



POLAC INTERNATIONAL JOURNAL OF ECONS & MGT SCIENCE (PIJEMS)
DEPARTMENT OF ECONOMICS & MANAGEMENT SCIENCE
NIGERIA POLICE ACADEMY, WUDIL-KANO



IMPACT OF ELECTRICITY GENERATION ON INDUSTRIAL SECTOR OUTPUT IN NIGERIA

Mande Muhammad

Department of Economics, Nigerian Defence Academy, Kaduna

Mustapha Muktar

Department of Economics, Bayero University Kano

Jude Ikubor

Department of Economics, Bayero University Kano

Abstract

Electricity is a critical driver of industrial productivity, particularly in emerging economies like Nigeria, where the industrial sector plays a pivotal role in economic diversification and development. Despite being Africa's largest economy, Nigeria faces significant energy challenges, with inadequate and unreliable electricity generation severely affecting industrial output. Consequently, this study examined how electricity generation (disaggregated into fossil fuels and hydro) impacts industrial sector performance. The study utilized annual time series data generated from the annual report of the Central Bank of Nigeria Statistical Bulletin, United States Energy Information Administration, World Development Indicators, and KNOEMA from 1981 to 2023. The study employed the Autoregressive Distributed Lag (ARDL) model. The result obtained shows that, in the long run, electricity generation using fossil fuels has a positive and statistically significant relationship with industrial sector output ($t = 3.47$, $P < 0.05$). In contrast, hydro has a negative and insignificant relationship with industrial sector output ($t = -0.46$, $P > 0.05$). However, the short-run results reported positive but insignificant relationships between fossil fuels ($t = 0.35$, $P > 0.05$) and hydroelectricity ($t = 0.49$, $P > 0.05$) with industrial output in Nigeria. The findings revealed that despite the abundance of other sources of energy in Nigeria, fossil fuels remain the major source of energy responsible for industrial sector output in Nigeria. The study suggests that to improve the impact of electricity generation on Nigeria's industrial sector output, a comprehensive strategy should focus on expanding the power generation capacity, modernizing the transmission infrastructure, and promoting energy efficiency.

Keywords: Electricity Generation, Fossil Fuels, Hydro, Industrial, Output, ARDL

1. Introduction

Apart from labour and capital, another significant factor that can impact a nation's industrial sector output is the availability of electricity (Henry et al., 2021). Nigeria can generate over 13,000 MW of electricity when its generation capacity is fully utilized, however, because of various inefficiencies and infrastructural deficiencies, only 4,000–5,000 MW of that energy can be distributed to homes and businesses (KPMG, 2021). In 2021, the World Bank Group estimated that around 43% of Nigerians, or 85 million people, had access to electricity, with many regions suffering from frequent power outages and load shedding. Nigeria has abundant energy resources, including renewable energy sources like

hydropower, solar power, wind power, and biomass, as well as fossil fuels like coal, natural gas, and oil (Ogundipe, 2013). Effective use of these resources might greatly increase the production of electricity, and, consequently, industrial productivity.

As of 2023, the industrial sector in Nigeria contributed approximately 24.7% of the country's GDP, making it a vital component of the country's economy (The Cable, 2023). The industry, which includes mining, manufacturing, construction, and utilities, employs millions of people and promotes economic diversification. However, the insufficient and unstable electricity supply seriously hinders the sector's ability to grow and compete. One important area for economic growth and development has been recognized as the

manufacturing sub-sector in particular. Nigerian manufacturing companies, however, have several electricity-related difficulties, such as recurrent blackouts, expensive self-generation, and variable power supply quality. These problems lower productivity and competitiveness domestically and globally, raising the cost of operations.

Several studies have highlighted the significant impact of electricity availability on the performance of small-scale businesses in Nigeria. Power outages and the ensuing reliance on expensive backup generators negatively impact the profitability and growth of these businesses, hindering their ability to contribute to the country's economic development. Consistently available and affordable electricity is a critical factor for Nigeria's future economic growth and sustainable development (Raji & Jimoh, 2022).

While Nigeria is blessed with abundant energy resources, a lack of strategic planning and investment in the electricity sector has hampered the country's ability to harness this potential. Addressing the electricity crisis in Nigeria through a comprehensive and long-term approach, including investment in grid-based and off-grid electrification solutions, could significantly boost the country's GDP growth by empowering businesses, industries, and households (Nwatu & Ezenwa, 2020). The most obvious effect of insufficient electricity generation is that industrial companies have to pay more for production. Many companies significantly rely on alternate sources of electricity, mainly diesel and petrol generators, due to the unreliability of grid power. An 87% increase in just one year has been reported in the cost of self-generating electricity, from ₦77.22 billion in 2021 to ₦144.5 billion in 2022, according to research by the Manufacturers Association of Nigeria (MAN). This heavy reliance on costly self-generation drives up manufacturing costs dramatically, which as a result, fuels unemployment and inflation. For example, the NBS pointed out that in 2022, the manufacturing sector's share of Nigeria's GDP was a pitiful 6.93%, illustrating the negative impact of power supply problems on industrial productivity.

Acknowledging the indispensable function of electricity in the advancement of industry, the Nigerian government has launched multiple initiatives to enhance

the production and distribution of energy. The unbundling of the National Electric Power Authority (NEPA), the establishment of the Power Holding Company of Nigeria (PHCN), and the subsequent privatization of the generation and distribution companies were all made possible by the Power Sector Reform Act of 2005, which was a major step towards restructuring the electricity sector. By promoting competition and private sector involvement, the Electricity Act 2023 aims to liberalize the power industry further. Another move to improve Nigeria's electrical supply was the recent elimination of electricity subsidies, which caused price hikes for Band-A consumers from ₦66 to ₦225 per kilowatt-hour (The Cable, 2024).

The performance and sustainability of Nigeria's industrial sector are closely associated with the efficiency of the nation's electricity generation. Improving industrial productivity, cutting operating costs, and accelerating the country's overall economic growth depends on resolving the power supply issues. In light of this, the purpose of this study is to examine the impact of electricity generation on Nigeria's industrial sector output.

2. Literature Review

2.1 Theoretical Framework: Neoclassical Growth Model

The neoclassical or endogenous theory was propounded by economists like Romer (1986). The theory is an improvement in the traditional Solow Growth model where technology is not considered an important factor that exerts influence on growth in the economy. The theory supports the second law of thermodynamics which states that a minimum quantity of energy is required to carry out the transformation of matter. This implies that renewable and non-renewable energy generation is an essential factor of production that can boost industrial sector production and output in the economy. The neoclassical growth theory takes the form of the conventional Cobb-Douglas production function which is expressed as follows:

$$Y = AK^{\alpha}L^{\beta} \quad (1)$$

The model shows that K represents the stock of capital, L is the stock of labour, A denotes the level of technological progress, and α and β are measures or

coefficients of the factor inputs elasticity. Therefore, since A is endogenously determined in the new growth model, it is thought to relate to energy in some way. Hence, A represents energy generation because the amount of technology per unit of time requires some energy. Thus, technology in this context refers to plants, machinery and equipment that without adequate generation and supply of energy; this technological stock will be obsolete. In other words, it is energy that determines the efficiency of the capital component of the function model. This is justified by the law of thermodynamics which holds that no production can occur without energy conversion. This implies that the level of output of the industrial sector in Nigeria depends on the amount of both renewable and non-renewable energy generated and consumed. Technically, it follows that energy generation will have a positive effect on the output level of Nigeria's industrial sector.

2.2 Empirical Literature

Eze (2024) investigated the impact of gasoline and renewable energy consumption on the production output of Nigeria's manufacturing industry from 1990 to 2022, utilizing data sourced from the Central Bank of Nigeria's Statistical Bulletin and the World Development Indicators. The research utilized the Auto-Regressive Distributed Lag (ARDL) model for its analytical approach. The ARDL Bounds co-integration test indicated the existence of a long-term relationship among the variables chosen for the analysis. The results indicate that gasoline use has a slight positive effect on manufacturing production in the short term, but it considerably undermines it in the long term. Conversely, the impact of renewable energy on manufacturing output is minimal, although it remains positive in both the short and long term.

Awujola et al. (2023) the study used annual time series data on hydro-electricity, petroleum and gas energy respectively as components of non-renewable energy in Nigeria spanning from 1986 to 2022 to study the effect of non-renewable energy on manufacturing output. The ARDL regression technique was used. The result showed that coal and petroleum energy consumption had no significant negative impact on manufacturing output. Furthermore, gas energy

consumption had a significant positive effect on textile and clothing output in Nigeria. Using data from 1980 to 2019, Ene et al. (2022) examined the effect of Nigeria's electricity supply on the manufacturing sector. The output of the manufacturing sector is negatively and insignificantly correlated with the supply of electricity, according to the autoregressive distributed lag (ARDL) model's results.

Using data from 1981 to 2019, Lawal and Owoicho (2021) investigated the effect of power usage on the manufacturing sector performance in Nigeria using the vector error correction model (VECM) Johansen cointegration technique. The outcome showed a negative correlation between manufacturing production and electricity usage. According to the study's findings, the manufacturing sector's growth has been impeded by inadequate electricity supplies.

The long-term impact of power consumption on the manufacturing sector's performance (output) in Nigeria was examined by Asaleye et al. in 2021. Data from 1981 to 2019 were used in the study, which employed the canonical cointegration regression approach. The outcome demonstrated that credit to the manufacturing sector and electricity usage has a negative impact on output. The investigation concluded that the availability of electricity as a manufacturing input has not enhanced industry performance. It was suggested that by optimizing productivity and eliminating waste, a framework for promoting energy efficiency in the industry be put into place.

The autoregressive distributed lag model was used by Agbede and Onuoha (2020) to investigate the effect of Nigeria's energy supply and consumption on industrial production using data spanning from 1981 to 2017. The results demonstrated that industrial output is positively impacted by the availability of electricity and a one-period lag in electricity generation.

Using ordinary least square (OLS) and Granger causality methodologies, Kassim and Isik (2020) investigated the relationship between Nigeria's industrial growth and energy consumption between 1985 and 2017. The findings indicated a positive but insignificant correlation between the expansion of the industrial sector and power consumption. Furthermore, the outcome

demonstrated a one-way causal relationship between growth and power usage.

Adelegan and Otu (2020) examined how Nigeria's industrial output was affected by its electricity consumption. The study used data from 1980 to 2018 and the autoregressive distributed lag (ARDL) approach. The findings showed that the consumption of gas, electricity, and petroleum products had a direct and significant impact on industrial output over both the short and long runs. In the short run, however, there was little to no correlation between industrial output and electricity use..

Amadu and Samuel (2020) used data from 1977 to 2014 to assess the long-term impact of electricity supply on the manufacturing sector performance in Cameroon using a fully modified ordinary least square technique. The outcome showed a long-term, strong positive link between the manufacturing sector's output and the electricity supply.

Using data from 1981 to 2018, Iwashokun et al., (2020) evaluated different sources of energy supply and manufacturing production in Nigeria using the autoregressive distributed lag (ARDL). The outcome demonstrated a short- and long-run positive-significant relationship between manufacturing production and hydroelectricity and gas; coal was found to be positive and statistically significant in the short run but positive and insignificant in the long run at a 5% significance level. Furthermore, the outcome demonstrated that every energy source contributed to the manufacturing output. Using data from 1980 to 2018, Ekene and Mbobo (2019) employed the ordinary least squares (OLS) technique to investigate the impact of power outages on the performance of Nigeria's industrial sector. The outcome demonstrated that the availability of electricity significantly and positively affects manufacturing output. Stabilizing the exchange rate was advised to prevent shocks that could impact the cost of imported machinery that energy-generating organizations utilize. Using data from 1981 to 2016, Iwashokun (2019) evaluated different sources of energy supply and manufacturing production in Nigeria using the autoregressive distributed lag (ARDL) and Toda-Yamamoto methodologies. The outcome demonstrated a short-run and long-run positive-significant relationship

between manufacturing production and hydroelectricity, gas, and coal. Furthermore, the outcome shows that every energy source utilized contributed to the industrial output.

Olamide (2019) investigated the relationship between Nigerian national development and electricity generation between 1981 and 2016. The Auto regression distributed lag (ARDL) bound test was used in the investigation. The study found that the production of electricity had a negative impact on both the short- and long-term growth of a country. These findings have policy implications for the Nigerian government, which include increasing the country's drive towards electricity generation sufficiency, maintaining an investment-friendly environment, and adopting a more varied mix of electricity energy generation sources that have the potential to spur industrialization and further the desired national development for the country's economy in the nearest future.

Similarly, Akinbola et al. (2017) employed data from 1981 to 2010 to examine the relationship between electricity supply and industrial development in Nigeria using the Johansen cointegration technique and the vector error correction model (VECM). The outcome showed that industrial development and power supply are positively correlated.

Using data from 1980 to 2014, Ugwoke et al. (2016) examined the impact of Nigeria's electricity supply on industrial output. The estimating method employed in the study was the error correction model. The outcome demonstrated the negative effects of trade openness and electricity supply on industrial output.

Considerable research has been conducted on Nigeria's epileptic electrical generation/supply and its impact on the production of the industrial or manufacturing sector but with varying outcomes. Some reveal a positive and significant relationship like Akinbola et al. (2017), Ekene and Mbobo (2019); Ibrahim et al. (2017), Onwe and King (2020); Ugwoke et al. (2016), others found a positive but insignificant relationship (Agbede & Onuoha, 2020; Chinedum & Nnadi, 2016; Kassim & Isik, 2020), studies of (Olamide, 2019; Asaleye et al. 2021; Lawal & Owoicho, 2021; Ene et al. 2022) identified a negative relationship.

In light of this, this study added to the current discussion by examining how Nigeria's industrial sector output is impacted by electricity generation. This study contributed to the body of literature in two ways: (1) by addressing the issue of low productivity in the nation's industrial sectors as a result of inadequate electricity generation; and (2) by addressing the question of how to employ electricity generation base on its sources (renewable and non-renewable) to promote industrial growth.

3. Methodology

This study examined the impact of electricity generation on Nigeria's industrial sector using annual time series data from 1981 to 2023. This time frame was selected because data were available and the 2005 electric power reform occurred during this time. Table 1 highlights the description of variables, their sources, and a priori expectations.

Table 1: Description of variables, sources and a priori expectation

Variable	Description	Source	A priori expectation
Industrial Sector Output (IND)	Total industrial sector output (crude petroleum and construction and manufacturing) at 2010 constant basic prices in millions of naira	Natural gas, Central Bank of Nigeria Statistical Bulletin	Dependent Variable
Electricity Generation via Fossil Fuel (FOS)	General term for non-renewable energy sources such as coal, natural gas, crude oil, petroleum products and non-renewable wastes measured in billion kilowatts.	US Energy Information Administration	Positive
Electricity Generation via Hydro (HYD)	Electricity is generated using the natural flow of moving water; it is one of the oldest and largest sources of renewable energy in Nigeria. It is measured in billion kilowatts.	US Energy Information Administration	Positive
Gross fixed Capital Formation (GFCF)	Gross fixed capital formation is measured by the total value of a producer's acquisitions, less disposals of fixed assets during the accounting period 2015 constant basic prices in millions of naira.	Knoema	Positive
Population Growth Rate (PGR)	This is the proxy for the labour force. The annual population growth rate for year t is the exponential rate of growth of the midyear population from year t-1 to t, expressed as a percentage.	World Development Indicators	Positive

3.1 Model Specification

This study adapted the model of Awujola et al. (2023) which stated that the relationship between the disaggregated components of non-renewable energy includes; Petroleum Energy Consumption (PEC), Coal Energy Consumption (CEC) and Gas energy consumption (GEC) and textile and clothing manufacturing sector outputs (TCO). Awujola et al. (2023) model takes the following form:

$$TCO = f(PEC, CEC, GEC) \quad (2)$$

In this study, electricity generation was disaggregated into non-renewable represented by fossil

fuel (FOS) and renewable represented by hydro (HYD). This is significant because it illustrates how the industrial sector is impacted by electricity generation, depending on the two major sources utilized in Nigeria. Thus, the following is the model that informed this study:

$$IND = f(FOS, HYD, GFCF, PGR) \quad (3)$$

Equation 4 is obtained by taking the log of Equation 3 and converting it into an economic regression model that needs to be estimated.

$$\ln IND_t = \alpha_0 + \alpha_1 \ln FOS_t + \alpha_2 \ln HYD_t + \alpha_3 \ln GFCF + \alpha_4 PGR_t + \varepsilon_t \quad (4)$$

Where $\ln IND_t$ is the log of industrial sector at time t , $\ln FOS_t$ is electricity generation using fossil fuel at time t , $\ln HYD_t$ is electricity generation using hydro at time t , $\ln GFCF_t$ is the log of gross fixed capital formation at time t , PGR_t is the population growth rate at time t , α_0 to α_3 are parameters to be estimated, and ε_t is the error term at time t .

4. Results And Discussion

4.1 Descriptive Statistics

Before testing the stationarity property of the variables, the study checked their descriptive statistics to ascertain the distribution of the data.

Table 2 describes the properties of the data for the estimation period. It is observed that Industrial sector output (IND) ranges between 9.02 and 9.73 with a mean growth rate of 9.40 average growth rate and a standard

deviation of 0.21, IND is negatively skewed. Fossil fuel (FOS) has an average of 2.56 with a range between 1.71 and 3.37 with a positive skewness. The median of HYD is 1.74 with a range between 0.62 and 2.13 growth rate of and a standard deviation of 0.38. HYD, however, is negatively skewed. It is further observed that GFCF ranges between 8.93 and 9.95 with an average point of 9.33 and a standard deviation of 0.22 and a positive skewness. Moreover, PGR is also observed with a mean rate of 2.61 and ranging between 2.38 and 3.00. It is positively skewed with a standard deviation of 0.13. The highest maximum and lowest minimum values of the variables are GFCF (9.95) and HYD (0.62) respectively. The maximum and minimum values for each measure suggest that their performances vary substantially. The Jarque- Bera statistics suggest that all variables are normally distributed at 5% significance level.

Table 2: Descriptive Statistics

	IND	FOS	HYD	GFCF	PGR
Mean	9.397790	2.562215	1.686654	9.336461	2.606977
Median	9.371898	2.544433	1.744144	9.317087	2.587000
Maximum	9.725685	3.366088	2.132153	9.949883	3.003000
Minimum	9.018666	1.713618	0.618424	8.925517	2.380000
Std. Dev.	0.206543	0.547551	0.379720	0.216909	0.129679
Skewness	-0.20751	0.136397	-1.12724	0.347175	0.629193
Kurtosis	1.886681	1.513886	3.632977	3.100417	3.774085
Jarque-Bera	2.529342	4.090286	9.824288	0.881868	3.910744
Probability	0.282332	0.129362	0.007357	0.643435	0.141512
Sum	404.1050	110.1753	72.52611	401.4678	112.1000
Sum Sq. Dev.	1.791722	12.59209	6.055878	1.976071	0.706301
Observations	43	43	43	43	43

Source: Computed by Authors using Eviews 10, 2024.

4.2. Unit Root Test of Stationarity

Table 3: Augmented Dickey-Fuller (ADF) Unit Root Results

Variables	Level	Prob.	At First Difference	Prob.	Order of Integration
IND	-3.336948	0.0743	-5.425400	0.0003	I(1)
FOS	-2.250385	0.4506	-7.803070	0.0000	I(1)
HYD	-2.571695	0.2945	-7.308544	0.0000	I(1)
GFCF	-7.790654	0.0000	-	-	I(0)
PGR	-1.394003	0.8457	-11.22235	0.0000	I(1)
CRITICAL VALUE AT 5%		-3.520787			

Source: Computed by Authors using Eviews 10, 2024.

The unit root results shown in Table 3 indicated that all the variables are stationary after the first difference except the Gross Fixed Capital Formation (GFCF), which was stationary at the level. This suggests that the variables are integrated of order $I(0)$ and $I(1)$ since the test statistic at the first difference is larger than the crucial value at the 5% significance level. The probability values that are obtained after differentiating the variables also support this. Each of these values is below 0.05%. This suggests that the cointegration tests of Johansen (1988), Engel-Granger (1987), and

Johansen-Juselieus (1990) cannot be applied to determine if the variables in this study have a long-term connection. This is because all the variables must be stationary at first difference according to the cointegration tests stated above and GFCF, which is stationary at level prohibits us from applying them.

After determining the order of integration, the study used the ARDL bounds testing approach for cointegration to determine whether the variables employed in the study had a long-term relationship. Table 4 presents the obtained result.

Table 4: ARDL Bounds Test for Cointegration

Table 4: ARDL Bounds Test for Cointegration		
Test Statistic	Value	K
F-statistic	3.714543*	4
Critical Bound Values		
Signif.	I(0)	I(1)
10%	2.2	3.09
5%	2.56	3.49
2.50%	2.88	3.87
1%	3.29	4.37

Source: Computed by Authors using Eviews 10, 2024.

* indicates that the F-statistics falls above the upper bound value at a 5% level of significance

The findings of the ARDL bounds test for cointegration for the research are displayed in Table 4. Comparing the computed F-statistic value to the critical value is the first step in this process. Consequently, at the 5% significance level, the estimated F-statistic of 3.714543, calculated at $k=4$ (number of explanatory variables), is above the upper critical bound of 3.49. Thus, the null hypothesis—that there is no long-run link between the variables—is rejected. This suggests that the variables have a long-term relationship.

4.4 Dynamic ARDL Relationships

After determining that the variables in the model have a long-run relationship, the next stage is to look at the short-run and long-run impact of generating electricity on the industrial sector. Tables 5 and 6 present the findings.

Table 5 displays the equation's short-run coefficients. As can be seen, the estimate of the second-year lag value of fossil fuel-generated electricity (FOS) is statistically

significant at 5%. Additionally, the output of the industrial sector is greatly impacted in the short run by the one- and two-year lag values of energy generated via hydropower (HYD) and the current and third-year lag values of the population growth rate (PGR). It appears that HYD has a greater short-run influence on industrial sector output than FOS. It is crucial to remember that the current values of electricity generation from hydropower (HYD) and fossil fuels (FOS) are not statistically significant and that the output of the industrial sector is adversely correlated with the one- and two-year lag values of FOS. This is made possible by Nigeria's inadequate electricity generated and subsequently supplied, which forces businesses in the industrial sector to rely too much on self-generated electricity, such as generator sets. This raises production costs and raises the average price of goods and services in the nation.

Table 5: Error Correction Regression ARDL (1, 3, 3, 0, 4) Selected Automatically Based on Akaike Information Criterion Dependent Variable: D(IND)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(FOS)	0.026006	0.075231	0.345680	0.7327
D(FOS(-1))	-0.051939	0.078485	-0.661767	0.5147
D(FOS(-2))	-0.167769	0.073734	-2.275339*	0.0325
D(HYD)	0.027523	0.056359	0.488356	0.6299
D(HYD(-1))	0.141762	0.055913	2.535409*	0.0185
D(HYD(-2))	0.117277	0.048283	2.428973*	0.0234
D(PGR)	0.326583	0.157589	2.072369*	0.0496
D(PGR(-1))	0.094306	0.148538	0.634893	0.5318
D(PGR(-2))	0.124626	0.099916	1.247305	0.2248
D(PGR(-3))	0.386849	0.102602	3.770376*	0.0010
ECM(-1)	-0.413324	0.079350	-5.208869*	0.0000
R-squared	0.637549			
Adjusted R-squared	0.508102			
Durbin-Watson stat	2.105594			

Source: Computed by Authors using Eviews 10, 2024.

* indicates significance at a 5% level of significance

The electricity provided by fossil fuels has a negative coefficient during the second year, meaning that a 1% increase in it will, in the short run, reduce industrial output by about 17%. Conversely, all of the HYD's one- and two-year lag values are positive, meaning that a 1% increase in them will result in an increase in industrial output by 14% and 12%, respectively. A 1% rise in the present and third PGR values will result in a 33 and 39% increase in industrial output, respectively. Similarly, the present and third PGR values are positively connected with industrial output. In Nigeria, the short-run impact of gross fixed capital formation (GFCF) on industrial output is insignificant. This suggests that the short-run effect of GFCF, a measure of technological advancement, on industrial output is insignificant. This may be a result of the low degree of technological

advancement in the nation; even the ones that are now in use are either out-of-date or not operating at their best.

Lastly, the error correction term (ECM) coefficient satisfies the theoretical requirement that it should be statistically significant and negative. As a result, the error correction coefficient of -0.413324 indicated a slow transition rate from short-run disequilibrium to long-run equilibrium. This suggests that 41% of the industrial output's short-run disequilibrium is addressed. Similarly, the R-squared and Adjusted R-squared results showed that population growth rate (PGR), gross fixed capital formation (GFCF), and electricity generation using fossil fuels and hydropower (FOS and HYD) account for 64 and 50% of the variation in industrial production, respectively. The Durbin-Watson value, approximately 2.10, indicates that the model contains no indication of serial correlation.

Table 6: Estimated Long-run Coefficients ARDL (1,3,3,0,4) Selected Automatically Based on Akaike Information Criterion Dependent Variable: IND				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
FOS	0.300873	0.086724	3.469315*	0.0021
HYD	-0.105071	0.226819	-0.463238	0.6475
GFCF	0.431726	0.269543	1.601697	0.1229
PGR	0.648809	0.265386	2.444776*	0.0226

Source: Computed by Authors using Eviews 10, 2024.

* indicates significance at a 5% level of significance

Table 6 demonstrates that while the long-run coefficient for hydroelectric power generation (HYD) is negative and statistically insignificant, the long-run coefficient for fossil fuel electricity (FOS) is positive and statistically significant. Additionally, as indicated by their t-statistic and probability values at the 5% level, gross fixed capital formation (GFCF) is positive but not statistically significant. At the 5% significance level, the population growth rate (PGR) proxy for the labour force has a positive coefficient and is statistically significant. The outcome suggests that Nigeria continues to rely more on fossil fuels than on hydropower and other renewable energy sources to generate electricity.

This study's a priori anticipation is supported by the positive sign of the coefficient of electricity generation via fossil fuels (FOS). This suggests that a 1% increase in fossil fuel-based electricity generation will result in a 30% rise in industrial output in the long run. Nevertheless, since hydropower generation—the primary renewable energy source in Nigeria—turns out to be negative and statistically insignificant, it defies the a priori prediction. Due to Nigeria's inadequate electricity supply, enterprises in the industrial sector are forced to rely largely on self-generated electricity, such as generator sets, which drives up production costs and raises overall prices. In a similar vein, although statistically insignificant, the positive sign of the coefficient of gross fixed capital formation (GFCF) complies with the study's a priori expectations. On the other hand, over the long run, the population growth rate (PGR) is positive, statistically significant, and consistent with a priori expectations. This suggests that an increase in PGR of 1% will increase industrial

output by 65%. This demonstrates how labour is more important to Nigeria's industrial sector than capital. This demonstrates how the industrial sector in Nigeria relies more on labour than capital.

According to electricity generation using fossil fuels as utilized in this study, the findings of this study negate the discovery of Awujola et al. (2023) who found the components of coal and petroleum energy (non-renewables) in the manufacturing sector to be negative and insignificant. Similarly, the study also contradicts the studies of Ene et al. (2022), Lawal and Owoicho (2021), and Asaleye et al. (2021). However, the findings are in line with the findings of Agbede and Onuoha (2020), Kassim and Isik (2020), Adelegan and Otu (2020), Amadu and Samuel (2020), Ekene and Mbobo (2019).

On hydro, this study contradicts the findings of Iwashokun et al. (2020) and Iwashokun (2019) which revealed that the component of hydroelectricity generation is positive and significant in the short-run and long-run.

4.5. Diagnostic Tests

Residual normality test results are shown in Table 7. Given that the probability value of 0.4848 for Jarque Bera is greater than 0.05, the study accepts the null hypothesis, which states that the residual is normally distributed. Likewise, given the probability values of serial correlation and heteroskedasticity, at 0.2399 and 0.9491, respectively, exceed the 0.05 level of significance, the study likewise accepts the null hypothesis that neither of these variables exists. Since their probability values of 0.2399 and 0.9491 respectively, are greater than 0.05 level of significance.

Table 7: Diagnostic Tests

Test Type	Statistics	Prob.
Jarque-Bera Normality test	1.511995	0.4695
Breusch-Godfrey Serial Correlation LM Test:	1.388746	0.2714
Heteroskedasticity Test: Breusch-Pagan-Godfrey	0.479357	0.9278

Source: Computed by Authors using Eviews 10, 2024.

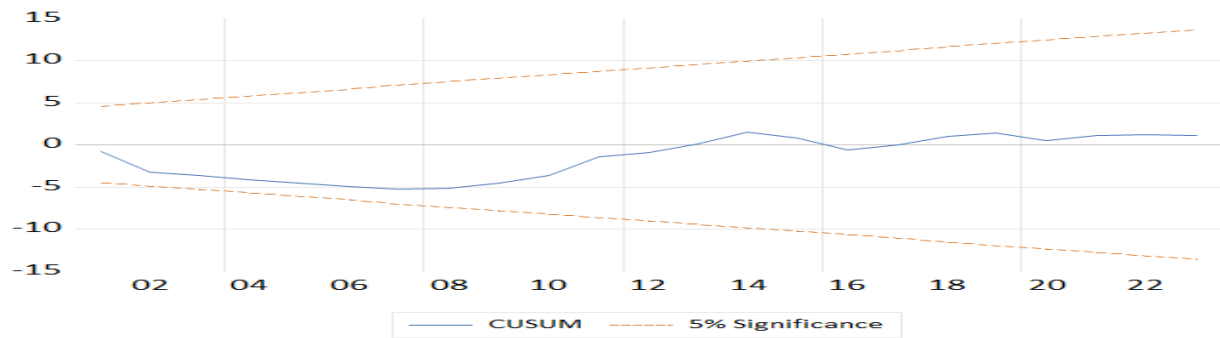


Figure 1: CUSUM residual test

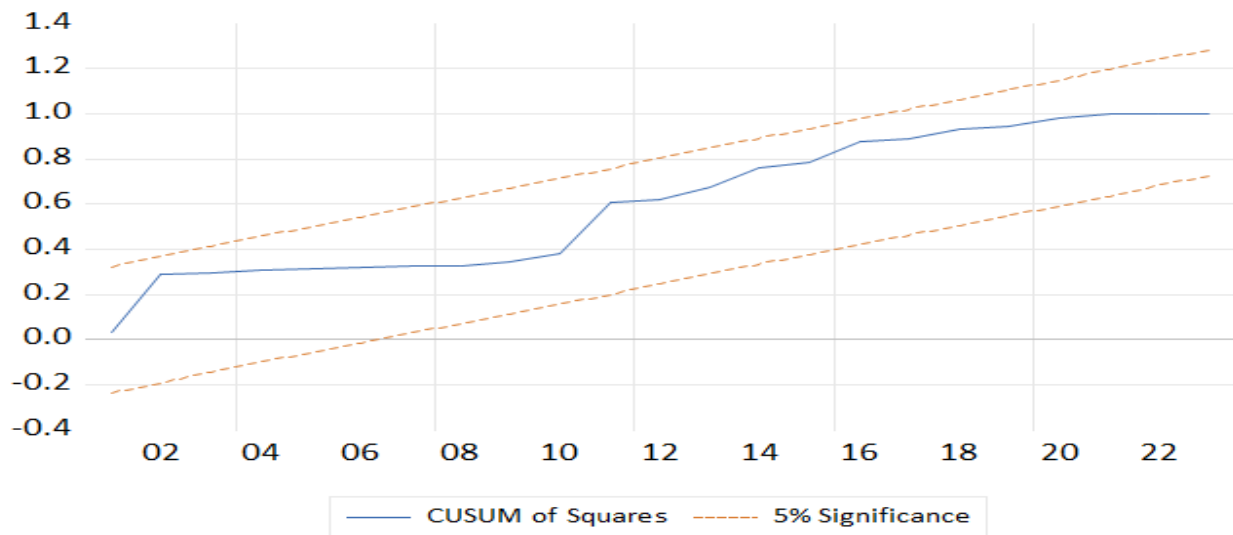


Figure 2: CUSUM of Squares Residual Test

4.6. Stability Test

Figure 1 and 2 presents the model stability test using the CUSUM and CUSUM of Squares Residual Tests. It can be seen that the result of the CUSUM and CUSUM of Squares stability test indicates that the model is stable. The model is stable because both the CUSUM and CUSUM of Squares lines fall in-between the two 5 per cent significance lines.

5. Conclusion and Recommendation

Using time series data spanning 1980 to 2022, this study empirically examined the relationship between electricity generation and industrial sector output in the Nigerian economy. The autoregressive distributed lag

model (ARDL) and the Augmented Dickey-Fuller (ADF) unit root were used to show and evaluate time-series data. The study discovered evidence of a long-run, statistically significant, and positive relationship between Nigeria's industrial output and the generation of electricity utilizing fossil fuels. Conversely, the study finds a statistically insignificant negative correlation between Nigerian industrial output and hydroelectricity generation.

Therefore, the study strongly suggests that consistent electricity generation, utilizing a renewable source, should be given priority for the industrial sector to operate as the engine of growth in the Nigerian economy and improve its outputs. In addition to

fostering the expansion of the industrial sector, this stable power supply would also lower production costs

and promote inclusive growth, this will in turn reduce Nigeria's inflation and unemployment problems.

Reference

- Adelegan, A. E., & Otu, E. (2020). Energy and industrial productivity in Nigeria: An insight from ARDL Approach. *East African Scholars Journal of Economics, Business and Management*, 3(5), 406-413. <https://doi.org/10.36349/EASJEBM.2020.v03i05.002>.
- Agbede, M. O., & Onuoha, F. C. (2020). Electricity consumption and industrial output in Nigeria. *International Journal of Arts and Social Sciences*, 1(2), 74-83.
- Akinbola, O. A., Zekeri, A., & Idowu, H. A. O. (2017). The power sector and its impacts on industrialization of businesses in Nigeria. *Archives of Business Research*, 5(12), 294-305.
- Akpan, G.E., Akpan, U.F. (2012), Electricity consumption, carbon emissions and economic growth in Nigeria. *International Journal of Energy Economics and Policy*, 2(4), 292-306.
- Amadu, I., & Samuel, F. (2020). Power supply and manufacturing growth: Evidence from Cameroon. *Energy Policy*, 147, 1-7.
- Asaleye, A. J., Lawal, A. I., Inegbedion, H. E., & Omowumi, A. (2021). Electricity consumption and manufacturing sector performance: Evidence from Nigeria. *International Journal of Energy Economics and Policy*, 11(4), 195-201.
- Awujola, A., Ezie, O., & Sunday, E. E., (2023). Effect of non-renewable energy on manufacturing output in Nigeria. *Asian Journal of Economics, Business and Accounting*, 23(21), 182-196.
- CBN, (2022). Central Bank of Nigeria Annual Statistical Bulletin, 1981-2022
- Chinedum, E. M., & Nnadi, K. U. (2016). Electricity supply and output in Nigerian Manufacturing sector. *Journal of Economics and Sustainable Development*, 7(6), 154 – 163.
- EIA US (2024). Data for electricity generation. Retrieved from: <https://www.eia.gov/international/overview/country/NGA>
- Ekene, O. E., & Mbobo, E. U. (2019). The impact of power outages on the performance of the manufacturing sector in Nigeria (1980-2018). *Sumerianz Journal of Economics and Finance*, 2(12), 169-177.
- Ene, E. E., James, T. H., Effiong, C. E., Ishaku, R. N., & Eduno, E. B. (2022). Electricity supply and manufacturing sector output in Nigeria. *Energy Economics Letters*, 9(1), 44-54 <https://doi.org/10.55493/5049.v9i1.4570>
- Eze, U. (2024). Impact of Gasoline and Renewable Energy Consumption on Manufacturing Sector Output in Nigeria: New Evidence from ARDL Model. Research Square. DOI: <https://doi.org/10.21203/rs.3.rs-4205989/v1>
- Henry, J. T., Ndem, B. E., Ujong, O. L., & Ihuoma, C. M. (2021). Electric power deficit and economic growth in Nigeria: A sectoral analysis. *International Journal of Energy Economics and Policy*, 11(6), 508-516.
- Ibrahim, S. S., Mukhtar, S., & Gani, I. M. (2017). Relationship between electricity consumption, manufacturing output and financial development: A new evidence from Nigeria. *Energy Economics Letters*, 4(3), 28-35.
- Iwashokun, A. F. (2019). *Energy sector development and manufacturing output in Nigeria (1981-2016)*. Being a Thesis Submitted to the Department of Economics, Faculty of Social Sciences, Obafemi Awolowo University, Ile-Ife-Nigeria.
- Iwashokun, A. F., Adejumu, A. V., & Olayiwola, A. S. (2020). Energy sector development and manufacturing output in Nigeria. *International journal of economics and finance issues*, 1(4), 217-235.
- Kassim, F., & Isik, A. (2020). *Impact of energy consumption on industrial growth in a transition economy: Evidence from Nigeria*. Germany: University Library of Munich.
- Knoema, (2024). Real gross fixed capital formation data.
- Lawal, E., & Owoicho, E. (2021). Impact of electricity consumption on manufacturing output in Nigeria. *Salem Journal of Business and Economy*, 7(7), 11-21.
- Nairametrics (2024). The contribution of the manufacturing sector to Nigeria's GDP declines to 8.23%. /

- Nairametrics, (2023). Manufacturers spent N144.5 billion on sourcing alternative energy in 2022 – MAN.
- NERC, (2024). The new tariff will reduce the 2024 electricity subsidy by N1.14trn.
- Nwatu, V. O. & Ezenwa, E.N. (2020). Economics and energy sector in Nigeria. SPE Nigeria Annual International Conference and Exhibition, Virtual, August 2020.
- Ogbonna, O.S., Idenyi, O.S., Nick, A. (2016), Power generation capacity and economic growth in Nigeria: A causality approach. *European Journal of Business and Management*, 8(32), 74-90.
- Omoke, P.C. (2010), Error correction, co-integration and import demand function for Nigeria. *International Journal of Development and Management Review*, 5(1), 20-31.
- Onwe, J. C., & King, O. (2020). Electricity consumption and manufacturing sector output in Nigeria: Evidence from ARDL approach. *Energy Economics Letters*, 7(2), 110-117. Available at:
- Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics*, 16(3), 289-326.
- Pesaran, M.H., Shin, Y. (1999), *An autoregressive distributed lag modelling approach to cointegration analysis*. In: Strom, S., editor. *Econometrics and Economic Theory in the 20th Century: The Ragnar Frish Centennial Symposium*. Cambridge: Cambridge University Press. 371-413.
- Raji, J. O., Adeel-Farooq, R. M. & Qamri, G. M (2022). Examining the role of biomass energy for a sustainable environment in African countries. *Research Square*, <https://orcid.org/0000-0001-6132-8358>
- Romer, P. (1986). Increasing returns and long-run growth. *Journal of Political Economy*, 94(5), 1002-1037.
- Shrestha, M.B., Bhatta, G.R. (2018), Selecting appropriate methodological framework for time series data analysis. *The Journal of Finance and Data Science*, 4(1), 71-89.
- Stern, D.I. (2004), Energy and economic growth. *Rensselaer Working Paper in Economica*, 410, 1-42.
- Ugwoke, T. L., Dike, C. K., & Elekwa, P. O. (2016). Electricity consumption and industrial production in Nigeria. *Journal of Policy and Development Studies*, 10(2), 8-19.
- World Bank Group (2021). Nigeria to Improve Electricity Access and Services to Citizens. <https://www.worldbank.org/en/news/press-release/2021/02/05/nigeria-to-improve-electricity-access-and-services-to-citizens>