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IMPACT OF ENERGY CONSUMPTION ON ECONOMIC GROWTH IN NIGERIA

By

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Abstract

This study investigates the relationship between energy consumption and Nigeria's economic growth from 1990 to 2022, considering the government policies aimed at fostering sustainable growth. Specifically, the study analysed the effects of natural gas, petroleum oil, and electricity consumption on the economic growth trajectory in Nigeria. This study is fundamentally grounded in the principles of endogenous growth theory. The analysis of time-series data was conducted employing the Johansen co-integration test alongside a multiple regression approach. The Johansen co-integration test conducted indicated the presence of a long-term relationship among the variables. The findings from the multiple regression analysis indicate that there exists a significant and positive correlation between electricity consumption, population growth, and climate change with economic growth in Nigeria. Nevertheless, the consumption of natural gas and labour exhibit a negative and statistically insignificant effect on economic growth in Nigeria. In light of the findings, the study advocates for the formulation of policies—such as transparent pricing mechanisms, enhanced regulatory oversight, and diversification of energy sources, to reduce the costs associated with petroleum and natural gas. This approach would enable both businesses and households to utilise these alternative energy sources more effectively, thereby fostering economic growth.

Keywords: Energy consumption, natural gas consumption, petroleum, real gross domestic production,

JEL Codes: Q4, O4

1. Introduction

Every country aspires to achieve long-term economic growth, and development is fuelled by energy consumption, particularly in less developed nations like Nigeria. Africa was referred to as "the hopeless continent" by the United Nations Economist Network (UNEN) in 2000 (Zhang, 2014) because of structural problems that hinder development, such as poverty and corruption. However, due to major developments, African economies are now outperforming those of other continents. According to the African Development Bank, Africa's economy is the second-fastest growing economy in the world as of 2017. Growth is predicted to average 3.4% in 2017, and 4.3% in 2018 (Sufi 2023). According to Oke and Sulaiman (2012), Nigeria, although hailed as a beacon of hope, continues to face obstacles that impede its potential as a hub for energy and an attractive destination for investment.

According to the 2021 World Development Indicator, Nigeria ranks 163 out of 213 countries, with a GDP per capita of $2,120, indicating the economic size (The World Bank, 2022). Notably, after gaining independence, Nigeria's GDP per capita increased by 283% from 1970 to 1979 and by 132% from 1960 to 1969. 1986 saw an economic restructuring as a result of ongoing difficulties. Liberalisation and structural changes made between 1988 and 1997 resulted in a 4% GDP growth. Nigeria's economy grew between 2006 and 2010, with steady GDP growth, despite the global economic crisis of 2007. The country's demand for crude oil declined slightly in 2008. Difficulties continued in the years that followed, affecting economic activity, particularly in 2012, when the non-oil and oil sectors saw decreases. In addition, security concerns and floods affected oil production. In real terms, the economy expanded by 3.98% in the fourth quarter of 2021, the GDP growth rate for the year 2022 was 3.10%, which was a decrease from the 3.40% recorded in 2021. As a result, while the services sector performed better in 2022 than it did in 2021, agriculture and industry performed worse in 2022. (Central Bank of Nigeria - CBN, 2023; National Bureau of Statistics - NBS, 2023).

Economic growth is heavily dependent on energy, and exploiting Nigeria's large gas reserves, estimated at 206.53 trillion cubic feet has the potential to support sustainable green growth (African Economic Outlook, 2023). Economic development can also be promoted by energy infrastructure investments, which can create jobs both temporarily during construction and permanently during operation and maintenance (Madu,2017).

Nigeria had 37.1 billion barrels of proven crude oil reserves at the start of 2023, with the majority of the oil being light, sweet, and exported. In 2023, the government planned a mini-bid round for seven offshore exploration blocks, the first under the 2021 Petroleum Industry Act (PIA), to attract international investors on favourable terms. Nigeria's crude oil production has fallen by 37% between 2012 and 2021, owing to issues such as ageing infrastructure, oil theft, and decreased investor interest. Despite having sufficient refinery capacity, Nigeria is dependent on imported petroleum products because its four state-owned refineries have been inactive since 2020. The Dangote Group's 650,000 barrels per day refinery, expected to reduce imports and potentially make Nigeria a petroleum product exporter, faced delays and is now set for completion in late 2023.

Nigeria primarily relies on fossil fuel-derived fuel sources for power generation, but it also uses hydropower to meet its electricity requirements. Nigeria's total electricity capacity in 2021 was 11.7 gigawatts (GW), up only slightly from 9.1 GW in 2012. In 2021, Nigeria generated approximately 31.5 gigawatt-hours (GWh), with fossil fuels accounting for 74% of the total and hydropower accounting for the remainder. In 2020, 55% of Nigerian households had access to electricity, up from 48% in 2010, with a significant difference in electrification rates between cities (84%) and rural areas (25%). Nigeria's power sector faces challenges such as inadequate infrastructure, high transmission losses, and frequent blackouts, forcing many people to rely on expensive generators or traditional biomass for energy. In response, the government launched its Energy Transition Plan in 2022, aiming to achieve carbon neutrality by 2060 for $1.9 trillion. Nigeria also has untapped hydropower potential, with plans to build projects such as the 700-megawatt Zungeru hydroelectric plant, which is expected to be completed in 2023. Furthermore, solar power initiatives, such as the Africa Minigrids Program, seek to improve rural electricity access by offering cleaner alternatives to diesel generators

Nigeria had an estimated 206.5 trillion cubic feet (Tcf) of proven natural gas reserves at the start of 2023. From 2012 to 2021, Nigeria's dry natural gas consumption averaged 649 billion cubic feet (EIA, 2023).

According to Odusina (2013), population is a major asset of developing countries in terms of economic growth and development, as well as the primary beneficiary of development. It frequently accounts for the majority of both the producers and consumers of goods and services. However, the impact of population on development is determined not only by absolute size, but also by quality and implications. Nigeria has a large population, estimated at 218.5 million people (United Nations, 2023). Her population accounts for approximately 2.85% of the global population, with a population growth rate of about 2.4% per year and a GDP growth rate of 2.2% (World Bank, 2023). This implies that Nigeria's current population growth rate exceeds its GDP growth rate. With rising population, it is becoming increasingly important to increase energy consumption and infrastructure; however, total energy consumption (percentage of GDP) in 2022 is 4.34%, which is lower than in previous years, which ranged from 7.06% in 2018 to 5.87% in 2020 and 5.19% in 2021 (World Bank, 2023).

Nigeria's climate is divided into three zones: tropical monsoon in the south, tropical savannah in the central regions, and Sahelian hot and semi-arid in the north. Rainfall decreases from south to north, with the southern regions receiving over 2,000 mm annually (up to 4,000 mm in the Niger Delta). In comparison, the northern areas get between 500 mm and 750 mm, mostly from June to September. Central regions experience distinct rainy (April to September) and dry (December to March) seasons, influenced by the Harmattan wind. Temperatures vary, with cooler plateau regions (21°C-27°C) and hotter interior lowlands (over 27°C). Coastal areas are cooler than inland lowlands. The country's mean annual temperature is 26.9°C, with the hottest months in April (up to 30°C) and cooler months in December and January (around 24°C). Rainfall primarily occurs from April to October, with minimal rain between November and March. Humidity decreases from south to north, with Lagos having an annual mean humidity of 88% (World Bank, 2021). Nigeria's gross capital formation was at a level of 156,578 million US dollars in 2022, up from 145,801 million US dollars the previous year, this is a change of 7.39%. As of 2022, approximately 60 million people in Nigeria were employed, according to the estimates. This presented an increase from around 58 million in the preceding year. Since 2010, the working population in Nigeria has remained above 50 million.

The Nigerian government has enacted several reforms to promote economic growth at different points in time. Reforms like the National Economic Empowerment and Development Strategy (NEEDS) in 2004, the Banking Sector Reform and the Growth of the Real Economic Sector in 2004, Yar'Adua's Seven Point + Two Special Interest Issues Agenda for Nigeria, the Jonathan Transformation Agenda, and Buhari's Change Agenda. Despite these changes and the initiatives taken to increase energy consumption, the GDP share of the energy sector fell from 7.06% in 2018 to 5.87% in 2020, 5.19% in 2021, and 4.34% in 2022. As a result of deficiencies in the energy sector, most Nigerians do not have access to power, and those who do often receive poor-quality services. This study aims to examine how energy consumption impacts Nigeria's economic growth. Its specific objectives are to investigate the effects of natural gas, electricity, and petroleum oil consumption on the country's economy.

The rest of this research paper is structured as follows: Section Two reviewed relevant literature on energy consumption on economic growth. The paper moves further to present the analytical techniques in Section Three. Results are presented and discussed in the fourth section. The fifth section summarizes, recommends, and draws an adequate conclusion from the study.

2. Literature Review

2.1 Conceptual Framework

Economists use real GDP growth or GDP per capita as their definitions and measures of economic growth. Cornwall (2023) defines economic growth as the process by which a nation's wealth increases over time. According to Anyanwu and Ojima (2021), economic growth is the consistent increase in the output of goods and services produced while utilising all of the economic production factors. Kuznet defined economic growth as the gradual increase in the ability to provide a population with diverse economic goods. This capacity results from technological advancements and the necessary institutional and ideological adjustments. This definition is divided into three sections. First, a nation's economic growth is indicated by the steady increase in the supply of commodities. Second, the permissive component of economic growth—that is, technological advancement—determines the expansion of the capacity to supply a broad range of commodities to the populace. Third, institutional and ideological changes must be made to encourage the appropriate use of innovations brought forth by deepening human understanding to guarantee the successful and widespread application of technology and its advancement (Jhingan, 2014). The definition of economic growth proposed by Professor Simon Kuznets will be used in this study due to its broad scope and long-term outlook.

According to Abner *et al.* (2021), energy consumption, expressed in kilowatt-hours (kwh), is the total energy needed for a specific process. This covers the usage of biomass, gas, oil, and diesel in addition to electricity. Martin (2015) discussed energy consumption in both primary and secondary stages. Initially, he defined energy consumption as the sum of all raw energy sources before physical alteration or potential conversion into electrical power at a traditional thermal power plant. Secondary energy consumption refers to the main energy sources after the physicochemical conversion of crude oil into petroleum products, biomass into fuels or synthetic gas, and mineral coal or fuel oil into secondary power. This study adopts the definition of energy consumption by Abner et al. (2021) because it offers an accurate representation and a consistent method of measuring energy usage. This definition makes it possible to measure and compare energy consumption across various processes, sectors, and geographical areas with accuracy.

2.2. Review of Empirical Literature

There is no clear consensus or conclusive evidence regarding the impact of energy consumption on economic growth, as the empirical literature demonstrates through contradictory and inconsistent findings. Somoye, Ozdeser, and Seraj (2022) examined Nigeria's economic growth from 1990Q1 to 2019Q4 with the utilization of renewable energy. The variables including real GDP and renewable energy consumption (RNEW) were subjected to non-linear ARDL. According to the findings, RGDP is increased by a negative shock to RNEW and decreased by a positive shock. To achieve the maximum benefits of renewable energy, the study suggests implementing cleaner technology. While the study suggests implementing cleaner technology to maximize the benefits of renewable energy, it falls short in providing detailed policy recommendations or practical steps for achieving this. Given the complex challenges in Nigeria's energy sector, more specific guidance on how to integrate cleaner technology would have strengthened the study's relevance.

Abner, Inim, Callistus, and Udo (2021) examined how Nigeria's economic development was affected by energy consumption from 2000Q1 to 2018Q4 using a multivariate framework. The results of the ARDL method demonstrated that energy consumption promotes economic growth. The variables that are taken into consideration are the following: the consumption of electric power, petroleum oil, liquefied natural gas, and real gross domestic product. Revisions to the pricing structure, energy-efficient policy, and billing system are suggested by the study. The use of the ARDL method is appropriate for examining long-run and short-run relationships, but the study could have benefited from using additional methodologies or robustness checks to confirm the findings.

For instance, alternative approaches like Vector Error Correction Models (VECM) or Cointegration tests might provide additional insights into the dynamic interactions between variables

Chinedu, Daniel, and Ezekwe (2019) studied the relationship between energy use and economic growth from 1980 to 2017. The Ex post-facto research method was used for the research design. The data analysis methods that were employed were the error-correction mechanism, the Co-integration test, and Engle-Granger. The variables that are used are real gross domestic product (RGDP), electricity, petroleum oil, and liquid natural gas. The results of the study indicate that there is no long-term relationship between RGDP and PETRO, GAS, or ELECT. As a result, there is no sustained relationship between economic expansion and energy consumption. Regulations that boost oil extraction companies to use cutting-edge technology to stop oil spills in oil drilling environments should be developed by the Nigerian government. The finding that there is no long-term relationship between real GDP (RGDP) and the consumption of petroleum oil (PETRO), liquid natural gas (GAS), or electricity (ELECT) is significant, but the study does not provide an in-depth explanation for this outcome. Exploring the potential reasons behind the absence of a sustained relationship, such as inefficiencies in energy use, structural economic issues, or external shocks, would provide a more comprehensive understanding of the results.

Vipin and Shuping (2016) Using a multivariate time-varying model, examined the connection between real GDP and energy consumption in the United States from 1973Q1 to 2014Q1. Granger causality between real US GDP and total energy was found to be bidirectional in the 1990s, but in the 2000s, the relationship changed to be unidirectional, with real US GDP driving energy consumption. The real US GDP and the quantity of coal consumed were correlated, and the patterns of variation for each fuel were similar. The US GDP and oil consumption typically show a bidirectional relationship, especially after 2009. Except for a brief period in the early to mid-2000s, when US GDP predicted energy consumption, natural gas consumption primarily shows the independence between natural gas consumption and economic growth. They agreed with Bowden and Payne (2009), who hypothesize that the impacts of various primary energy sources on energy policies will vary. The Granger causal relationships have changed, as the study indicates, but the policy implications of these findings are not adequately explored. Examining how these alterations might affect energy and economic policy would improve the study's practical implications.

Osman, Gachino, and Hoque (2016) Using a panel VAR Granger causality test, investigated the relationship between electrical energy and economic growth in the Gulf Corporation Council countries from 1975 to 2012 and discovered a bidirectional relationship. One policy implication of this research and development is that renewable energy must be prioritised (Satrovic, 2018b). Moreover, capital must be drawn into this industry. Regulations and subsidies that support renewable energy sources must be adopted. In terms of initiatives related to renewable energy, small-scale installations of PV solar panels and solar-powered water heaters may be introduced in urban areas. Lastly, citizens should be educated to boost their awareness of renewable energy. Their findings may not apply to Nigeria because the country is not a member of the Gulf Cooperation Council.

Aminu and Aminu (2015) Using data from Nigeria from 1980 to 2011, re-examined whether energy consumption drives economic growth. In addition to the RGDP and total energy consumption, the study also included labour and capital. The results of the Granger causality test show that labour and capital have a bigger influence on output growth than energy consumption. It is recommended that the nation raise labour productivity and savings to produce more capital in light of the findings. The research spans a sizable amount of time, from 1980 to 2011. Nonetheless, there have been substantial changes to policies and economic conditions. Ohwofasa, Obeh, and Erakpoweri (2015) applied the error correction method to look at how energy provision affected economic growth between 1980 and 2010. Exports, government spending, GDP, and power usage were the variables used. The results showed that there was no long-term correlation between the dependent and explanatory variables. In contrast, the short-term link shows a significant beneficial influence on government spending, investment in per capita income, and consumption. Among other recommendations made by the research was to investigate the widespread corruption in the power industry. The study focused on electricity supply on economic growth while this study is on energy consumption.

Akinwale, Jesuleye, and Siyanbola (2013) deployed the vector autoregression (VAR) model and ECM to examine the association between Nigeria's real GDP growth and electricity consumption. They found no feedback effect and just a unidirectional causal relationship between real GDP and power usage. The report offers suggestions that can help the government create and carry out policies. It is recommended that the government implement policies that foster the private sector's use of renewable energy sources by providing fiscal incentives such as tax rebates, subsidies, and reduced import taxes for equipment imported from other countries. The study covers a relatively long period from 1970 to 2005. However, economic conditions and policies have changed significantly.

This study differs from earlier contributions in several ways. The sample used for the data set is more current and wider. Furthermore, no prior study has looked at how Nigeria's use of natural gas, electricity, and petroleum has impacted the country's economic growth between 1990 to 2022. Finally, this study included climate change in the model because climate change is a major force behind change in the energy sector.

3. Methodology

3.1 Theoretical Framework and Model Specification

The research adopts the endogenous growth model based on the premise that internal forces are what drive economic growth. It therefore forms the theoretical underpinning of this study as it assumes that higher energy consumption can stimulate technological advancements and innovation, leading to sustained economic growth. The endogenous theory's aggregate production function can be obtained as follows from the aforementioned:

$$Y = f(A, K, L) \qquad (3.1)$$

Where; Y = Aggregate real output; K = Stock of capital; L = Stock of labour and A = Technology. Based on the endogenous growth theory adopted as the theoretical framework, the multiple regression technique was employed because it permits to control explicitly for many other factors that simultaneously influence the dependent variable. This research adapts and modifies the model of Aqeel and Butt (2001), which investigates how Pakistan's energy use affects the country's economic expansion. As such, the model for this study incorporates real gross domestic product (RGDP) as the dependent variable. Capital (CAP) measured by gross capital formation, labour (LAB) measured by total employment, petroleum consumption (PETO), gas consumption (NAGS), electricity consumption (ELEC), population growth (POPG), and climate change (CLCH) are the independent variables. The model can be specified functionally as;

$$RGDP = f(CAP, LAB, PETO, NAGS, ELEC, POPG, CLCH) \quad (3.2)$$

Econometrically, Equation 3.2 can be written as;

$$RGDP_t = \alpha_0 + \beta_1 CAP_t + \beta_2 LAB_t + \beta_3 PETO_t + \beta_4 NAGS_t + \beta_5 ELEC_t + \beta_6 POPG_t + \beta_7 CLCH_t + \mu_t \quad (3.3)$$

Where, RGDP = real gross domestic product; CAP = capital measured by gross capital formation; LAB = labour measured by total employment; PETO= petroleum consumption; NAGS = natural gas consumption, ELEC = electricity consumption; POPG = population growth; CLCH = climate change; α_0 = constant term; β_1 - β_7 = slopes of the coefficient.

To interpret the coefficient values as elasticities, the model is transformed into log form and respecified as follows:

$$\ln RGDP_t = \alpha_0 + \beta_1 \ln CAP_t + \beta_2 \ln LAB_t + \beta_3 \ln PETO_t + \beta_4 \ln NAGS_t + \beta_5 \ln ELEC_t + \beta_6 \ln POPG_t + \beta_7 \ln CLCH_t + \mu_t \quad (3.4)$$

This research spans a period of 32 years (1990 to 2022) due to the data availability during this time frame as well as the fact that it is sufficiently extended to address any reforms implemented to boost Nigeria's economic growth. Secondary data were collected from a variety of sources, including the Energy Information Administration (2023), the World Bank Indicator database (2023), the Central Bank of Nigeria (2023), and the National Bureau of Statistics (2023).

3.2 Estimation Technique and Procedures

Time series data, which is subject to stationarity, were used for this study. A descriptive statistic of the variables served as the basis for the analysis. The Augmented Dickey-Fuller (ADF) Test was then used to determine the variables' unit root properties. To determine whether the variables under investigation had a long-term relationship, the Johansen cointegration test was utilised.

4. Empirical Result and Discussion

4.1 Descriptive Statistics

As shown in Table 4.1, the highest mean value is 4.6039 for real gross domestic product (RGDP), which is followed by petroleum consumption (PETO) at 2.4936. The lowest mean value is 1.2628 for electricity consumption (ELEC). The standard deviations of these variables are 0.208 for RGDP, 0.116 for PETO, 0.223 for natural gas consumption (NAGS), 0.159 for ELEC, 0.016 for climate change (CLCH), 0.645 for capital formation (CAP), 0.104 for labour force (LAB), and

0.110 for population growth (POPG). This suggests that all of the variables' estimated values are as near to their true values as possible, indicating that the estimate-related error is statistically insignificant. In other words, the estimated results are reliable. According to the skewness values, RGDP, CAP, LAB, and NAGS are negatively skewed, while PETO, ELEC, CLCH, and POPG are positively skewed. The probability values for RGDP, PETO, NAGS, ELEC, 0.013, CAP, 1.503, LAB, and 0.359 are displayed by the Jarque-Bera statistic, which assesses whether or not the series is normally distributed. Since their probability values are greater than the 5 per cent significant level, this suggests that RGDP, PETO, NAGS, ELEC, CAP, LAB, and POPG are normally distributed, whereas CLCH is not. The decision rule states that if the probability value for Jarque-Bera is more than 5%, the null hypothesis (i.e., the residuals are normally distributed) will be accepted; if not, it will be rejected.

Table 4.1: Summary of Descriptive Statistics

	RGDP	ELEC	CAP	NAGS	PETO	POPG	LAB	CLCH
Mean	4.603952	1.262839	3.693946	4.010873	2.493584	2.157207	7.682555	1.429022
Median	4.614124	1.267172	3.844950	4.042457	2.447506	2.153937	7.688835	1.423737
Maximum	4.872969	1.491362	4.814428	4.336380	2.693378	2.339531	7.864940	1.476542
Minimum	4.336063	1.033424	2.419576	3.602060	2.337362	1.978683	7.504288	1.404149
Std. Dev.	0.208482	0.158815	0.645476	0.223096	0.116255	0.110205	0.103831	0.015739
Skewness	-0.048510	0.028422	-0.278158	-0.145616	0.625894	0.051890	-0.018117	1.174758
Kurtosis	1.350401	1.485175	2.357743	1.659112	1.910323	1.782964	1.955211	3.915456
Jarque-Bera	3.754561	3.159647	0.992725	2.588844	3.787254	2.051428	1.502733	8.742636
Probability	0.153006	0.206011	0.608741	0.274056	0.150525	0.358540	0.471721	0.012635
Sum	151.9304	41.67368	121.9002	132.3588	82.28826	71.18782	253.5243	47.15771
Sum Sq. Dev.	1.390875	0.807114	13.33246	1.592692	0.432490	0.388646	0.344986	0.007927
Observations	33	33	33	33	33	33	33	33

Source: Researcher's Compilation Using Eviews 10

4.2. Correlation Matrix

This is a measure of how closely related the variables in the model. It was used to check if multicollinearity exists or not.

Table 4.2: Correlation Matrix Result

	RGDP	ELEC	CAP	NAGS	PETO	POPG	LAB	CLCH
RGDP	1.000000							
ELEC	0.776264	1.000000						

CAP	0.735929	0.730276	1.000000					
NAGS	0.771035	0.772805	0.758194	1.000000				
PETO	0.571426	0.623469	0.554356	0.574628	1.000000			
POPG	0.776425	0.767636	0.779479	0.777018	0.617386	1.000000		
LAB	0.763604	0.752346	0.789195	0.768705	0.582791	0.795165	1.000000	
CLCH	0.019977	-0.045041	0.103553	0.078125	-0.156747	0.037452	0.065391	1.000000

Source: Researcher's Compilation Using Eviews 10

The correlation matrix presented in Table 4.2 shows the coefficient values that are below the threshold of 0.80 for all the variables. This suggests that there is no multicollinearity in the model. Thus, the null hypothesis can be accepted.

4.3 Unit Root Test

The result of the Augmented Dickey-Fuller test, which was used to determine the stationarity or unit root of the variables, is shown in Table 4.3.

Table 4.3: Summary of ADF Test

Variables	ADF Statistics	Critical Value @5%	Order of Integration	Remarks
RGDP	**-3.0117**	**-2.9604**	**I(1)**	**Stationary**
PETO	**-6.8556**	**-2.9604**	**I(1)**	**Stationary**
NAGS	**-3.7846**	**-2.9810**	**I(1)**	**Stationary**
ELEC	**-7.1370**	**-2.9604**	**I(1)**	**Stationary**
CLCH	**-7.7988**	**-2.9604**	**I(1)**	**Stationary**
CAP	**-4.0966**	**-2.9604**	**I(1)**	**Stationary**
LAB	**-4.0459**	**-2.9640**	**I(1)**	**Stationary**
POPG	**-4.9473**	**-2.9604**	**I(1)**	**Stationary**

Source: Author's compilation using Eviews Output 10

Table 4.3 shows that all the variables are stationary at first difference, that is, the series are integrated of order one at a 5% level of significance.

4.4 Cointegration Test

The Johansen cointegration test was used to determine if the variables are co-integrated and the result is shown in Table 4.4.

Table 4.4: Summary of Johansen Cointegration Test

Hypothesized No of CE(s)	Eigenvalue	Trace statistic	Critical value @ 5%	Max-Eigen statistic	Critical value @ 5%
None*	0.9595	305.29	159.53	99.398	52.363
At most 1*	0.9389	205.89	125.62	86.658	46.231
At most 2*	0.7758	119.23	95.754	46.347	40.078
At most 3*	0.6659	72.887	69.819	33.985	33.877
At most 4	0.4669	38.902	47.856	19.505	27.584
At most 5	0.3251	19.398	29.797	12.191	21.132
At most 6	0.2073	7.2067	15.495	7.2005	14.265
At most 7	0.0002	0.0062	3.8415	0.0062	3.8415

Source: Author's compilation using Eviews Output 10

Trace and Maximum-Eigen statistics are used to determine the cointegrating equation(s). This long-run relationship can also be observed by comparing the likelihood ratio with the critical values at a 5 per cent level of significance. The null hypothesis of no cointegration can be rejected if the trace and Max-Eigen statistics are found to be greater than the critical value at 5% at any level of cointegration. From the co-integration estimate presented in Table 4.4, it is observed that there are four cointegrating equations. It is therefore concluded that there is a long-run relationship among the variables. Thus, the null hypothesis of no cointegration is rejected. Since a long-run relationship exists among the variables, the study conducted a multiple regression model.

4.5. Regression Estimate

Table 4.5 presents the multiple regression results on the impact of energy consumption on economic growth, with capital stock, labour force, petroleum, electricity, and natural gas consumption, as well as population growth and climate change, serving as explanatory variables.

Table 4.5: Multiple Regression Result

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	6.263926	5.325110	1.176300	0.2506
ELEC	0.629528	0.182751	3.444741	0.0020
NAGS	-0.080497	0.152861	-0.526604	0.6031
PETO	-0.401488	0.099286	-4.043745	0.0004
CAP	-0.131179	0.060522	-2.167472	0.0399
LAB	-1.049030	0.871456	-1.203767	0.2400
CLCH	0.343135	0.387722	0.885003	0.3846
POPG	3.209007	0.827605	3.877460	0.0007
R-squared	0.985101	F-statistic		236.1401
Adjusted R-squared	0.980929	Prob(F-statistic)		0.000000

Source: Author's compilation using Eviews Output 10

From the result in Table 4.5, the constant value is 6.2639 and it implies that the value of economic growth will be 6.2639 if all the variables are kept fixed or constant (zero). Electricity consumption (ELEC) has a positive value of 0.6295, which means that, on average, a 1% increase in ELEC will increase RGDP by 0.63%. The p-value of 0.0020 suggests that the ELEC is statistically significant with economic growth in Nigeria. The coefficient of petroleum consumption (PETO) with a negative value of -0.405 implies that on average, a 1% increase in PETO will reduce RGDP by 0.41%. Judging from the p-value of 0.0004, it can be concluded that PETO is statistically significant with RGDP at a 5% level. Moreover, the coefficient values for labour force (LAB), capital formation (CAP), and natural gas (NAGS) are -0.0805, -0.1312, and -1.0490, respectively. This means that a percentage increase in NAGS, CAP, and LAB will, on the average, result to decrease in real GDP by a 0.081%, 0.13%, and 1.05%, respectively. However, because the p values exceed the critical value at five per cent, NAGS and LAB are not statistically significant, whereas CAP is. Population growth (POPG) and climate change (CLCH) have coefficient values of 3.209 and 0.343, respectively, with p values of 0.0007 and 0.3846. This means that POPG and CLCH are positive, but CLCH is statistically insignificant, suggesting that on average, a 1% increase in POPG and CLCH will increase economic growth by 3.21% and 0.38% respectively.

Evaluation Based on Economic Criteria

According to economic postulations, the expected and observed relationships of the variables are reported in Table 4.6.

Table 4.6: Summary of Economic A Priori Test

Parameters	Variables		Expected Relationships	Observed Relationships	Conclusion
	Regressand	Regressor			
β_0	RGDP	Intercept	+/-	+	Conform
β_1	RGDP	ELEC	+	+	Conform
β_2	RGDP	NAGS	+	-	Non-Conform
β_3	RGDP	PETO	+	-	Non-Conform
β_4	RGDP	CAP	+	-	Non-Conform
β_5	RGDP	LAB	+	-	Non-Conform
β_6	RGDP	CLCH	-	+	Non-Conform
β_7	RGDP	POPG	+/ -	+	Conform

Source: Researcher's Computation

The economic a priori test reveals that the constant term, ELEC and POPG conform to a priori expectation. The positive relationships between ELEC, POPG and RGDP are expected. This is because a stable electricity supply will help businesses to reduce diesel or petrol costs in their production, thereby, enhancing output growth. Population growth would also contribute to economic growth as people are engaged in the production of goods and/or rendering of services.

Petroleum consumption (PETO), NAGS, LAB, CAP and CLCH however failed to conform to a priori expectation. Petroleum consumption is expected to have a positive impact in the sense that the production of oil is one of the ways of exploring natural resources and diversifying the economy. If oil is produced and there is no one to consume, then, the energy sector will be redundant and the revenue coming from the sector will cease. The same applies to NAGS. Any energy sources should help businesses and households to grow and contribute to economic growth in such a way that the costs of purchasing them do not adversely affect the income of households and the profits of the firms. Conversely, CLCH has a negative impact and this is expected. Thus, CLCH conforms to the a priori expectation. Climate change is extreme weather conditions that affect productive sectors of the economy, which in turn affect economic growth negatively. The rising temperatures are expected to have severe consequences on economic growth as it will affect water quality, agricultural productivity and human health.

Labour force (LAB) and Capital formation (CAP) are expected to have a positive impact but do not conform to a priori expectations. With the labour force, people are expected to aid more production of energy for people to consume. Similarly, capital formation can help investments in the energy sector which will drive investments and the growth of the economy.

Evaluation Based on Statistical Criteria

The statistical reliability of the calculated parameters is assessed in this section using the R^2, adjusted R^2, and F-test. Below is how these tests are carried out:

Coefficient of Determination (R^2) Test: The study's regression result indicates an R^2 of 0.9851, indicating a very high and robust explanatory power for the variables. That is to say, fluctuations in PETO, ELEC, NAGS, POPG, CAP, LAB and CLCH in Nigeria account for or explain 99% of the variations in the RGDP. About 1% of the changes are explained by other potential RGDP determinants that the model does not account for.

The adjusted R^2: This validates the R2 value of 0.9809, which suggests that the independent variables (PETO, ELEC, NAGS, POPG, LAB, CAP and CLCH) account for 98% of the variance in the dependent variable (RGDP). Consequently, this lends credence to the claim that the variables have a very high and powerful explanatory power.

The F-statistic: The model's overall significance is evaluated using the F-test. When confirming the overall importance of an estimated model, the F-statistic plays a crucial role. According to the outcome, the F-statistic is 236.140, and the probability of the F-statistic is 0.00000. The fact that the F-calculated is greater than the F-tabulated, suggests that all the variables are jointly highly statistically significant.

Evaluation Based on Econometric Criteria

The results of the study model are assessed in this subsection using the following econometric tests: autocorrelation, normality, and heteroscedasticity.

Test for Autocorrelation

The study's Durbin-Watson (DW) statistics is 1.6457 which is approximately 2. The fact that d* is close to two suggests that there is no autocorrelation. The value 1.6 tends more towards two than it does towards zero. As a result, the models' variables do not exhibit autocorrelation, and their predictive power is solid.

Test for Heteroscedasticity

This test is used to determine if each observation's error variance is constant or not. The following is the hypothesis testing:

H_0: The residuals do not exhibit heteroscedasticity.

H_1: There is a heteroscedasticity in the residuals

Table 4.7: Heteroscedasticity Test Result

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	0.986721	Prob. F(7,25)	0.4630
Obs*R-squared	7.143642	Prob. Chi-Square(7)	0.4141
Scaled explained SS	2.461386	Prob. Chi-Square(7)	0.9300

Source: Author's compilation using Eviews Output 10

To accept the null hypothesis that the residuals have no heteroscedasticity, the estimated F-test statistic (F) must exceed the significance level of 0.05. Therefore, the probability (F-stat) is 0.4630. This indicates that the probability F statistic is significant at a level higher than 0.05. The null hypothesis, which states that the model has no heteroscedasticity in the residuals, is thus accepted by the study. This makes our estimates reliable for prediction.

Test for Normality

Testing the model's normality is the purpose of this experiment. Figure 1 presents the outcome of the application of the histogram normality test in this instance.

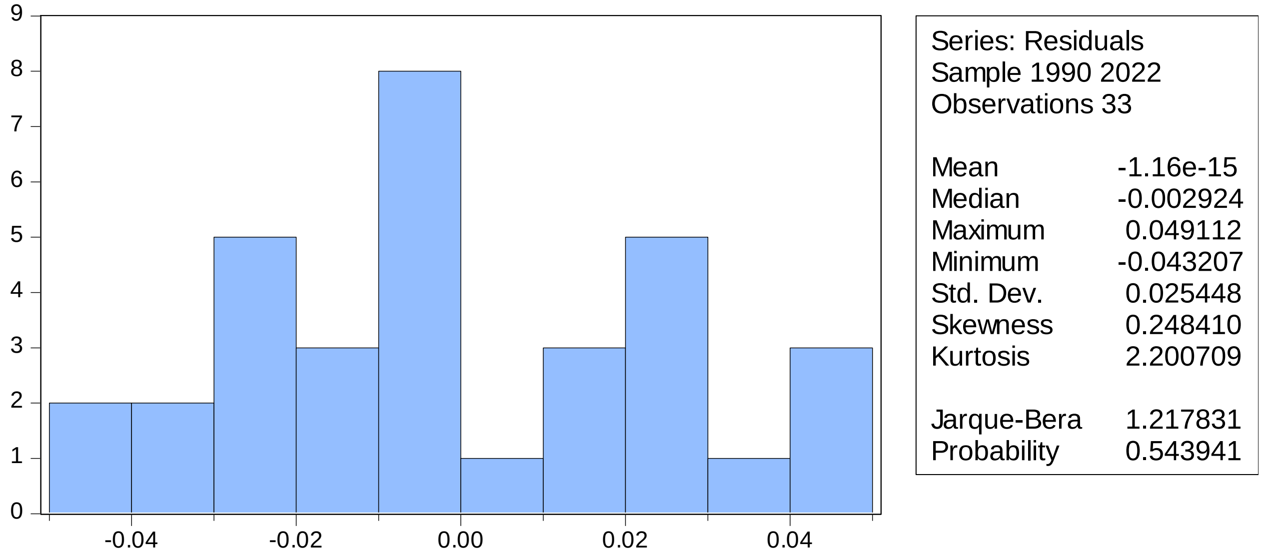

Figure 4.1: Histogram Normality Test
Source: Eviews 10 Output

The Jarque-Bera probability value is 0.54 is greater than 0.05, as shown in Figure 4.1. This implies a normal distribution for the model. Therefore, the null hypothesis which states that the residual is normally distributed is accepted.

5. Conclusion and Policy Recommendations

This study examined the impact of energy consumption on economic growth in Nigeria from 1990 to 2022. The results from the findings show that there is a positive correlation between ELEC, POPG, CLCH, and economic growth in Nigeria. According to the implication, ELEC, POPG, and CLCH have significantly increased energy consumption, which has aided in Nigeria's economic progress. The result however reveals a negative relationship between PETO, NAGS and economic growth in Nigeria. Similarly, CAP and LAB had negative impacts on economic growth, since government investments in the energy sector are low, thereby causing low labour participation in the sector. We therefore recommend that the government should create policies such as transparent pricing mechanisms, strengthen regulatory oversight, and diversification of energy sources; to reduce the prices of petroleum and natural gas.

This will help businesses and households to consume these alternative energy sources efficiently, and contribute to economic growth.

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