Energy Consumption and Economic Growth Nexus in Nigeria

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Abstract
This study is on the effect of Energy Consumption on Economic Growth in Nigeria. The study used the econometrics method of Autoregressive Distributed Lag (ARDL) error correction model to analyse time series data on Nigeria Growth Rate of Real Gross Domestic Product, electricity consumption, petroleum products' consumption and natural gas' consumption for the period 1981-2019. These data were obtained from World Bank International Data bank, World Bank Development Indicators, Central Bank of Nigeria Statistical Bulletin, National Bureau of Statistics among others. The findings of the study show that electricity consumption (ELEC) is a positive and significant determinant of growth rate of Nigeria Gross Domestic Product both in the long and short run. Petroleum product consumption has a positive and insignificant relationship with growth rate of Nigeria Gross Domestic Product. Consumption of natural gas has a positive and significant relationship with growth rate of Nigeria Gross Domestic Product at 10% level of significant. The study therefore recommends that government through the electricity generation companies (GENCOS) should generate more electricity at a reduced cost for domestic consumption that will reduce electricity tariff. This will propel growth in the industrial sector in particular and other sectors of the economy. Total overhaul of the power sector is highly recommended. The petroleum sector particularly our refineries should be made functional to meet the daily domestic demand of petroleum products which will enhance economic activities in the other sectors of the economy. Production and distribution of natural gas should be improved for a greater impact in the economic development of the country since its consumption indicated a positive relationship with growth rate of GDP.

Keywords: Energy Consumption, Real Gross Domestic Product, ARDL

1. Introduction

Energy is widely regarded as a propelling force behind any economic activity and indeed industrial production. Energy is central to the economy because it drives all economic activities. This characterisation of energy directs our attention to its sources in nature, to activities that convert and reconvert this energy, and finally to activities that use the energy to produce goods and services for household consumption. Traditionally, energy is treated as an intermediate input in the production process. This treatment of the role of energy underscores its importance and contribution to development. All economic activities and processes require some form of energy. This effectively makes energy a critical primary factor of production. Given the state of technological advancement in the economy, capital and labour perform supporting roles in converting, directing, and amplifying energy to produce goods and services needed for growth (and poverty reduction).

The energy sector plays a pivotal role in attempts to achieve sustainable economic growth and development, balancing economic and social developments with environmental protection (encapsulated in the 'strap line' for the 2016 Johannesburg World Summit on Sustainable Development of 'people, planet, and prosperity'). Energy is central to practically all aspects of sustainable development. Energy services are essential ingredients of all three pillars of sustainable development economic, social, and environmental. Economies that have replaced human and animal labour with more convenient and efficient usage of energy and technology are also the ones that have grown fastest. No country in modern times has succeeded in substantially reducing poverty without adequately increasing the provision and use of energy to make material progress (Rosen 2009).

The importance of energy lies in other aspect of development - increase in foreign earnings when energy products are exported, transfer of technology in the process of exploration, production and marketing; increase in employment in energy industries; improvement of workers welfare through increase in worker's salary and wages, improvement in infrastructure and socio-economic activities in the process of energy resource exploitation. Thus in the quest for optimal development and efficient management of available energy resources, equitably allocation and efficient utilization can put the economy on the part of sustainable growth and development. Arising from this argument, adequate supply of energy thus becomes central to the radical transformation of the nation's economy.

In Nigeria, energy serves as the pillar of wealth creation evident by being the nucleus of operations and engine of growth for all sectors of the economy. The output of the energy sector (electricity, petroleum products and natural gas) usually consolidate the activities of the other sectors which provide essential services to direct the production activities in agriculture, manufacturing, mining, commerce etc. Nigeria is endowed with abundant energy resources but suffers from perennial energy crisis which has defied solution.

The co-existence of vast wealth in natural resources and extreme personal poverty referred to as the "resource curse" or 'Dutch disease' (Auty,1993) afflicts Nigeria. The size of the economy marked by the Gross National Income per capita is put at $1,190 and ranked 162 out of 213 countries in the world development index in 2017 (The World Bank, 2011).

On economic growth, the GDP per capita of Nigeria expanded by 132% between independence in 1960 and 1969, and rose to a peak growth of 283% between 1970 and 1979. The severity of this malaise led to the restructuring of the economy in 1986. In the period 1988-1997 which constitutes the period of structural economic adjustment and liberalization, the GDP responded to economic adjustment policies and grew at a positive rate of 4%. In 2006, the real GDP growth rate was 7%. The economy when measured by the real GDP, grew by 7.87% in 2010 and 1.94% in 2018, (National Bureau of Statistics-NBS, 2019 and Central Bank of Nigeria - CBN, 2019).

According to Alam (2016), energy is the indispensable force driving all economic activities. This implies that, the greater the energy consumption, the more the economic activities going on in the nation and, as a result, a greater economy emerges. All economic processes must require energy; this, therefore, makes energy always an essential factor of production (Stern 1997).

The benefits of energy to every economy cannot be over-emphasised. It is the foundation to other aspects of development. This could be through increase in foreign earnings generated from the exportation of energy products, reduction of unemployment by energy industries, transfer of technology in the process of exploration, improvement in infrastructure in the process of energy resource exploitation and many other benefits to the economy. Energy plays the most vital role in the economic growth, progress, and development, as well as poverty eradication and economic security of any nation. Increase in economic growth significantly depends on the continuing availability of energy from sources that are affordable, accessible, and also environmentally friendly. The standard of living of a given country can be directly related to the per capita energy consumption as energy is an important factor in all the sectors of any country's economy. These include provision of basic needs such as cooked food, lighting, powering appliances, piped water or sewerage, essential health care (refrigerated vaccines, emergency, and intensive care), educational aids, communication (radio, television, the use of IT equipment), and transport, to mention but a few. Energy also fuels productive activities, including agriculture, commerce, manufacturing, industry, and mining.

Indeed, by not ensuring a minimum access to energy services for a broad segment of the population in the Nigeria economy, the economic growth beyond the level of subsistence has proven to be a real challenge to the Nigeria economy as the productive capacity of the entire economy has been jeopardized. This paper therefore seeks to answer the following questions; how has the Petroleum energy consumption affected economic growth in Nigeria? In what ways has electricity consumption contributed to the economic growth in Nigeria? What is the relationship between natural gas consumption and economic growth in Nigeria?

2. Literature and Theoretical Review

2.1 Energy Consumption in Nigeria

Energy access, or the lack of it, can be said to be one of the most pressing problems of the twenty first century, because it is not a widely recognized fact that sustainable development, or development in real terms, is impossible in the absence of access to energy services. In recognition of this fact, the United Nations system designated 2012 as the year of Sustainable Energy for All (SEFA), and has followed this up with the designation of the decade 2014-2024 as the Decade of Sustainable Energy for All.

Energy access does not refer to access to a source of energy. It refers to access to the benefits derived from that source of energy and the services it provides, is referred to as energy services. Energy services include household access to electricity, and to clean cooking facilities, and to energy that empowers work, making life easier, healthier, and safer. The benefits of 'energy services' are derived from the use of efficient energy sources, over and above that derived from basic biomass, which is the fuel of the poor in developing countries, such as Nigeria. These benefits make fundamental differences to peoples' lives and standards of living. With efficient energy for work, grinding foodstuff is done in a fraction of the time that would otherwise have been spent to do it manually. Efficient energy services provide lighting for reading and greater productivity at night; cooking safely and without the stress of having to regularly source firewood or other basic biomass; refrigeration so that one is freed from having to buy food daily, or have needed food rotting away; telecommunications so that there is no longer the need to embark on costly and long journeys in pursuit of transactions that can easily be concluded over the phone; and transportation, without which the people will have to walk long distances, or travel by donkey, camel, horseback, or bicycles. Firewood, crop waste, dung, and wood shavings and other energy sources used by the poor, cannot provide these and many other services.

Whilst millions of people now have access to modern energy services, one fifth of the world's population lacks access to electricity. Twice as many still rely on traditional uses of biomass for cooking. Cumulatively, more than 95% of those without modern energy access live in the developing countries of Asia, and of sub-Saharan Africa, with the great majority residing in the rural areas. More than half of the populations in developing Asia and 80% of the population in sub-Saharan Africa exist without clean cooking facilities. In sub-Saharan Africa, the electrification rate is 31% and the number of people relying on biomass is 80%.

2.2 The Nigerian Energy Challenges

Nigeria's energy need is on the increase, and its increasing population is not adequately considered in the energy development program. The present urban-centered energy policy is deplorable, as cases of rural and sub-rural energy demand and supply do not reach the center stage of the country's energy development policy. People in rural areas depend on burning wood and traditional biomass for their energy needs, causing great deforestation, emitting greenhouse gases, and polluting the environment, thus creating global warming and environmental concerns. The main task has been to supply energy to the cities and various places of industrialization, thereby creating an energy imbalance within the country's socioeconomic and political landscapes. Comparing the present and ever-increasing population with the total capacity of the available power stations reveals that Nigeria is not able to meet the energy needs of the people. The rural dwellers still lack electric power.

The nature of Nigeria's energy crises can be characterized by two key factors. The first concerns the recurrent severe shortages of the petroleum product market of which kerosene and diesel are the most prominent. Nigeria has five domestic refineries owned by the government with a capacity to process 450,000 barrels of oil per day, yet imports constitute more than 75% of petroleum product requirements. The state-owned refineries have hardly operated above a 40% capacity utilization rate for any extended period of time in the past two decades. The gasoline market is much better supplied than kerosene and diesel because of its higher political profile. This factor explains why the government has embarked on large import volumes to remedy domestic shortages of the product. According to the Minister for Energy, the subsidy to support the imports of gasoline alone will be in the range of 700 to 800 billion naira in 2008. The weaker political pressures exerted by the consumers of kerosene (the poor and low middle class) and diesel (industrial sector) on the government and the constraints on public financing of large-scale imports of these products, as in the case of petrol, largely explain their more severe and persistent market shortages.

The second dimension of Nigeria's energy crises is exemplified by such indicators as electricity blackouts, brownouts, and pervasive reliance on self-generated electricity. This development has occurred despite abundant energy resources in Nigeria. The electricity market, dominated on the supply side by the state-owned PHCN, formerly called NEPA, has been incapable of providing minimum acceptable international standards of electricity service reliability, accessibility, and availability for the past three decades. The nature of this poor record in electricity supply is apparent in the trend in transmission and distribution losses. The double-digit transmission and distribution losses are extremely large by international standards and are among the highest in the world. The system losses are five to six times higher than those in well-run power systems. The high level of power losses and the significant illegal access to the public power supply are indicative of the crisis in the industry.

Though the peak electricity demand has been less than half of the installed capacity in the past decade, load shedding occurs regularly. Power outages in the manufacturing sector provide another dimension to the crisis. In 2004, the major manufacturing firms experienced 316 outages. This increased by 26% in 2005, followed by an explosive 43% increase between 2006 and 2007. Though no published data exist, the near collapse of the generating system to far below 2,000 MW for prolonged periods of time suggests a reason for the number of outages in 2008 to be very high. This poor service delivery has rendered public supply a standby source as many consumers who cannot afford irregular and poor quality service substitute more expensive captive supply alternatives to minimize the negative consequences of power supply interruptions on their production activities and profitability. An estimated 20% of the investment into industrial projects is allocated to alternative sources of electricity supply.

In summary, the causal factors in Nigeria's energy crisis include the following: Weak concern for cost recovery and lack of adequate economic incentives to induce the state-owned companies (NNPC and PHCN) to engage in efficient production and investment behavior. This seems apparent in the existence of large input and output subsidies.

Multiplicity of economic and noneconomic objectives without proper identification of the trade-offs among these different objectives. This is implicit in its pricing policies in both electricity and petroleum products markets.

Institutional and governance failures which induced gross distortions and inefficiency in production, investment choices and high costs of operation, low return on investment, and expensive delays along with cost overruns in the state energy enterprises.

2.3 The New Growth Theory

According to received economics, classical economists did not recognise energy as a factor of production in the production process, neither did the neoclassical economists. Today, economist have developed models that incorporate the role of resources, including energy in the growth process. Time series analyses have shown that energy and GDP co-integrate and energy use Granger causes GDP when additional variables such as energy prices or other production inputs are included. The primary driving force of economic growth is the growth of productivity, which is the ratio of economic output to inputs (capital, labour, energy, materials and services (KLEMS). This has led to several criticisms of the neoclassical economic theory and other theories of growth, on a number of grounds, especially on the basis of the implications of thermodynamics for economic production and the long-term prospects of the economy. Therefore, there have been paradigm shifts towards incorporating energy into the modern growth model to reflect the role of energy in the economy.

Consequently (Stern 1999) notes that energy is a factor of production that is non-reproducible, though of course energy vectors – fuels – are reproducible (see also, Hall, et al., 2001 and 2003). In the extreme, energy use rather than output of 1964). There have been different theories of economic growth before the growth theory proposed by Romar (1994), including the Solow-Swan model, also known as exogenous growth model. The Solow-Swan model attempts to explain long-run economic growth by looking at productivity, capital accumulation, population growth, and technological progress. At its core is the neoclassical aggregate production function of Cobb-Douglas type, which enables the model to make contact with microeconomics' (Accemoglu 2009). One of the basic assumptions of the Solow model is the diminishing returns to labour and capital and constant returns to scale as well as competitive market equilibrium and constant savings rate, which is adopted from the Domar model. However, what is crucial about the Solow model is the fact that it explains the long run per capita growth by the rate of technological progress, which comes from outside the model.

By the mid-1980s, a group of growth theorists had become increasingly dissatisfied with common accounts of exogenous factors determining long-run growth. They favoured a model that replaced the exogenous growth variable (unexplained technical progress) with a model in which the key determinants of growth were explicit in the model. Consequently, the endogenous (new) growth theory emerged due to some flaws in the exogenous growth theory and holds that economic growth is primarily the result of endogenous and not external forces (Romer 1994). Endogenous growth theory holds that investment in human capital, innovation, and knowledge are significant contributors to economic growth. The theory also focuses on positive externalities and spill-over effects of a knowledge-based economy which will lead to economic development. In the new growth model, the savings rate and rate of technological progress are unexplained. Endogenous growth theory tries to overcome this shortcoming by building macroeconomic models out of their microeconomic foundations. Households are assumed to maximise utility subject to budget constraints, while firms maximise profits. Crucial importance is usually attached to the production of new technologies and human capital. The engine of growth can be as simple as a constant return to scale production function (the AK model) or more complicated set ups with spill-over effects (spill-over are positive benefits of a firms that are attributed to costs from other firms), increasing numbers of goods, increasing qualities, etc.

Often, endogenous growth theory assumes constant marginal product of capital at the aggregate level, or at least that the limit of the marginal product of capital does not tend towards zero. This does not imply that larger firms will be more productive than small ones, because at the firm level the marginal product of capital is still diminishing. Therefore, while it is possible to construct endogenous growth models with perfect competition, in many endogenous growth models the assumption of perfect competition is relaxed, and some degree of monopoly power is thought to exist.

According to the AK production model, the simplest form of production function with diminishing return is:

Where:

A = a positive constant that reflects the level of technology in the economy

K = capital

Using the Romar model, a typical firm's production function can be depicted as:

Y = f(AK, L)

Where:

A = Public ideas and innovations (technological changes)

K = Capital stock of the firm

L = Labour stock of the firm

'A' includes the development of new ideas which are mainly done by the government since they are non-rival. When these new ideas that create an enabling environment for smooth running of business are added to the model as factors of production, the returns to scale tend to be increasing. This makes new technology the vital machinery for the achievement of long-run growth and it is itself derived from investment made in research technology.

In this model, Romar regards investment in research technology as an endogenous fact.

From the foregoing, an aggregate production function can be derived from the endogenous theory as follow:

Y = F (A, K, L)

Where

Y = aggregate real output

K = stock of capital

L = stock of labour
A = Technology (or changes in technological inputs)

2.4 The Theory of the Firm (Transaction Cost Theory)

This theory is a neoclassical microeconomics theory which states that the existence of firms (corporations) is to make decisions in order to earn higher profits. Businesses interface with the market forces to ascertain pricing and demand and resources allocated according demands of the consumers to earn higher net profits. The theory of the firm goes along with the theory of the consumer, which also tries to explain how consumers try to maximize their total utility. Modern theorist's today takes on the theory of the firm to sometimes draw a distinction between sustenance and profit maximization. Given the big nature of public structure of ownership, public firms must be inefficient due to the inherent problem that characterizes such sector because who is in charge of the state is not really clear due to conflicting objective. But when the unproductive public firms run into financial crisis, it is only the government that will be held responsible to offset the loss because what belongs to government seems to belong to no individual, therefore efficiency gain is questionable. The choice between private and public ownership is to formerly privatize public sector activities for the firms to make profit and improve output.

Classical economists like Adam Smith, also advocated the idea of maximizing his own self-interest. Today the real actors in any economy are the industrial sector and tend to boast economic growth. The separation of ownership and control problem will thus ensue. Therefore, if the government ignores this lapse, the privatization policy will merely transform the nature of parastatals problems that cannot be amended and the theory is most relevant to this study because it tries to examine the role of ownership change in resource allocation, product decision and by supported efficiency improvement within the context of privatization.

2.5 Empirical Review

For the past thirty years, researchers have explored the relationship between energy consumption and economic growth for different nations and time using diverse methodologies so that a broad literature has been accumulated in this field. Alam (2016) accepted the fact that there is a departure from neoclassical economics doctrine which includes only capital, labour and technology as factors of production to one which now includes energy as a factor of production. He added that energy drives the work that converts raw materials into finished products in the manufacturing process. Simpson (2019), states that there is a bidirectional relationship between energy and economic growth.

Many researchers (Onyebuchi (2016), Adekoya and Adewale (2014), Akinbami (2001), Fabbenle and Karayinnis (2013), Chineke and Igwiro (2018), Ngala (2017)), Aniefiok and Imoh (2014) have looked into the availability of renewable energy resources in Nigeria with a view to establishing their viability in the country's economy.

To Chineke and Igwiro (2018), Nigeria receives abundant solar energy that can be usefully harnessed with an annual average daily solar radiation of about 5.25 $kWh/m^2/day$. This was shown in their work, as quoted in Oyedepo (2012). This solar energy potential varies between 3.5 $kWh/m^2/day$ at the coastal areas and 7 $kWh/m^2/day$ at the northern boundary. The average amount of sunshine house all over the country is estimated to be about 6.5 h. This gives an average annual solar energy intensity of 1,934.5 $kWh/m^2/year$; meaning that, over the course of a year, an average of 6,372,613 PJ/year (approximately 1,770 TWh/year) of solar energy falls on the entire land area of Nigeria. According to the study, this is about 120,000 times the total annual average electrical energy generated by the Power Holding Company of Nigeria (PHCN). With a 10% conservative conversion efficiency, the available solar energy resource is about 23 times the Energy Commission of Nigeria's (ECN) projection of the total final energy demand for Nigeria in the year 2030 (ECN, 2005). This source of energy can be harnessed as a reliable and sustainable source of power supply to enhance the sustainable developmental trend in the country.

In a study on electricity power supply, Ganiyu, Adebayo, Oluwatomi, Ahmed, Sulaimon and Lukman (2018) did a joint study on analysis of the power sector performance in Nigeria. The results showed that the average value of the overall efficiency for the ten years period of study was 15.68% while the thermal efficiency had the average value of 15.37%. The result confirmed that deregulation of power sector has no effect on the efficiency of Nigerian power sector when the results were compared with the international best practice standards which are 30% and above for overall efficiency and 45% and above for thermal efficiency. The study therefore suggested possible strategies for efficient power sector improvement. Ngala (2017) performed a statistical analysis of the wind energy potential in Maiduguri, Borno State, using the Weibull distribution and 10year (1995 to 2004) wind data. A cost benefit analysis was also performed using the wind energy conversion systems for electric power generation and supply in the State.

Yu and Choi (2018), in their research work, carried out on the Philippines' economy, find that there is a positive relationship between energy consumption and economic growth. Furthermore, they define the relationship as a unidirectional one where economic growth served as the dependent variable and energy consumption was the independent variable. Kraft and Kraft (2008) found a unidirectional relationship from expansion in GDP to energy consumption in USA. They point out that an increase in GNP will cause a corresponding increase in the consumption of energy as a factor of production. Erol and Yu (2007) examined the relationship between energy consumption and GDP for six developed countries (Canada, Italy, Japan England, France and Germany) for the period 1952 to 1982 and found a bidirectional causality relationship for Japan, and unidirectional from GDP to energy consumption for Germany and Italy, unidirectional from energy consumption to GDP for Canada, They discovered non-causality for France and England.

Edet and Boniface (2016) jointly carried out a study on Power sector reform and electricity growth in Nigeria. This study is based on the elementary supply theory. It covers from 1981 to 2015. Econometric approach for the study relies on time series data regression. The study adopted the contemporary econometric approach of error correction mechanism (ECM). The results showed that all the variables were stationary and statistically significant and conform to the apriori expectation. From the results, the study recommends that government should totally transfer ownership in all electricity production and supply chain to the private investors and only monitor or regulate the market.

Onyebuchi (2016) estimated the technical potential of solar energy in Nigeria with 5% device conversion efficiency put at 15.0 x 10^{14} kj of useful energy annually. This equates to about 258.62 million barrels of oil annually, which corresponds to the current national annual fossil fuel production in the country. This is source of wealth to Nigeria's economy and will amount to about 4.2 x 10^{5} GW/h of electricity production annually; about 26 times the recent annual electricity production of 16,000 GW/h in the country. This, if tapped, would reduce the cost of production or doing business in the country, increase the level of investment, create employment and reduce poverty.

3. Methodology

3.1 Model Specification

Following Aniefiok and Imoh (2014), who carried out a study on the Energy Consumption and economic growth in Nigeria under the endogenous growth methodological framework where technology was seen as an endogenous factor which could be related to energy. Their study revealed that energy is an essential factor of production and is also capital intensive. We therefore adapted the growth model used by Aniefiok and Imoh (2014) with a modification of the model to accommodate the disaggregation of the total energy into different forms of energy to specify our model in order to assess the effect of energy consumption to the economic growth in Nigeria from 1981 to 2019.

The model is therefore, specified as follows:
Given the choice of our variables, we take the functional specification as follows:

The model used is stated as follows:

$$GRGDP = f(ELEC, PETC, NGC) \quad (3.1)$$

Where:

GRGDP = Growth Rate Gross Domestic Product
ELEC = Electricity Consumption
PETC = Petroleum Consumption
NGC = Natural Gas Consumption

For purpose of estimation we rewrite equation (3.1) above in the linear form, as:

$$GRGDP = \beta_0 + \beta_1 ELEC + \beta_2 PETC + \beta_3 NGC + \mu \quad (3.2)$$

Where:

β_1 to β_3 = represent the slope/coefficients
β_0 = the intercept

μ = the stochastic term or the error term at time *t*.

3.2 Estimation Procedures

Augmented-Dickey Fuller Unit Root Test

The Augmented Dickey Fuller (ADF) unit root test determines the order of integration of the time series. Consider the following AR(1) process:

$$yt = \rho y_{t-1} + x'_t\delta + \varepsilon_t \quad (3.3)$$

Where x_t are optional exogenous regressors which may include a constant, or a constant and a trend, ρ and δ are parameters to be estimated, and the ε_t are white noise. The ADF test is conducted by estimating equation 3.4 after subtracting y_{t-1} from both sides of the equation:

$$\Delta y_t = \alpha y_{t-1} + x'_t + \varepsilon_t \quad (3.4)$$

Where $\alpha = \rho - 1$. The null and alternative hypotheses may be written as:

$$H_0: \alpha = 0 \quad (3.5)$$
$$H_1: \alpha < 0$$

and evaluated using the conventional $t_{\text{-ratio}}$ for α:

$$t_\alpha = \frac{\tilde{\alpha}}{se(\tilde{\alpha})} \quad (3.6)$$

where $\tilde{\alpha}$ is the estimate of α, and $se(\tilde{\alpha})$ is the coefficient standard error.

If the series is not an AR(1) process the assumption of white noise disturbances $\varepsilon_t$is violated. The violation of the assumption of white noise disturbances ε_t is corrected by assuming that the *y* follows an AR(*p*) process and adding p lagged difference terms of the dependent variable *y* to the right-hand side of the test regression:

$$\Delta y_t = \alpha y_{t-1} + x'_t\delta + \beta_1\Delta y_{t-1} + \ldots + \beta_p\Delta y_{t-p} + v_t \quad (3.7)$$

This specification is then used to test the null hypothesis H_0 against the alternative hypothesis H_1.

ARDL Bounds Cointegration Approach

The ARDL bounds cointegration approach has three distinct advantages. First of all, it allows for a combination of variables that are integrated of order one, order zero, or fractionally integrated. Secondly, it yields unbiased estimates of the long-run model. Thirdly, it is relatively more efficient in the case of small and finite sample data sizes.

The ARDL approach makes use of the bounds cointegration test. Here, for each level of significance two sets of critical values are computed: the upper bound and the lower bound. If the computed F-Statistic exceeds the upper critical value, the null hypothesis of no cointegration will be rejected and vice versa. The test is inconclusive if the F-statistic value is between the upper and lower bound.

The upper and lower bounds are computed on the assumption that all variables included in the "unrestricted" error correction model (ECM) are integrated of order zero and order one respectively, while the F-statistic is obtained by conducting a joint F-test for the coefficients (b_1, b_2, …, b_j) of the lagged explanatory variables of the "unrestricted" ECM. The "unrestricted" ECM is derived from a corresponding differenced ARDL in Equation (3.2). The general model is stated below:

$$\Delta y_t = \alpha_0 + b_1 y_{t-1} + b_2 x_{t-1} + \cdots + b_j z_{t-1} + \sum_{i=1}^{n} \alpha_{1i} \Delta y_{t-i} + \sum_{i=0}^{n} \alpha_{2i} \Delta x_{t-i} + \cdots + \sum_{i=0}^{n} \alpha_{ji} \Delta z_{t-i+\varepsilon_t} \quad (3.8)$$

Where Δy_t denotes the differenced endogenous variable; Δx_t and Δz_t denote the differenced exogenous variables; and e_t denotes the error term.

Specifically, the ARDL model for this study has been explicitly stated as:

$$GRGDP_t = a_1 + \beta_{11} GRGDP_{t-1} + \beta_{12} ELEC_{t-1} + \beta_{13} PETC_{t-1} + \beta_{14} NGC_{t-1} + \sum_{i=1}^{n} \beta \sum_{i=1}^{n} \beta_{11} GRGDP_{t-1} + \sum_{i=1}^{n} \beta \sum_{i=1}^{n} \beta_{12} ELEC_{t-1} + \sum_{i=1}^{n} \beta \sum_{i=1}^{n} \beta_{13} PETC_{t-1} + \sum_{i=1}^{n} \beta \sum_{i=1}^{n} \beta_{14} NGC_{t-1} + \varepsilon_{1t} \quad (3.9)$$

4. Analysis and Discussion of Findings

4.1 Unit Root Test Results

The results of Augmented Dickey Fuller (ADF) unit root test are presented in Table 4.1.

Table 4.1: ADF Unit Root Test Result Summary

Variables	Lags Included	Prob Value @ Levels	Prob Value @1st Diff	ADF Test Statistic @1st Diff	5% Critical Value	Order of Integration
GRGDP	1	0.0021	-	-3.893	-3.000	I(0)
ELEC	1	0.7239	0.0000	-6.892	-2.969	I(1)
PETC	1	0.1887	0.0000	-5.692	-2.969	I(1)
NGC	1	0.1682	0.0000	-6.086	-2.969	I(1)
Note(s): Lag selection based on Schwarz Information Criterion (SIC)						

Source: Authors Computation, 2021

The results indicate different orders of integration for the time-series variables. Specifically, ELEC, PETC and *NGC* appear to be stationary at first difference, while GRGDP was stationary at levels. This makes the time-series variables unsuitable for conventional cointegration methods which require the same order of integration for cointegration analysis, such as those proposed by Johansen (1995) and Gregory and Hansen (1992b). However, the Autoregressive Distributed Lag (ARDL) bounds cointegration method suffices at this juncture because it allows for different orders of integration.

4.2 ARDL Bounds Cointegration Test Results

Table 4.2: Bounds Cointegration Test

	Computed Wald (F-Statistic): 5.882							
	10% Level		**5% Level**		**2.5% Level**		**1% Level**	
k = 3	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
F*	2.72	3.77	3.23	4.35	3.69	4.89	4.29	5.61

Source: Authors Computation, 2021

k signifies the number of regressors

F* corresponds to the model with unrestricted intercept and trend

In Table 4.2, the bounds test statistic (5.882) was found to have exceeded the upper-bound (4.35) at the 5% level of significance and therefore resulted to the rejection of the null hypothesis of "no cointegration". Based on this result, a "restricted" error correction model was estimated alongside a long-run model as seen in Tables 4.3, in order to capture short-run dynamics as well as long-run equilibrium, respectively.

Table 4.3-a: Error Correction Model (ECM) Estimates Short-Run Estimates

Dependent Variable: ΔGRGDP				
Regressors	**Coefficient**	**Standard Error**	**t-statistic**	**Prob.**
ΔLELEC	4.927	1.998	2.42	0.031
ΔLPETC	2.984	2.649	1.13	0.280
ΔLNGC	1.312	0.704	1.86	0.085
ECT_{t-1}	-1.052	0.292	-3.60	0.003

Table 4.3-b: Long-Run Estimates

Dependent Variable: GRGDP				
Regressors	**Coefficient**	**Standard Error**	**t-statistic**	**Prob.**
LELEC	0.423	1.121	0.38	0.712
LPETC	0.733	3.756	-0.20	0.848
LNGC	0.295	0.823	1.8438	0.0801

Source: Authors Computation, 2021

4.3 Discussion of Findings

In the error correction model, interest lies in the error correction term (ECT_{t-1}) which appears to be expectedly negative and statistically significant at the 5% level (based on its *p*-value (0.003)). Its magnitude (-1.052) indicates a moderate rate of adjustment to long-run equilibrium and specifically implies that approximately 105.2% of all discrepancies in long-run equilibrium will be corrected in each period.

On the other hand, in the long-run model, all of the coefficients are expectedly positive; 0.423. 0.733 and 0.295 for ELEC, PETC and NGC respectively. Their p-values of 0.712, 0.848, and 0.725 for ELEC, PETC and NGC respectively indicated that they are statistically insignificant at 5% level of significance. This implies that increase in consumption of electricity (ELEC), Petroleum product (PETC) and Natural Gas (NGC) in Nigeria will cause growth rate of Gross Domestic Product (GRGDP) to increase by 0.423. 0.733 and 0.295 units respectively.

In short run, the coefficients of all the variables are equally positive; 4.927. 2.984 and 1.312 for ELEC, PETC and NGC respectively. Their p-values of 0.031, 0.280, and 0.085 for ELEC, PETC and NGC respectively indicated that electricity consumption is a significant determinant of GRGDP at 5% level of significant while that of petroleum and natural gas are not. This implies that increase in consumption of electricity (ELEC), Petroleum product (PETC) and Natural Gas (NGC) in Nigeria will cause growth rate of Gross Domestic Product (GRGDP) to increase by 4.927. 2.984 and 1.312 units respectively.

4.4 Model Evaluation Results

R^2 and Adjusted R^2

The coefficients of determination (R^2 and adjusted R^2) were used to evaluate the explanatory capabilities of the estimated models. The results are presented in Tables 4.4.

Table 4.4: Coefficients of Determination for the ARDL Model

R^2	Adjusted R^2
0.8445	0.7129

Source: Author Generated

In Table 4.4, the adjusted R^2 has a magnitude of 0.8445 and therefore implies that the previously estimated ARDL model explains as much as 84.45% of the variation in its endogenous variable.

Residual Normality Test

The Jarque-Bera (J-B) test was utilized to examine the distribution of the residuals of the previously estimated models. The results are presented in Tables 4.5.

Table 4.5: Jarque-Bera Normality Test for the ARDL Model

Skewness	**Kurtosis**	**JB Statistic**	**Prob.**
9.58	2.83	0.3364	0.4041

Source: Author Generated

In Table 4.5, the p-value (0.3364) of the J-B test exceeds the 0.05 benchmark, and therefore indicates that the residuals of the error correction model (ECM) of the ARDL model are normally distributed.

Heteroskedasticity Test

The Breusch-Pagan-Godfrey (BPG) test was utilized to test for heteroskedasticity in the residuals of the previously estimated models. The results are presented in Tables 4.6.

Table 4.6: Breusch-Pagan-Godfrey Heteroskedasticity Test for the ARDL Model

BPG Statistic (Obs * R-sq)	**Prob.**
25.00	0.4058

Source: Author Generated

In Table 4.6, the p-value (0.4058) of the BPG test exceeds the 0.05 benchmark, and therefore indicates that the residuals of the ARDL model are homoskedastic.

Autocorrelation Test

The Breusch-Godfrey (BG) test was utilized to test for higher order serial correlation in the residuals of the previously estimated models. The results are presented in Tables 4.7.

Table 4.7: Breusch-Godfrey Serial Correlation Test for the ARDL Model

BG Statistic (Obs * R-sq)	**Prob.**
6.348	0.1118

Source: Author Generated

In Table 4.7, the p-value (0.1118) of the BG test exceeds the 0.05 benchmark, and therefore indicates that the residuals of the ARDL model are not serially correlated.

The Eigenvalue Stability Test

The Eigenvalue stability condition was used to examine the stability of the ARDL model. The result is captured in the following:

Table 4.8. Eigenvalue Stability Condition

Eigenvalue	**Modulus**
0.9151412	0.915141
0.6600043	0.660004
0.387348	0.387348
-0.1629975	0.162997

Source: Author Generated

The result shows that the entire eigenvalues lie inside the unit circle. The implication is that all the variables satisfy stability condition.

The following are the summary of major findings of the study:

1. Electricity consumption (ELEC) is a positive and significant determinant of growth rate of Nigeria gross domestic product both in the long and short run.
2. This result implies that as electricity consumption increasing, the growth rate of Nigeria gross domestic product will be increasing.
3. Petroleum product consumption has a positive and insignificant relationship with growth rate of Nigeria gross domestic product.
4. This indicates that an increase in the consumption of petroleum product will lead to an increase in growth rate of Nigeria gross domestic product.
5. Consumption of Natural gas has a positive and significant relationship with growth rate of Nigeria gross domestic product at 10% level of significant.
6. The implication of this result is that higher consumption of natural gas will lead to a rise in growth rate of Nigeria gross domestic product.

Based on the findings of this study the following recommendations were made:

1. Government through the electricity generation companies (GENCOS) should generate more electricity adequate enough for domestic consumption that will reduce electricity tariff. This will propel growth in the industrial sector in particular and other sectors of the economy. Total overhaul of the power sector is highly recommended.

2. The petroleum sector particularly our refineries should be made functional to meet the daily domestic demand of petroleum products which will enhance economic activities in the other sectors of the economy.
3. Production and distribution of natural gas should be improved for a greater impact in the economic development of the country since its consumption indicated a positive relationship with growth rate of GDP.

4.5 Concluding Remarks

Energy is a propelling force behind any economic activity and indeed industrial production. Energy is central to every economy because it drives all economic activities. This characterisation of energy directs our attention to its sources in nature, to activities that convert and reconvert this energy, and finally to activities that use the energy to produce goods and services for household consumption. Traditionally, energy is treated as an intermediate input in the production process. This treatment of the role of energy underscores its importance and contribution to development of other sectors of the economy which attracted the attention of the researcher. The findings of this study established positive relationships between electricity, petroleum and gas energy consumptions and the growth rate GDP in Nigeria. This study therefore concluded that improved energy output and consumption will enhance the attainment of economic growth in the Nigerian economy.

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