the acceptance of the null hypothesis that all coefficients in the error correction model are stable.

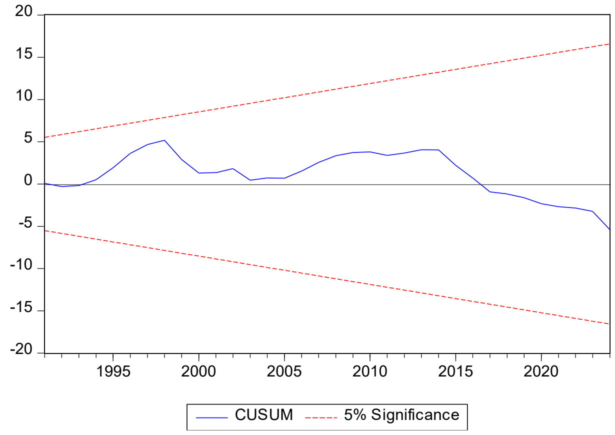

Fig. 1: CUSUM Test.

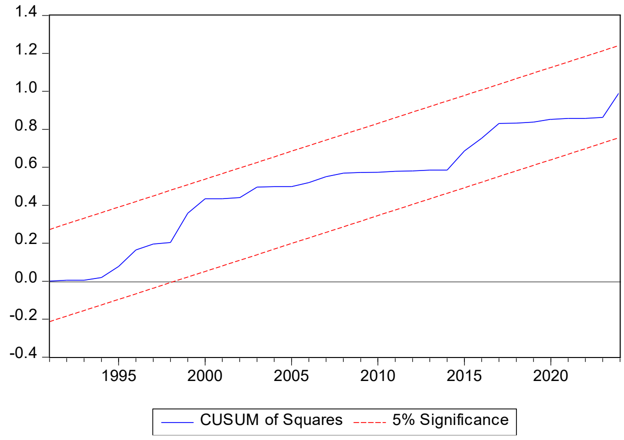

Fig. 2: CUSUMSQ Test.

5. Conclusion and Recommendations

Based on the result of this study, there is no long-run relationship among the variables used for the study. The result obtained from the Error Correction Model (ECM) shows that in a shorter span of time, PMS consumption and electricity consumption growth slightly influenced GDP per capita, while coal consumption and labour consumption were found to have a strong short-run effect on GDP per capita. The result analysis revealed that the adoption of various energy sources has a significant impact on the economic development in the country within a short period. The result may also suggest inefficiency in the use of natural sources of energy in Nigeria due to overreliance on the natural grid, which has not been well-functioning. This is understandable as Nigeria is operating far below full employment equilibrium, and the increase in GDP per capita does not translate to development strides that have continued to worsen over the years. A lot still needs to be done in the areas of creating alternative sources of energy, improving operations of existing energy distribution companies, enhancing the depth and breadth of the market, and building regulatory capacity to appropriately position the energy market to face the challenges ahead. The study recommended that the government should improve energy generation, energy transmission, and energy distribution to boost its consumption among economic agents such as households, firms, markets, and the government itself. This research also recommends further studies that would investigate the effect of renewable energy adoption on the digital transformation of the energy sector in Nigeria.

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