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ELECTRICITY CONSUMPTION AND ECONOMIC GROWTH: EVIDENCE FROM NIGERIA

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Abstract: As one of the significant components of energy consumption, the importance of electricity to economic growth has been recognized by economists and business people, engineering, and government agencies. This paper seeks to investigate the impact of electricity consumption on economic growth in Nigeria from 1986 to 2021 by using the Autoregressive Distributed Lag (ARDL) model. The properties of the series were first checked using Augmented Dickey fuller (ADF) and Phillip Peron (PP) unit root tests, and the result found a mixture of the order of integration, which paved the use ARDL model. The findings of the ARDL bond test indicate the present cointegration. Evidence from the short run reveals that the speed of adjustment is negative and statically significant, confirming the expected equilibrium process in the short-run dynamics among the variables under study. The results also show that energy consumption, inflation, and industrial product are statistically significant and positively affect Nigeria's short and long-run economic growth. At the same time, Unemployment is negative and statistically significant both in the short and long run. Based on the findings, the paper recommends that government should undertake serious measures to curtail the shortage of electricity consumption in the country to promote economic growth in general. The government should adopt appropriate policies to reduce Unemployment, adversely affecting economic growth.

Keywords: *electricity consumption, economic development, economic growth, energy economics, Nigeria energy policy.*

Abstrak: Paper ini bertujuan untuk menginvestigasi dampak konsumsi listrik terhadap pertumbuhan ekonomi di Nigeria dari tahun 1986 hingga 2021 dengan menggunakan model Autoregressive Distributed Lag (ARDL). Sifat-sifat dari deret waktu tersebut diperiksa menggunakan uji akar unit Augmented Dickey fuller (ADF) dan Phillip Peron (PP), dan hasilnya menemukan adanya campuran urutan integrasi, yang membuka jalan untuk menggunakan model ARDL. Temuan dari uji ikatan ARDL mengindikasikan adanya kointegrasi. Bukti dari jangka pendek menunjukkan bahwa kecepatan penyesuaian adalah negatif dan signifikan secara statistik, yang mengkonfirmasi proses keseimbangan yang diharapkan dalam dinamika jangka pendek. Hasil penelitian juga menunjukkan bahwa konsumsi energi, inflasi, dan produk industri secara statistik signifikan dan secara positif mempengaruhi pertumbuhan ekonomi jangka pendek dan jangka panjang Nigeria. Pada saat yang sama, pengangguran negatif dan signifikan secara statistik baik dalam jangka pendek maupun jangka panjang. Berdasarkan hasil studi, paper ini menyarankan pemerintah untuk serius menangani kekurangan listrik dan mengadopsi kebijakan yang relevan untuk mengurangi pengangguran guna mendukung pertumbuhan ekonomi di Nigeria.

Kata kunci: *ekonomi energi, kebijakan energi nigeria, konsumsi listrik, pembangunan ekonomi, pertumbuhan ekonomi.*

INTRODUCTION

Energy scarcity has recently plagued the World. The sudden rise in the World's energy demand is the cause of this occurrence[1]. Established and emerging countries depend heavily on energy consumption (electricity) to stimulate societal and economic activity. Whether economic growth comes before energy consumption or the other way around is still up for debate in the energy economics literature. However, much has been written about in the literature on energy economics for many years, mainly in industrialized economies. This highly intriguing dynamic relationship in developing economies, specifically in Sub-Saharan Africa (SSA), is poorly understood.

Numerous studies attest to the vital importance of electricity for both households and commercial enterprises[2]. According to Stern, Burke, and Bruns[3] and Lechthaler[4], electricity is a capital creation and production factor. It can reduce the air population that leaves home[5] and lengthen workdays[6]. Despite its importance, there are still several issues with access to energy. In developing nations, the World Bank[7] estimates that in 2014, nearly one billion people lacked access to electricity. About 40% of Nigerians were without electricity that year[8].

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[1] Lira Peter Sekantsi and Nicholas Okot, 'Electricity Consumption–Economic Growth Nexus in Uganda', *Energy Sources, Part B: Economics, Planning and Policy* 11, no. 12 (8 December 2016): 1144–49, https://doi.org/10.1080/15567249.2015.1010022; Jean Gaston Tamba et al., 'Electricity Consumption and Economic Growth: Evidence from Cameroon', *Energy Sources, Part B: Economics, Planning and Policy* 12, no. 11 (2 November 2017): 1007–14, https://doi.org/10.1080/15567249.2017.1349211.

[2] Andrew Adewale Alola and Uju Violet Alola, 'Agricultural Land Usage and Tourism Impact on Renewable Energy Consumption among Coastline Mediterranean Countries', *Energy and Environment* 29, no. 8 (19 May 2018): 1438–54, https://doi.org/10.1177/0958305X18779577; Bebonchu Atems and Chelsea Hotaling, 'The Effect of Renewable and Nonrenewable Electricity Generation on Economic Growth', *Energy Policy* 112 (January 2018): 111–18, https://doi.org/10.1016/j.enpol.2017.10.015; Rohan Best and Paul J. Burke, 'Electricity Availability: A Precondition for Faster Economic Growth?', *Energy Economics* 74 (August 2018): 321–29, https://doi.org/10.1016/j.eneco.2018.06.018; M. T. Costa-Campi, J. García-Quevedo, and E. Trujillo-Baute, 'Electricity Regulation and Economic Growth', *Energy Policy* 113 (February 2018): 232–38, https://doi.org/10.1016/j.enpol.2017.11.004.

[3] Paul J. Burke, David I. Stern, and Stephan B. Bruns, 'The Impact of Electricity on Economic Development: A Macroeconomic Perspective', *International Review of Environmental and Resource Economics*, 2018, https://doi.org/10.1561/101.00000101.

[4] Lucas Bretschger et al., 'Knowledge Diffusion, Endogenous Growth, and the Costs of Global Climate Policy', *European Economic Review* 93 (April 2017): 47–72, https://doi.org/10.1016/j.euroecorev.2016.11.012.

[5] D Feng et al., 'A Survey of Energy-Efficient Wireless Communications', *IEEE Communications Surveys & Tutorials* 15, no. 1 (2013): 167–78, https://doi.org/10.1109/SURV.2012.020212.00049.

[6] Claire Salmon and Jeremy Tanguy, 'Rural Electrification and Household Labor Supply: Evidence from Nigeria', *World Development* 82 (June 2016): 48–68, https://doi.org/10.1016/j.worlddev.2016.01.016.

[7] Tariq Khokhar, 'World Bank Open Data', *World Bank Blogs*, 2017, https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS.

[8] Best and Burke, 'Electricity Availability: A Precondition for Faster Economic Growth?'

A variety of factors causes the rise in power demand around the World. Urbanization, population increase, economic expansion, and entrepreneurial thought are at the top. In 2050, the global energy demand is predicted to double.

Electricity is one of the primary sources of energy consumption. Thus, economists, businesspeople, engineers, energy, and government organizations have acknowledged its significance for economic growth. The US Energy Information Administration (EIA) has claimed that there is a link between a nation's economy and its usage of energy, particularly electricity. According to the EIA's Annual Energy Outlook 2013[9], "Short-term changes in electricity use are frequently positively correlated with changes in economic output."

Electricity is a production component and a catalyst for capital creation; it has the potential to reduce air pollution from residential sources and boost work hours[10]. Nigeria is one of the nations that has struggled mightily to supply its inhabitants with enough electricity. Since Nigeria became independent in 1960, the industry has underperformed because, despite numerous reforms, nearly 80 million Nigerians lack access to energy in their homes[11]. According to UNDP[12], just 47% of Nigerians had access to electricity in 2009. Nigeria began producing electricity in 1896, and the first utility firm was the Nigerian Electricity Supply Firm (NESCO), founded in 1929.

In 1951, NESCO was replaced by the Electric Corporation of Nigeria (ECN), which had been in business for 22 years. ECN acquired both NESCO's assets and operations. The Nigeria Dams Authority (NDA) joined the ECN as a partner in 1962 to help develop hydropower[13]. The National Electric Power Authority (NEPA) was created due to the 1972 merger between ECN and NDA. NEPA was later privatized and changed its name to the Power Holding Company of Nigeria (PHCN), most likely due to inefficiency and scant or no funding[14]. As a result of the industry reform in 2005, the Nigerian Electricity

[9] Energy Information Administration, 'U.S. Economy and Electricity Demand Growth Are Linked, but Relationship Is Changing', *EIA Web Site*, 2013, http://www.eia.gov/todayinenergy/detail.cfm?id=10491.

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[12] United Nations Development Programme, 'Access to Electricity', *UNDP Sustainable Energy Hub*, n.d., https://www.undp.org/energy/our-work-areas/energy-access/access-electricity.

[13] Bernard Njindan Iyke, 'Electricity Consumption and Economic Growth in Nigeria: A Revisit of the Energy-Growth Debate', *Energy Economics* 51 (September 2015): 166–76, https://doi.org/10.1016/j.eneco.2015.05.024.

[14] E. S. Simpson, 'Electricity Production in Nigeria', *Economic Geography* 45, no. 3 (19 May 1969): 239, https://doi.org/10.2307/143093.

Regulatory Commission (NERC), which now oversees 11 distribution businesses, was elevated to the position of chief regulator. Private investors now hold 60% of the company's shares. The industry underwent additional restructuring in 2013, but little to no progress was made in producing and distributing energy because Nigeria could only have around 3,500 MW, significantly less than was needed to meet the demand of about 180 million Nigerians[15].

The sector generated 5,222 MW of peak power on December 18, 2017, setting a new national record. The research's primary goal is to investigate the causal link between Nigeria's economic growth from 20 to 2021 and electricity consumption[16].

Several studies have investigated the relationship between energy consumption and economic growth, providing substantial insights on the matter. Majeed et al.[17] studied Pakistan's energy consumption, revealing that adverse shocks significantly impact the environment. Similarly, Minh Ha & Ngoc[18] found an asymmetric effect of energy consumption on Vietnam's economic growth, with negative changes having a larger impact than positive ones.

In Nigeria, Nathaniel & Bekun[19] observed a growth-stimulating effect of electricity consumption but an inhibiting effect of urbanization. Chen et al.[20] established a threshold-based relationship between renewable energy use and economic growth across

[15] Eric Kehinde Ogunleye, 'Political Economy of Nigerian Power Sector Reform', in *World Institute for Development Economics Research* (Oxford University PressOxford, 2016), 1–29, https://doi.org/10.1093/oso/9780198802242.003.0020.

[16] Ogunleye.

[17] Muhammad Tariq Majeed et al., 'Asymmetric Effects of Energy Consumption and Economic Growth on Ecological Footprint: New Evidence from Pakistan', *Environmental Science and Pollution Research* 28, no. 25 (2021): 32945–61, https://doi.org/10.1007/s11356-021-13130-2.

[18] Nguyen Minh Ha and Bui Hoang Ngoc, 'Revisiting the Relationship between Energy Consumption and Economic Growth Nexus in Vietnam: New Evidence by Asymmetric ARDL Cointegration', *Applied Economics Letters* 28, no. 12 (12 July 2020): 1–7, https://doi.org/10.1080/13504851.2020.1789543.

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[20] Chaoyi Chen, Mehmet Pinar, and Thanasis Stengos, 'Renewable Energy Consumption and Economic Growth Nexus: Evidence from a Threshold Model', *Energy Policy* 139 (April 2020): 111295, https://doi.org/10.1016/j.enpol.2020.111295.

103 countries. In South Asia, Usman et al.[21] highlighted the significant contribution of ICT to India's economic growth and energy efficiency.

Lawal et al.[22] demonstrated a significant positive relationship between electricity consumption and economic development in sub-Saharan African economies, albeit with a threshold energy intensity level. Tiwari et al.[23] found a long-term relationship between economic growth and electricity consumption in India's agricultural sector.

Aydin[24] showed a bidirectional causality between nonrenewable electricity consumption and economic development for OECD countries, while Churchill & Ivanovski[25] found electricity consumption to be positively related to gross state product in Australia. In Nigeria, Bekun & Oluwatoyin Agboola[26] identified a positive relationship between economic growth and electricity consumption, supporting the electricity-induced growth hypothesis.

Balcilar et al.[27] reported unidirectional causality from economic growth to electricity consumption in Pakistan, affirming the conservative hypothesis. Rahman[28] explored the effects of electricity consumption, economic growth, and globalization on CO2 emissions, confirming the Environmental Kuznets Curve (EKC) hypothesis. Munir et al. (2020) supported the EKC hypothesis for ASEAN-5 countries as well.

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[21] Ahmed Usman et al., 'The Effect of ICT on Energy Consumption and Economic Growth in South Asian Economies: An Empirical Analysis', *Telematics and Informatics* 58 (May 2021): 101537, https://doi.org/10.1016/j.tele.2020.101537.

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[28] Mohammad Mafizur Rahman, 'Environmental Degradation: The Role of Electricity Consumption, Economic Growth and Globalisation', *Journal of Environmental Management* 253 (January 2020): 109742, https://doi.org/10.1016/j.jenvman.2019.109742.

Imam et al.[29] underscored corruption's negative impact on technical efficiency in Sub-Saharan Africa's electricity sector. Nkalo and Agwu highlighted the importance of consistent electricity supply for economic growth in Nigeria, suggesting policies to boost power generation and distribution[30]. Yu et al.[31] demonstrated a positive impact of electricity production on industrial development and sustainable economic growth in BRICS countries.

Sankaran et al.[32] found both short-run and long-run relationships among electricity consumption, economic growth, and CO2 emissions in late industrialized nations. Lastly, Oyeyemi[33] noted the detrimental effect of irregular electricity supply on output growth in Nigeria's manufacturing sector, calling for increased attention to the power sector. These studies collectively underscore the vital role of energy, particularly electricity, in economic growth and environmental sustainability.

The importance of electricity production and consumption for the growth of industrial production and the promotion of sustainable economic development has been well established through extensive research. Analytical techniques have been used to examine the linkages between these variables, such as cointegration and Granger causality tests. Empirical evidence underscores a substantial relationship between electricity consumption and economic growth. Some findings suggest either unidirectional or bidirectional causality between the two facets. In particular, recent studies have estimated the long-run correlation between energy consumption and economic growth across countries using the Autoregressive Distributed Lag (ARDL) bound test approach and error correction method.

These scholarly works have delineated both short-run and long-run interdependencies among the variables. They have postulated hypotheses related to

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[29] Mahmud I. Imam, Tooraj Jamasb, and Manuel Llorca, 'Sector Reforms and Institutional Corruption: Evidence from Electricity Industry in Sub-Saharan Africa', *Energy Policy* 129 (June 2019): 532–45, https://doi.org/10.1016/j.enpol.2019.02.043.

[30] Kelvin Ukoima and Ekwe Ogbonnaya Agwu, 'Review of the Impact of Electricity Supply on Economic Growth : A Nigerian Case Study Review of the Impact of Electricity Supply on Economic Growth : A Nigerian Case Study', *IOSR Journal of Electrical and Electronics Engineering* 14, no. February (9 June 2019): 28–34, www.iosrjournals.org 29.

[31] Zhongdong Yu et al., 'The Effects of Electricity Production on Industrial Development and Sustainable Economic Growth: A VAR Analysis for BRICS Countries', *Sustainability (Switzerland)* 11, no. 21 (23 October 2019): 5895, https://doi.org/10.3390/su11215895.

[32] A. Sankaran et al., 'Estimating the Causal Relationship between Electricity Consumption and Industrial Output: ARDL Bounds and Toda-Yamamoto Approaches for Ten Late Industrialized Countries', *Heliyon* 5, no. 6 (June 2019): e01904, https://doi.org/10.1016/j.heliyon.2019.e01904.

[33] Agbede Moses Oyeyemi, 'Disaggregate Energy Supply and Industrial Output in Nigeria', *International Journal of Economics, Business and Management Research* 2, no. 02 (1 January 2018): 154–72.

growth, conservation, feedback, and neutrality for various nations. Differences in structural and macroeconomic parameters account for the heterogeneity in the results of these studies. Regardless of the differences in their results, these studies as a whole provide important insights for policy makers who seek to promote economic development through the rational use of energy. In addition, there is a strong emphasis on the need for a consistent and sufficient supply of electricity for the enhancement of industrial output growth in developing countries.

In order to establish the causal relationship between electricity consumption and economic growth, these studies use a variety of econometric methods. The influence of additional factors such as ICT, renewable energy consumption, and trade openness on this relationship has also been examined in several studies. The results of most of these studies are consistent. They suggest that an increase in electricity supply contributes to higher economic growth. However, it has also been found that the intermittent nature of electricity supply can act as a significant impediment to the growth of economic output in certain countries. Accordingly, these studies advocate implementing policies aimed at increasing generating and distributing capacity to stimulate economic growth.

Despite a large body of literature examining the relationship between energy consumption and economic growth, particularly in Nigeria and other developing countries, some gaps seem to persist. A considerable number of studies use the Autoregressive Distributed Lag (ARDL) model and its variants, such as the nonlinear ARDL, but predominantly focus on aggregate or non-electric forms of energy consumption. The specific impact of electricity consumption, both in aggregate and disaggregated forms, on economic growth in Nigeria remains understudied. A research that focuses on the intricacies of the nexus between electricity and energy growth in Nigeria, using the ARDL model for the specific period of 1986 to 2021, would fill this gap.

Another shortcoming of the existing studies is that they primarily measure the overall impact of electricity consumption on economic growth, seemingly overlooking sectoral effects. While the study by Tiwari et al.[34] examines sectoral impacts in India, this perspective is lacking in the Nigerian context. Given the differences in electricity demand and impacts across sectors, an examination of the sectoral impacts of electricity consumption on economic growth in Nigeria could provide more detailed insights for policy planning. In addition, while some studies consider environmental impacts, the interplay between electricity consumption, economic growth, and environmental

[34] Tiwari, Eapen, and Nair, 'Electricity Consumption and Economic Growth at the State and Sectoral Level in India: Evidence Using Heterogeneous Panel Data Methods'.

outcomes in Nigeria requires further investigation. Therefore, this area of research offers rich opportunities for further investigation.

This study makes use of secondary data covering the period from 1986 to 2021, obtained from the World Development Indicator (WDI), 2021[35]. The choice of 1986 as the starting year coincides with the implementation of the Structural Adjustment Program (SAP) in Nigeria.

The theoretical literature has shown that economic growth is related to electricity consumption and Industrial Production. Therefore, the academic economic growth function can be presented as follows:

$$GDP = f(ELC, INP) - - - - - - - - - - - - - - - - (1)$$

GDP represents the authentic gross domestic product, ELC represents electricity consumption, and INP represents industrial production. In line with the objectives of this study, Inflation Rate and employment are included in the economic growth function as intermittent variables. Therefore, the new economic growth model is written as follows:

$$GDP = f(ELC, INP, INF, ENPL) - - - - - - - - - - - - - - - - (2).$$

Testing for stationarity of the series has become one of the popular tests. This is because undertaking a unit root test to determine variables' stationarity helps prevent spurious results. The augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests will be employed to test for stationary.

If the results from ADF and PP unit root test indicate that the variables are integrated in the same order, then a cointegration test can be conducted. Cointegration means that one or more linear combinations of time series variables are stationary even if they are non-stationary when not combined (Ziramba, 2008). The study applied the ARDL bounds test.

The application of the ARDL bound test in investigating the long-run relationship between the variables involves estimating an unrestricted error correction model (UECM) in first difference form (Madhavan et al. 2010). The research applies the following UECMs:

$$RGDP = f(\beta o + \delta_1 ELCt + \delta_2 INPt + \delta_3 INFt + \delta_4 UNPL + \mu t - - - - - - - - - (3)$$

[35] Mark Bevir, 'World Development Indicators', *Encyclopedia of Governance*, 2012, https://doi.org/10.4135/9781412952613.n571.

The steps that will be used in data analysis are the pre-estimation and estimation tests. The Augmented Dickey-Fuller (ADF) unit root tests have been carried out. The tests are based on the equations below:

$$\Delta y_t = \mu + \delta t + \rho y_{t-1} + \sum_{i=1}^{p-1} \pi_i \Delta y_{t-i} + \varepsilon_t \quad \text{_____ (4)}$$

$$\Delta y_t = \mu + \rho y_{t-1} + \sum_{i=1}^{p-1} \pi_i \Delta y_{t-i} + \varepsilon_t \quad \text{_____ (5)}$$

$$\Delta y_t = \rho y_{t-1} + \sum_{i=1}^{p-1} \pi_i \Delta y_{t-i} + \varepsilon_t \quad \text{_____ (6)}$$

In each case, the unit root presence is tested based on the null hypothesis of a unit root, i.e., whether the parameter $\rho = 0$ or otherwise in the three equations above. If ρ equals zero), the series contains a unit root; if not, the series is referred to as stationary. In equation (4), the ADF-test with both a constant and time trend is specified. Equation (5) identifies the ADF test with a regular only and no time trend, and equation (6) defines the ADF test with no constant and no time trend, respectively. Hence, the set of hypotheses corresponding to equations (4) to (6) to be tested are:

$H_0 : \delta = \rho = 0$ (The series has a unit root with no time trend.)

$H_1 : \delta \neq 0 ; \ \rho < 0$ (The series is stationary with a deterministic movement.)

$H_0 : \mu = \rho = 0$ (The series has a unit root with no constant and no time trend.)

$H_1 : \mu \neq 0 , \ \rho < 0$ (The series is stationary with a non-zero mean.)

$H_0 : \rho = 0$ (The series has a unit root.)

$H_1 : \rho < 0$ (The series is fixed with a zero compromise and no time trend).

The test regression for the Phillips and Perron Unit Root Test PP tests is:

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \alpha_2 \left(t - \frac{T}{2}\right) + \mu_t \quad \text{_____ (7)}$$

Where $\boldsymbol{u_t}$ am I (0) and may be heteroskedastic. The PP tests correctly for any serial correlation and heteroskedasticity in the errors $\boldsymbol{u_t}$ Of the test regression by directly modifying the test statistics tπ=0 and Tπˆ.

Furthermore, to capture the relationship between electricity consumption and economic growth in Nigeria, the study employed the ARDL model, otherwise known as the Bound test, to investigate the impact of electricity consumption on economic growth in Nigeria. The prior expectations for the variables under study are:

$\delta_1, \delta_2 and \ \delta_3$ are positive (>0) while$\delta_4 isnegative$ (<0)

The ARDL regression analysis model employed in the study can be expressed as follows:

$$\Delta RGDP_t = \alpha_0 + \sum \beta_1 \Delta RGDP_{t-1} + \sum \beta_2 \Delta ELC_{t-1} + \sum \beta_3 \Delta INP_{t-1} + \sum \beta_4 \Delta INF_{t-1} + \sum \beta_5 \Delta UNPL_{t-1} + \varepsilon_t \dots\dots\dots\dots (8)$$

where α is the intercept, RGDP, ELC, INP, INF, and UNPL are the variables used in the model, ε_t is the white noise, and Δ is the first difference operator. To test the long-run equilibrium relationship among the variables, the study employs the "F-test" in the ARDL Bounds test based on the null hypothesis of no cointegration [i.e., H0: $\delta_1 = \delta_2 = \delta_3 = \delta_4 = 0$], contrary to the alternative hypothesis of cointegration [i.e., H1: $\delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq 0$]. Accordingly, the computed "F-statistic" is compared to the upper and lower bounds critical value to reject or accept the null hypothesis[36].

DISCUSSION

The starting point of our formal analysis is the examination of the character and patterns of the data. Therefore, descriptive statistics describe the basic features of the data used in this study. The aim of these statistics is merely to summarize the data set rather than being used to test the hypotheses. Table 1 presents the descriptive results of the variables used in the study. The variables are economic growth (LRGDP), electricity Consumption (ELC), Industrial product (LINP), Inflation rate (INF), and Unemployment rate (UNPL), respectively, where (LRGDP is the dependent variable while (ELC), Industrial product (LINP), Inflation rate (INF) and Unemployment rate (UNPL) are independent variables. Therefore, table 1 shows that ELC has the highest mean of 185.3963, followed by LRGDP with the standard of 31.21866, while LINP has 29.02618, the lowest mean of 4.747083, respectively. In terms of median, the ELC still has the highest value of 200.3426 among the variables, followed by LRGDP with 31.18221, then LINP with 28.90778. The maximum and minimum values of the variables under study show that ELC has a maximum of 238.9499 and minimum of 101.0148, LRGDP with 31.92671 as the maximum and 30.4748 as the minimum, and LINP has a maximum of 29.53077and minimum of 28.69521respectively. Also, the descriptive statistics present the indicators of skewness and kurtosis and the test for normality of the variables to know the nature of the variables under study. This allows us to make some inferences about the distribution of the variables.

[36] M. Hashem Pesaran, Yongcheol Shin, and Richard J. Smith, 'Bounds Testing Approaches to the Analysis of Level Relationships', *Journal of Applied Econometrics* 16, no. 3 (19 May 2001): 289–326, https://doi.org/10.1002/jae.616.

Table 1. Descriptive Statistic

	LRGDP	ELC	LINP	INF	UNPL
Mean	31.21866	185.3963	29.02618	19.44256	4.747083
Median	31.18221	200.3426	28.90778	12.71577	3.972
Maximum	31.92671	238.9499	29.53077	72.8355	9.788
Minimum	30.4748	101.0148	28.69521	5.388008	3.7
Std. Dev.	0.508226	44.84734	0.295005	17.57475	1.820499
Skewness	0.114952	-0.425571	0.666203	1.737876	1.922407
Kurtosis	1.428278	1.753293	1.891706	1.700204	1.995322
Jarque-Bera	3.784749	3.418084	4.505437	4.45732	3.14586
Probability	0.150714	0.181039	0.105113	0.107213	0.143511
Sum	1123.872	6674.268	1044.942	699.9321	170.895
Sum Sq. Dev.	9.040295	70394.93	3.045987	10810.51	115.9976
Observations	36	36	36	36	36

Before conducting the cointegration analysis, the time series properties of the series were checked first. Various methods can be used to examine the stationarity or otherwise of the series. In this study, three different unit root tests were employed to have robust results. These are Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests. The tests are conducted at the level and first difference with trend and intercept. The Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests have a null hypothesis stating that the series in question has a unit root against the alternative that the variable does not have a unit root. Table 2 presents the results of various unit root tests with trend and intercept:

Table 2. Unit Root Tests.

	ADF Unit Root Test at Level		ADF Unit Root Test at First Difference	
Variables	T statistic	Probability	T statistic	Probability
RGDP	-3.673114	0.0396**	-4.268429	0.0007*
ELC	-1.848453	0.6593	-5.609416	0.0003*
INF	-3.794239	0.0043*	-4.013057	0.0001*
INP	-1.722727	0.7190	-4.417359	0.0067*
ENPL	-0.059983	0.9932	-5.349621	0.0006*
	PP Unit Root Test at Level		PP Unit Root at First Difference)	
	T statistic	Probability	T statistic	Probability
RGDP	-1.772061	0.6966	-3.212277	0.0190**
ELC	-1.838945	0.6641	-5.609416	0.0003*
INF	-3.376883	0.0710	-6.574037	0.0000*

	ADF Unit Root Test at Level		ADF Unit Root Test at First Difference	
Variables	T statistic	Probability	T statistic	Probability
INP	-1.122290	0.9106	-4.297919	0.0090*
ENPL	0.051360	0.9954	-5.348255	0.0006*

Source: Author's Computation, 2023
Note: * & ** indicate Stationary at 1% and 5% significance, respectively.

Table 2 presents the unit root tests using ADF and PP with trend and intercept. ADF unit root tests indicate that RGDP and INF were stationary at 1% and 5% significance levels. At the same time, ELC, INP, and EMP were stationary at the first difference at a 1% level of significance and a 5% energy level at the first difference. The results of PP unit root tests show that all the series under study except RGDP were stationary at the first difference at a 1% significance level. In comparison, RGDP was stationary at the first difference at a 5% significance level. Therefore, an examination of Table 2 reveals that the series are a mixture of the order of integration as some variables were stationary at the first difference and are thus characterized as *I (1)* processes, while others were stationary at the level and are thus characterized as *I (0)* process. This mixture of *I (1)* and *I (0)* processes justified using the ARDL model in this research to check the cointegration due to its advantage over other estimators. As one of the requirements for using the ARDL model is that some variables should be *I(0*) while other variables should be *I(1),* and none of the variables should be *I(2)*. Since the variables were found to have characteristics of both I(0) and I(1), the next step of the study estimates the short-run and long-run elasticity based on the optimal lag model ARDL (2,2,1,1,1) selected using the Akaike information criterion shown in figure 1.

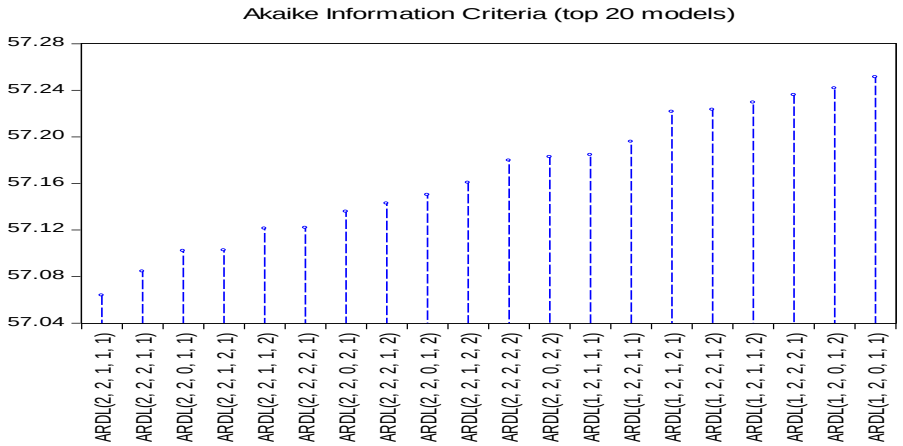

Figure 1. Model selection using Akaike Information Criterion
Source: Author's Computation, 2023.

After selecting the optimal lag model for the ARDL regression analysis, this research examines the cointegration among the variables using the ARDL bounds test

based on the null hypothesis of no long-run relationship. Evidence from Table 2 shows that the F-statistic value (11.33> I1 Bound) lies above the upper bound critical values at 10%, 5%, 2.5%, and 1%, rejecting the null hypothesis of no long-run relationship exists at the 1% level of significance and concluded that, the variables under study are co integration in the long run. This finding is consistent with Nathaniel and Bekum's[37] results for Nigeria, who also used the ARDL bounds test to confirm a significant long-run relationship among their variables of interest in Nigeria, and Rahman's[38] for the top electricity-consuming countries, who found evidence of cointegration between electricity consumption and economic growth for the top consuming countries using the ARDL model.

The cointegration analysis in this study using the ARDL bounds test confirms a long-run relationship among the variables under study, which is consistent with previous research in the field. Additionally, the findings of this study revealed a positive impact of electricity consumption on economic growth, supporting the energy-growth nexus for Nigeria. The ARDL bounds test was used to examine the cointegration relationship among the variables of this research, and it confirmed a significant long-run relationship at the 1% level of significance. The results of this study contribute to the existing literature that highlights the importance of considering the energy-growth nexus in developing countries such as Nigeria.

Table 3. ARDL Bounds Test

F-statistic	Significance	I0 Bound	I1 Bound	Null Hypotheses
11.32924	10%	2.2	3.09	No long-run relationship
K=4	5%	2.56	3.49	
	2.5%	2.88	3.87	
	1%*	3.29	4.37	

Note: *Denotes rejection of the null hypothesis at a 1% significance level
Source: Author's Computation, 2023.

Since the variables are cointegrated, the study estimated the short-run and long-run elasticity, shown in Table 3. The result indicates that the speed of adjustment [ECT (-1) = -0.01 with P- Value =0.0000] is negative and statically significant at 1%, confirming

[37] Nathaniel and Bekun, 'Environmental Management amidst Energy Use, Urbanization, Trade Openness, and Deforestation: The Nigerian Experience'; Nathaniel and Bekun, 'Electricity Consumption, Urbanization, and Economic Growth in Nigeria: New Insights from Combined Cointegration amidst Structural Breaks'.

[38] Rahman, 'Environmental Degradation: The Role of Electricity Consumption, Economic Growth and Globalisation'.

the expected equilibrium process in the short-run dynamics among the variables under study.

Table 3 presents both the short-run and long-run dynamics of the ARDL model. The result reveals that in the short run, Electricity Consumption (ELC), Inflation (INF), and Industrial Product (INP) are statistically significant at a 1% level and have a positive impact on Economic Growth (RGDP) in Nigeria. In comparison, Unemployment (UNPL) is statistical significance at a 1% level and has adverse effects on Economic growth in Nigeria respectively. In the long run, also, the results reveal Electricity Consumption (ELC), Inflation (INF), and Industrial Product (INP) are statistically significant at 1% and 5% levels of significance and have a positive impact on Economic Growth (RGDP) in Nigeria.

These findings are consistent with the results of Lawal et al.[39] for Sub – Sahara African Countries, Chen et al.[40] in 103 countries, and Bekun and Agboola[41], who found similar relationships between electricity consumption, inflation, industrial production, and economic growth. This study estimates short-run and long-run elasticities using the ARDL Bounds Test, which confirms the expected equilibrium process in the short run. However, this finding is inconsistent with the findings of Majeed et al.[42], who found no significant relationship between electricity consumption and economic growth.

This study conducted the ARDL Bounds Bounds ARDL in Pakistan, which found no significant relationship between electricity consumption and economic growth. This study conducted the ARDL Bounds Test to estimate the short-run and long-run elasticities of electricity consumption, inflation, industrial product, and unemployment on economic growth in Nigeria.

This study utilizes ARDL methodology to examine the short-run and long-run dynamics between electricity consumption, inflation, industrial product, unemployment, and economic growth in Nigeria. These study on the determinants of economic growth in Nigeria showed that unemployment has a negative impact. Analysis conducted using the Autoregressive Distributed Lag model shows that this variable is statistically significant at the 5% level for both short-run and long-run dynamics. However, other

[39] Lawal et al., 'Examining the Linkages between Electricity Consumption and Economic Growth in African Economies'.

[40] Chen, Pinar, and Stengos, 'Renewable Energy Consumption and Economic Growth Nexus: Evidence from a Threshold Model'.

[41] Bekun and Oluwatoyin Agboola, 'Electricity Consumption and Economic Growth Nexus: Evidence from Maki Cointegration'.

[42] Majeed et al., 'Asymmetric Effects of Energy Consumption and Economic Growth on Ecological Footprint: New Evidence from Pakistan'.

variables such as electricity consumption, inflation rate, and industrial products have a positive impact on economic growth.

Further investigation using the ARDL limit test approach to cointegration showed a significant relationship between these explanatory variables and economic activities of interest in Nigeria. Specifically, it was found that an increase in electricity consumption results in higher levels of industrial production which in turn boosts the overall level of output in the economy.

Additionally, high inflation rate adversely affects mainly by reducing the purchasing power of consumers thereby limiting their ability to access locally offered goods to the detriment of business profit margins.

Overall, these findings suggest that policymakers should prioritize increasing employment opportunities while ensuring continued investment to encourage efficient use of energy in industries, as well as making policies aimed at reducing inflationary pressures - all important efforts needed to support the acceleration of socio-economic development goals in different parts of the Nigerian economy over time.

Table 4. ARDL Cointegration Result

Cointegrating Form

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(RGDP(-1))	-0.3015460	0.102427	2.944020	0.0075*
D(ELC)	27.990525	7.219131	4.650730	0.0000*
D(INF)	28.751821	8.675961	4.875302	0.0000*
D(UNPL)	-28.639401	8.394091	-5.365091	0.0000*
D(INP)	1.494065	0.232059	6.438286	0.0000*
CointEq(-1)	-0.010698	0.001171	-9.133698	0.0000*

Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ELC	2.890612	0.257562	3.522640	0.0004*
INF	2.926642	0.676351	4.246022	0.0000*
UNPL	-4.275013	2.064876	-2.151662	0.0159**
INP	7.717521	3.342125	3.335850	0.0202**

*&** indicate statistical significance at 1% and 5% level
Source: Author's Computation, 2023.

To determine the appropriateness and adequacy of the ARDL model, the study conducts some robust diagnostic tests; this includes a serial correlation test, heteroscedasticity test, misspecification of the model test, normality tests, and parameter stability tests. After estimating the ARDL regression, the next step is to determine the appropriateness of the ARDL model. The study conducts some diagnostic tests (e.g., serial correlation, heteroscedasticity, and normality tests) and parameter stability tests to examine the "independence" of the residuals in the ARDL model by employing the "Harvey Heteroskedasticity Test" to test for Heteroskedasticity problems, the "Breusch–Godfrey Serial Correlation LM Test" to push for serial correlation, the "Ramsey Test" to test for equation misspecification and the "Jarque–Bera Test" to test for normality of the variables. Evidence from Table 4 reveals that the residuals in the ARDL model have no Heteroskedasticity problems, exhibit no serial correlation, no misspecification (i.e., in its functional form), and are typically distributed. These tests show in Table 4 and Figure 2 below.

Table 5. Post Estimation Test

Diagnostics Check	F- STATISTIC	Prob.	Null Hypotheses
Harvey Heteroskedasticity Test	1.560597	0.1862	No Heteroskedasticity
Breusch-Godfrey Serial Correlation LM Test	1.489113	0.2450	No Serial correlation
Ramsey RESET Specification Test	1.380772	0.1812	No specification error

Source: Author's Computation, 2023.

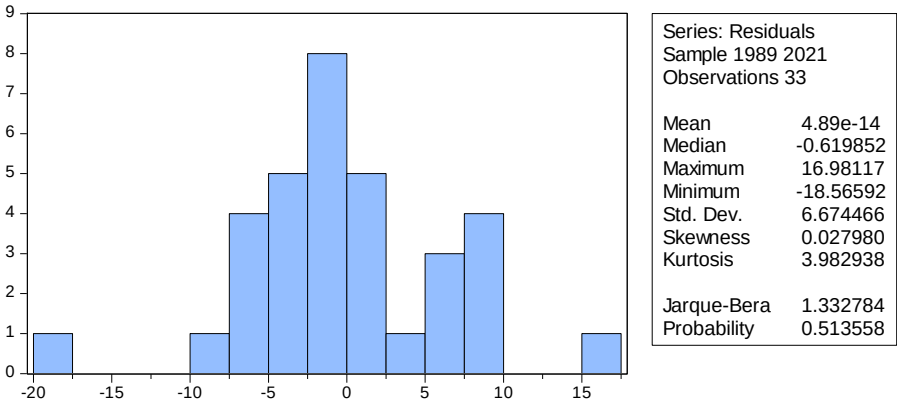

Figure 2. Normality Test
Source: Author's Computation, 2023

To check the stability and adequacy of the ARDL approach, the research analyses the reliability of the cointegration by using Cumulative sum of recursive residuals (CUSUM) and cumulative sum of squares of recursive residuals (CUSUMSQ) Tests. As mentioned in the methodology, the cumulative sum (CUSUMSQ) test tests the

randomness of a sequence of zeros and ones (Data plot to convert a data set with exactly two distinct values to a series of zeros and ones). For this test, the zeros to negative ones. The test is based on the maximum distance from zero of a random walk defined by the cumulative sum of the sequence. An ample enough space is indicative of non-randomness, while the cumulative sum of squares (CUSUMSQ) tests are based on the recursive regression residuals

Figure 3 reveals that both CUSUM and CUSUM of squares are within the 5% significance level; thus, ARDL model is robust, stable, and adequate in its form.

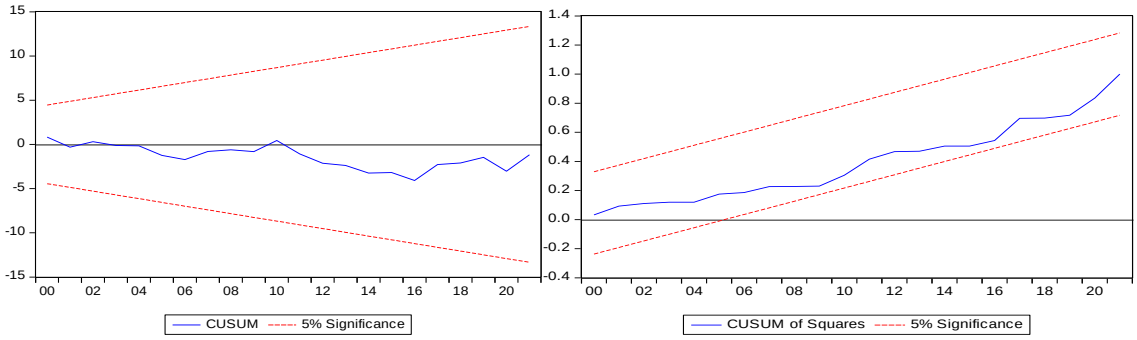

Figure 3. Stability Checks
Source: Author's Computation, 2023.

CONCLUSION

This paper investigated the causal relationship between electricity consumption and economic growth in Nigeria by employing the ARDL bounds testing procedure to identify the long-run equilibrium relationship. The study appoints electricity consumption, industrial production, inflation rate, and employment as intermittent variables to form a multivariate framework covering the period between 1996 and 2021. The results from the ARDL bounds test reveal a long-run relationship between economic growth, electricity consumption, industrial product, inflation rate, and Unemployment. The coefficients on electricity consumption, Industrial Product, and inflation rate are positive and significant, meaning that an increase in these variables boosts economic growth. On the contrary, the coefficient of Unemployment is negative and significant, meaning that Unemployment retard economic growth in Nigeria.

Based on the findings, the paper recommends that the government undertake serious measures to curtail the shortage of electricity consumption in the country to promote economic growth by introducing other energy sources. The government should adopt appropriate policies to reduce Unemployment, hurting economic growth. Similarly, the government should encourage other means of electricity sources by using

both private and public enterprises in the country to mitigate the electricity problem in the economy.

DISCLOSURE

Conflicts of Interest

The author declares that there is no conflict of interest regarding the publication of this paper.

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Author Bio note

My name is Badamasi Sani Mohammed, an Economics instructor with over three years of experience in a university setting. My research primarily concentrates on Development Economics. In addition, I possess a robust background in higher education, with over fifteen years of experience dedicated to the instruction of Economics.

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