
Research

Electricity Energy Consumption and Industrial Sector Performance in Nigeria: An Empirical Analysis

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Abstract: Electricity demand in Nigeria by the industrial sector has continued to increase while its supply has remained on a decline over the years. The shortages of electricity supply formed the major background for the energy crisis in Nigeria. Therefore, this paper examined the effects of electricity consumption on industrial performance in Nigeria. Using time series data from the Central Bank of Nigeria Annual Report, Statistical Bulletin, Publications of the International Monetary Fund and the National Bureau of Statistics over the years 1985 to 2023. The article used Ordinary Least Squares (OLS) Methods. The findings revealed that a unit rise in industrial electricity consumption enhances industrial performance. The paper stresses that irregular electricity supply weakens industrial performance in Nigeria. Therefore, the paper stresses the need for a comprehensive energy mix to complement the existing energy sources for the development of the industrial sector performance in Nigeria.

Keywords: Industrial output, electricity consumption, Capacity utilization, Exchange Rate.

1. Introduction

The Nigerian industrial sector has, over the years, been faced with a series of problems, the top among which is the poor nature of electricity supply in the power sector. In Nigeria, poor electricity supply is the greatest infrastructure problem confronting the business sector (Adenikinji & AERC, 2005). Every successive government has promised to take drastic measures to stabilise the sector in order to drive growth in the industrial sector, but to no avail. The electricity crisis has become a matter of grave concern not only to Nigerians but also to the international community, especially many foreign investors. Demand for electricity has continued to grow while its supply appears to have

tremendously declined in Nigeria despite government policies and huge investment in the power sector. The threat to electricity supply regarding national economic sustainability, development, and appreciable growth is conspicuously visible in Nigeria compared to the way each country in the world seeks and exploits various alternative sources of energy to generate electricity in the most economical and environmentally friendly way.

The performance of the Nigerian power sector on the International Best Practices comparative rating is worrisome. Perhaps no other sector feels it as much as the industrial sector, wherein some notable international companies and organisations are self-generating electricity. In the words of Adekinju (2005), electricity users, both firms and households, have responded to NEPA's inefficiency through self-generation. The data for some countries within the Southern Africa Development Community (SADC), such as Botswana and South Africa, are comparable to those of the United States of America (USA) and France. Libya, with a population of only 5.5 million, has a generating capacity of 4,600 megawatts, approximately the same as Nigeria, which has a population of over 220 million. South Africa, with a population of 44.3 million, has a generating capacity of 45,000 megawatts, almost eleven times the generating capacity of Nigeria, which has three times the population of South Africa (Agbo, 2007). The United Kingdom (UK), with a population of 64 million, generates 356,800 gigawatts, while Germany, with a population of 80.62 million, generates 614,000 gigawatts. Furthermore, Malaysia, with a population of 28.33 million, generates 118,000 gigawatts. But Nigeria, with a population of over 230 million, generates a meagre electricity of 0.54 gigawatts.

According to the World Factbook (2020), the comparative indicators between Japan and Nigeria showed that Japan, with a population of about 160 million people and zero natural resources, has a high power generating capacity of 124 gigawatts, 100% grid access, a 5% carbon emission rate, and 100% energy conservation compliance. In contrast, Nigeria, despite its huge deposits of energy resources such as crude oil, natural gas, coal, hydropower, solar energy, and fissionable materials for nuclear energy, has consistently suffered from energy shortages, which serve as a major impediment to both industrial and technological growth. Lack of access to adequate energy is most prevalent in Nigeria and is characterised by a low power generating capacity of 0.54 gigawatts, less than 40% grid access, a 60% carbon emission rate, and 2% energy conservation compliance.

The Council for Renewable Energy of Nigeria estimated that power outages brought about a loss of 126 billion naira (USD 984.38 million) annually. Apart from the huge

income loss, it has also resulted in health hazards due to avoidable exposure to carbon emissions caused by constant use of 'backyard generators' in different households and business enterprises, leading to unemployment, high costs of living, and grave deterioration in living conditions. The Energy Information Administration (2007) discovered that only 40% of Nigerians have access to electricity. However, the majority of the electricity is supplied to urban areas. In Nigeria presently, the total installed capacity of the generating stations has not equated to the energy demand of the people due to poor infrastructure and policies, despite the government's increasing investments in this sector.

Comparing the present and ever-increasing population with the total capacity available in power stations reveals that Nigeria is not able to meet the energy needs of the people. The demand is projected to rise from 5,746 MW in 2005 to 297,900 MW in 2030, which translates to the construction of 1,686 MW every year to meet this demand (Sambo, 2008). The projections for continued rapid energy demand imply some severe problems for the future, including resource depletion, energy degradation, and environmental problems due to dependency on only two sources of energy (hydropower and gas) for generating electricity.

Over the last four decades, the gap between energy supply and demand in Nigeria has been growing and is expected to continue. Inefficiency in boosting electricity supply has been responsible for the gap between the demand and supply of electric power due to the poor maintenance of existing hydro plants and the loss of power transmission in Nigeria. In addition, indicators such as constant blackouts and persistent reliance on self-generating plants are pointers to the underutilisation of resources in Nigeria's industrial sector. Based on these premises, the existing relationship between industrial electricity consumption and industrial performance in Nigeria has not been adequately addressed. The government needs to adequately address the challenge of infrastructure deficits, particularly electricity supply, and consciously implement macroeconomic policies that could provide the productive sectors of the economy with appropriate incentives and infrastructural facilities for the adequate supply of petroleum products, a good transportation network, etc., for meaningful development of the industrial sector in Nigeria (Ejedegba, 2021).

This paper, therefore, contributed to the literature by examining the effects of industrial electricity consumption on industrial performance and investigating other energy resources available in Nigeria yet to be explored and harnessed, and enhancing energy security in Nigeria.

This paper, therefore, objectively examined the effects of electricity consumption on industrial performance in Nigeria for the period from 1985 to 2023.

2. Review of Literature

Electricity consumption is the energy distributed and used by different sectors of the economy, while energy demand is the electricity that the end users require to meet their energy needs. Energy is the lifeblood of any industry, which is a necessary condition for industrial and economic survival. For developing nations, the growth in the utilisation of energy is directly and closely related to expansion in industrialisation (World Bank, 2005). However, electricity generation and supply (distribution) in Nigeria has not really expanded industrialisation as perceived by the World Bank (2005).

Energy is widely regarded as a propelling force behind tiny economic activity and indeed industrial production. Qjinnaka (2008) argued that the consumption of energy tracks with the national product. In a modern economy where industrialisation is taking place, and mass production is needed for domestic consumption and exports, electricity is regarded as a primary factor that facilitates the efficiency and productivity of other factors of production, particularly labour and capital. Meanwhile, Ndebbio (2006) argued that electricity supply drives the industrialisation process.

Industrialisation, as explained by Uдах (2010), is a deliberate and sustained application and combination of appropriate technology, infrastructure, managerial experts, and other important resources for production. Industrialisation has attracted considerable interest in development economics in recent times; industrial production in a country accelerates the pace of structural transformation and also brings about diversification of economies, enables a country to fully utilise its factor endowment, and depends less on foreign supply of finished goods.

A lot of empirical literature exists on electricity and its effect on economic performance. However, this study narrows its focus to the relationship it has with industrial development. Ogunjobi (2015) used time series data for the period between 1980 and 2012. The data collected are then analysed using co-integration and error correction techniques to estimate the short-run and long-run dynamics of the research models, respectively. The results established that in the long run, there is a significant positive relationship between industrial growth and electricity consumption, electricity generation, labour employment, and foreign exchange rates, while it showed a negative relationship between industrial growth and capital input, proxied by gross capital formation. The study, therefore,

recommends that the government should take an urgent approach towards reforming electricity supply in such a way as to increase industrial production and to monitor the privatisation policy of the electricity sub-sector to provide employment in order to reduce the high rate of unemployment in Nigeria. However, the study does not examine the sources available for energy generation in Nigeria.

In the same vein, Ziramba (2009) assessed the relationship between disaggregate energy consumption and industrial output in South Africa by undertaking a co-integration analysis using annual data from 1980 to 2005. The study investigated the causal relationships between the various disaggregate forms of energy consumption and industrial production.

The study showed that industrial production and employment are long-run effects, forcing variables for electricity consumption. The study applied the Toda and Yamamoto (1995) Statistical Inference in Vector Autoregressions and the Granger causality test for the analysis. It was found that bi-directional causality between oil consumption and industrial production existed. There is also evidence of causality between employment and electricity consumption, as well as coal consumption, causing employment.

Meanwhile, Liew, Nathan, and Wong (2012) analysed the interdependence between energy consumption and sectoral outputs in Pakistan for the period from 1980 to 2007. The study utilised the Johansen-Juselius co-integration approach and the Granger causality test. The co-integration estimate revealed that energy consumption exhibited long-run relationships with agriculture as well as with services output. However, there is no evidence of a long-run relationship observed between energy consumption and industrial output. Furthermore, the causality estimate revealed a bidirectional causal relationship between energy consumption and agricultural output, while a unidirectional causation was observed from services and industrial output to energy consumption.

Mojekwu and Iwuji (2012) analysed the impact of power supply and macroeconomic variables on the manufacturing sector's performance in Nigeria, using time series data from 1981 to 2009. The multiple regression analysis (MRA) showed that power supply has a significantly positive impact on capacity utilisation, while interest and inflation rates have adverse impacts on capacity utilisation in Nigeria. The R^2 of 88.54 per cent shows changes in capacity utilisation as a result of the predictor variables. It was recommended that the ongoing power reform of privatising the sub-sector should be fully

undertaken by the government, and that single-digit lending and inflation rates should be adequately sustained.

However, Osabase and Bakare (2014) investigated the relationship between electricity generation/supply and the manufacturing sector's performance, using time-series data from 1975 to 2011. The variables utilised included the index of manufacturing production, electricity generation, government capital expenditure, inflation rate, exchange rate, and capacity utilisation. The study employed correlation analysis, the Granger causality test, and the Johansen co-integration test for the empirical analysis. The correlation results revealed a weak positive nexus between electricity generation and the index of manufacturing production in Nigeria. The Granger causality test showed a unidirectional causality between electricity generation and the index of the manufacturing sector's production. Further tests showed three co-integration equations at the five percent level for the trace statistics; however, no co-integration was found at the five and one percent levels for the Max-Eigen test. In view of the findings, it is observed that irregular electricity supply has been a major bane to output growth in the manufacturing sector. Therefore, it was recommended that the power sector, by means of guided private sector initiative, should be given more attention for the growth of the nation's economy.

The most significant effect of electricity supply on industrial outfits and their productivity is cost. Cost is a variable input in the measurement of profit. Profit is only realisable where the cost of production is less than revenue. As a fixed cost, therefore, access to a sufficient and affordable supply of electricity is a crucial determinant of productivity and growth. It is observable that industries suffer operation and maintenance costs arising from power fluctuations (Lai et al., 2008). In the views of Odularu and Okonkwo (2009), only 40% of Nigerians have access to electricity (Energy Information Administration, 2007). However, the majority of the electricity is supplied to the urban areas. According to the encyclopedia on energy (2006), energy is a vital ingredient for economic and industrial growth, and this has been discovered for as long as economic data has been compiled.

Velasquez and Pichler (2010) reiterated that a sufficient and affordable supply of energy (in this case, electricity) has had a decisive significance for industrial productivity and economic growth. Since a country's economic growth is a composite of the economic activities of enterprises, the less cost they have to tolerate, the better a country's chance of harnessing their input towards greater levels of gross domestic product and growth. Okpara

(2011) concedes that industrial productivity can contribute immensely to economic growth and poverty reduction.

Ejedegba (2021) examined the features of oil price and energy consumption in Nigeria and the challenges they pose for national industrial development. The study used secondary annual time series data spanning from 1981 to 2019. The study used ordinary least squares (OLS) methods in analysing the data.

Oke (2006) attributed the non-competitiveness of Nigeria's export goods to poor infrastructure, especially electricity supply, which drives the running cost of firms. Archibong (1997) argued that the positive side of SAP could not be fully established due to administrative bottlenecks, rigidities, and poor infrastructure, especially electricity supply. This undermined the effectiveness of fiscal and other incentives designed to stimulate the growth and diversification of the economy.

Ndebbio (2006) submitted that one important indicator of whether a country is industrialised or not is the megawatt of electricity consumed. He further argued that a country's electricity consumption per capita in kilowatt hours (kWh) is proportional to the state of industrialisation of that country. Ekpo (2009) elaborated on the folly of running a generator economy and its adverse effects on investment. He strongly argued that for Nigeria to jump-start and accelerate the pace of economic growth and development, the country should fix the power supply problem. Aigbokan (1999) opined that fixing the energy sector is tantamount to shifting the production possibility curve of the country's economy.

3. Theoretical framework

This paper adopts a framework based on the conventional neo-classical aggregate production technology by Ghali and El-Sakka (2004), where energy, capital, and labour are taken as separate inputs, that is:

$$Y_t = f(K_t, L_t, E_t) \quad (1)$$

Where Y = real gross domestic product (GDP), K is the capital stock, L is the level of employment, E is total energy consumption, and the subscript t denotes the time period. Taking the differential of equation (1) yields,

$$dY_t = Y_K dK_t + Y_L dL_t + Y_E dE_t \quad (2)$$

Where: d is the partial derivative of (2) with respect to its i th argument. On dividing equation (2) by Y and rearranging the resulting expression, we obtain the following growth equation:

$$Y = aKt + bLt + cEt$$

(3)

Where a dot on the top of a variable means that the variable is now in a growth rate form, the constant parameters a , b , and c are the elasticities of output with respect to capital, labour, and energy, respectively. The relationship between output and capital, labour, and energy inputs described by the production function in equation 1 suggests that their long-run movements may be related. Allowing for short-run dynamics in factor-input behaviour in the analysis above would also suggest that past changes in capital, labour, and energy could contain useful information for predicting the future changes of output, *ceteris paribus*.

Furthermore, both micro- and macro-econometric models have also been used to estimate economies that are highly influenced by their energy sector. For instance, Stern and Cleveland (2004) employed a micro-econometric model in the study analysis by specifying the production function as a modified version of Ghali and RI-Sakka (2004):

$$(Q_i, Q_m) - f(A, X_L, X_n, E_i, H_p) \quad (4)$$

Where:

Q_i = various outputs, such as manufactured goods and services. X_i = various inputs, such as capital, labour, etc.

E_i = different energy inputs, such as electricity, oil, etc.

A is the state of technology, as defined by the total factor productivity indicator. The relationship between energy and an aggregate of output, such as gross domestic product, can then be affected by (a) substitution between energy and other inputs, (b) technological change - a change in A , (c) shifts in the composition of the energy input, and (d) shifts in the composition of output. Also, shifts in the mix of the other inputs - for example, to a more capital-intensive economy from a more labour-intensive economy - can affect the relationships between energy and output. It is also possible for the input variable X to affect total factor productivity.

The models are modified to capture the objectives of the study by incorporating the following variables (Industrial Performance, Gross Fixed Capital Formation, Gross Domestic Product, Exchange Rate, and Capacity Utilisation). Industrial output (IND) is utilised in the model to capture the output of the industrial sector, as well as the direction of the manufacturing sector. Electricity consumption is the aggregate amount of power supplied by the Power Holding Company of Nigeria (PHCN) to the industrial sector in

megawatts per hour (MW/h). Government Fixed Capital Formation (GFCF) is used to capture expenditure made on infrastructural development by the government to enhance the growth of the manufacturing and other sectors in the economy. Gross Domestic Product (GDP) measures economic growth and increases productivity levels.

The exchange rate (EXR) is the rate at which the Naira is exchanged for the US dollar and other currencies. This affects the output of the manufacturing sector, as manufacturers incur high costs importing plants and generators to augment the poor electricity supply. The capacity utilisation (CPU) in the model measures the extent to which the manufacturers use their production potential. Capacity utilisation can be defined as the percentage of total capacity that is actually being achieved in a given period.

3.1 Model Specification

In order to reflect the peculiarities of Nigeria's electricity supply on industrial performance, this study uses a modified version of Ghali and El-Sakka's (2004) model by adding the aforementioned variables and the re-specified equation (4) as follows:

$$IND = (IELEC, GFCF, GDP, EXR, CU) \quad (5)$$

Where: IND = Industrial Performance (Proxy Industrial Output); GDP = Gross Domestic Product; EXR = Exchange Rate; and CU = Capacity Utilisation. Equation 5 is written in linear form.

$$IND_t = \beta_0 + \beta_1 IELEC_t + \beta_2 GFCF_t + \beta_3 GDP_t + \beta_4 EXR_t + \beta_5 CPU_t + e_1 \quad (6)$$

Where:

t = time period

β_0 = intercept

β_1 - β_5 are parameters

e_1 = error term, also known as the white noise random element.

From the model, the a priori expectations are $\beta_1 > 0$, $\beta_2 > 0$, $\beta_3 > 0$, $\beta_4 > 0$, $\beta_5 > 0$

3.2 The Model A Priori Expectations

In line with economic theory, the study expects a direct relationship between electricity consumption and industrial growth. Adequate electricity supply and distribution constitute a central core to industrial development, which cannot be overemphasised. In accordance with this, industrialisation has been a key determinant that fosters high growth indices in emerging economies of the world, including China, Indonesia, and Taiwan (Nazima, 2017). These economies have achieved high growth rates due to high industrial development, which further caused declining poverty trends and high growth statistics

(Knivilla, 2008). Development of industrial sectors brings substantial changes in the real sector of the economy and also leads to a rise in the national income of the country, which in the long run brings about the creation of employment.

Gross fixed capital formation will have a positive relationship with industrial output. Gross fixed capital formation captures expenditure made on infrastructural development by the government to enhance the growth of the manufacturing and other sectors in the economy. With adequate provision for capital expenditure in the energy sector, this will stimulate small-scale enterprises, which are central and critical in every human society. It is through entrepreneurship that societies can attain any level of development. Small-scale and medium industries are said to be the secret behind the rapid development of countries like Japan, China, and Malaysia. Low entrepreneurship is also said to be a major cause of the underdevelopment of most countries in Africa, Asia, Latin America, and elsewhere.

A direct relationship is expected between industrial output and gross domestic product. Uninterrupted electricity supply contributes to industrial performance, which in turn causes a rise in economic growth. It is expected that a positive relationship exists between the exchange rate and industrial production. Favourable exchange rate policies enhance access to foreign exchange for production, thereby increasing manufacturing output and employment while reducing inflation. In this vein, capacity utilisation is assumed to have a direct relationship with industrial performance. The industrial production and capacity utilisation figures usually reflect similar changes in overall economic activity. A high level of industrial production refers to the extent of optimal utilisation of the installed productive capacity of such an industry.

Given the nature of the models, it became expedient for this study to make use of time-series data, which are basically secondary data. The data for electricity consumption in the industrial sector of Nigeria were obtained from the Central Bank of Nigeria (CBN) Statistical Bulletin for industrial electricity consumption. The other variables were sourced from CBN's Annual Reports, Statistical Bulletins, as well as the publications of the IMF and the National Bureau of Statistics (NBS). The variables are Industrial Output, Gross Fixed Capital Formation, Gross Domestic Product, Exchange Rate, and Capacity.

Utilisation.

The study employs four methods of data analysis. First, descriptive statistics are used to examine the trend and magnitude of the selected variables. Second, the Augmented

Dickey-Fuller (ADF) test was used to test whether the data series used for the selected variables were stationary. The Augmented Dickey-Fuller (ADF) Unit Root Test is used because of its superiority over the Dickey-Fuller (DF) test. In the ADF test, the more negative the value, the stronger the rejection of the hypothesis that there is a unit root at some level of confidence. Third, the Johansen co-integration test is used to check whether the regression residuals are co-integrated; that is, to test whether there is a long-run relationship between the dependent and independent variables in the model. Lastly, the fully modified least squares method (FMQLS) is used to account for serial correlation effects and for the endogeneity in the regressors that results from the existence of a co-integrating relationship.

4. Results and Discussion

4.1 Descriptive Statistics

The measures that were used to describe the data set are the central tendency and measures of dispersion. Measures of central tendency include the mean and median, while measures of dispersion or variability include the standard deviation, the minimum and maximum values of the variables, kurtosis, skewness, and Jarque-Bera.

Table 1. Descriptive Statistics

	IND	1ELEC	GFCF	GDP	EXR	CPU
Mean	116.7038	307.1547	12.87135	3.563243	81.24541	45.16486
Median	116.9000	257.9000	12.09000	4.210000	92.70000	43.00000
Maximum	170.9000	594.4800	35.22000	15.33000	169.9000	73.30000
Minimum	10.00000	121.0000	5.460000	-10.93000	0.610000	29.30000
Std. Dcv.	44.90864	115.8002	6.267641	4.934220	63.20549	9.903709
Skewness	-0.798953	0.655999	1,962755	-0.480644	-0.124503	0.543262
Kurtosis	3.121123	2.420512	7.496087	4,160173	1.446994	3.168076
Jarque-Bera	3.958962	3.171430	54,92100	3.499703	3.813823	1.863543
Probability	0.138141	0.204801	0.000000	0.173800	0.148538	0.393855
Sum	4318.040	11364.72	476,2400	131.8400	3006.080	1671.100
Sum Sq. Dev.	72604.30	482748.9	1414.200	876.4750	143817.6	3531.004
Observation	38	38	38	38	38	38

Source: Author's regression output (2023).

Table 1 above shows the descriptive statistics of the variables involved in the analysis. The means for industrial output, industrial electricity consumption, gross fixed capital formation, gross domestic product, exchange rate, and capacity utilisation are 116.7038, 307.1547, 12.87135, 3.563243, 81.24541, and 45.16486, respectively. The range of

industrial electricity consumption means is substantial in magnitude, as gross domestic product appears to be lower. The result shows that industrial electricity consumption has a mean of 307.1547, while gross domestic product has the lowest value of 3.563243. This result implies that industrial electricity consumption is quite high due to the provision and maintenance of expensive energy back-up to minimise the expected outages from the national grid. The persistent reliance on self-generating plants is a pointer to low productivity and underutilisation of resources in Nigeria's industrial sector; this has no impact on the economic growth of Nigeria. Also, the result reveals underutilisation of the installed capacity level of industrial production and inadequate infrastructural development in Nigeria.

The maximum and minimum values of all the variables, ranging from 10.00000 to 170.9000, 121.0000 to 594.4800, 5.460000 to 35.22000, -10.93000 to 15.33000, 0.610000 to 169.9000, and 29.30000 to 73.30000 are for industrial output, industrial electricity consumption, gross fixed capital formation, gross domestic product, exchange rate, and capacity utilisation, respectively. This result shows that industrial electricity consumption has the highest maximum value of 594.4800, caused by the huge running cost on diesel and gas by industries to maintain a constant electricity supply, while the minimum value is -10.93000 of gross domestic product, which indicates non-performance of the industrial sector in economic growth. This finding affirms the study of Lee and Anas (1992) that industrial establishments in Nigeria spend an average of 32% of their variable costs on infrastructure, with electric power accounting for more than half of this share.

Skewness and kurtosis provide summary information about the shape of a distribution. The skewness indicator is used in distribution analysis as a sign of asymmetry and deviation from a normal distribution, while the kurtosis indicator is also used as a sign of flatness or peakedness of a distribution. The result from Table 1 shows that only three variables have less than zero skewness (< 0), which are industrial output (-0.798953), gross domestic product (-0.480644), and exchange rate (-0.124503). This implies that the values are concentrated on the right of the mean, with extreme values to the left; however, industrial electricity consumption, gross fixed capital formation, and capacity utilisation are normally distributed.

Also, the kurtosis result implies that gross fixed capital formation (7.496087) and gross domestic product (4.160173) are leptokurtic distributions, sharper than a normal distribution, with values concentrated around the mean and thicker tails. This indicates a

high probability for extreme values, with kurtosis > 3 . For industrial output (3.121123) and capacity utilisation (3.168076), these are mesokurtic distributions, which are normal distributions with kurtosis equal to 3, while industrial electricity consumption (2.420512) and exchange rate (1.446994) are platykurtic distributions, flatter than a normal distribution, with a wider peak. The probability for extreme values is less than that of a normal distribution, and the values are spread around the mean.

4.1 Stationarity Test

In order to test for the stationarity of the time series data used in this research, the conventional stipulation of the ADF test shows that the calculated ADF test statistics must be, to a greater extent, negative. In this case, it must be greater than or equal to any of the critical values in absolute terms before a variable is regarded as stationary. The result is presented in Table 2 below:

Table 2. Test for Unit Root at Level

Variables	Test Statistics	5% Critical Value	P -value	Level	Stationary /Non-Stationary
IND	-5.749590	-2.981038	0.0001	1(1)	S
IBLHC	-6.891954	-2.951125	0.0000	1(1)	S
GFCF	-4.674462	-2.945842	0.0006	1(0)	S
GDP	-3.368738	-2.945842	0,0189	1(0)	S
F.XR	-6.360290	-2,948404	0.0000	1(0)	S
CPU	-3.174402	-2.945842	0.0299	1(0)	S

Source: Author's Regression output (2023).

The results from Table 2 show that gross fixed capital formation, gross domestic product, exchange rate, and capacity utilisation are stationary at the level, while industrial output and industrial electricity consumption are stationary at the first difference. This can be seen by comparing the test statistics (in absolute terms) of both the ADF test statistic with the critical values (also in absolute terms) at the 5% level of significance. This finding established a short-run relationship among the selected variables for the study.

4.2 Johansen Co-integration Test

This study employed the Johansen Co-integration Test to check whether the regression residuals are co-integrated, that is, to test whether there is a long-run relationship between the dependent and independent variables in the model. This test makes use of Trace Statistics by comparing their values with the critical values at the 5% level. If the

values of the Trace Statistics are greater than the critical values, the study concludes that there will be a long-run relationship. Otherwise, the regression residual is not co-integrated.

Table 3. Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace -Statistics	0.05 Prob.**	Critical value
None *	0,670260	101,7082	95.75366	0.0183
At most 1	0.520608	62.87743	69.81889	0,1578
At most 2	0.386154	37.14415	47.85613	0.3408
At most 3	0.285814	20.06378	29.79707	0.41.86
At most 4	0.209576	8.282374	15.49471	0.4357
At most 5	. 0.001452	0.050871.	3.841466	0,8215

Trace least indicates 1 contributing equation(s) at the 0.05 level.

* denotes rejection of the hypothesis at the 0.05 level

** MacKinnon-Haug-Michelis (1999) p-values

Source: Author's regression output (2023)

The results from Table 3 show that the Trace test indicates at least one co-integrating equation at the 0.05 level. This denotes the rejection of the null hypothesis at the 0.05 level. The statistical significance is evidenced by the p-values. Based on the findings from the results, there is a long-run equilibrium relationship between the dependent and independent variables since the Trace statistic is greater than the critical value at the 5% level of significance. 4.3 Fully Modified Least Squares Regression Result

Table 4. Fully Modified Least Squares Result

Dependent Variable: IND

JWethod; Fully Modified Least Squares (FMOLS)

Date: 04/01/23 Time: 11:38

Sample (adjusted): 1985 2023

Included observations: 38 after adjustments.

Cointegrating equation deterministic: C

Long-run covariance estimate (Bartlett kernel, Newey-West fixed bandwidth = 4.0000)

Variable	Coefficient	Sid. Error	t-Statistics	Prob.
IELEC	0.094738	0.053636	1.766325	0.0875
GFCF	-1.854379	1.398072	-1.326383	0.1947

GDP	-2.010557	1.196036	-1.681016	0.1031
EXR	0.449801	0.103279	4.355187	0.0001
CPU	0.760634	0.626376	1.214342	0.2341
C	45.03214	21.61444	2.083428	0.0458
R-squared	0.649125	Mean dependent var	1	17.4517
Adjusted R-squared	0.590646	S.D. dependent var	45	31139
S.L. of regression	28.99058	Sum squared resid	-	25213.60
Long-run variance	572:2824			

Source: Author's regression output (2023).

Table 4 reports the fully modified least squares multiple regression results. According to the results, industrial electricity consumption has a positive relationship with industrial output in Nigeria. The findings revealed that a unit rise in industrial electricity consumption increased industrial output by 9.4% and is significant at the 8 per cent level. This result is consistent with the study's a priori expectation. This indicator only reflects a meagre impact of industrial output growth in Nigeria compared to other countries. This finding established that electricity supply is one of the major determinants of industrial output growth in Nigeria. This result corroborates the study of Ogunjobi (2015), which established a positive relationship between industrial output and electricity consumption in Nigeria. In the same vein, Ziramba (2009) affirmed that only electricity consumption has a significant long-run impact on real output in South Africa.

However, the coefficient of gross fixed capital formation was negative with industrial output against the study's a priori expectation within the period investigated. The result means that a percentage change in gross fixed capital formation will bring about a reduction in industrial performance by 0.01-8 units in Nigeria. This signifies that gross fixed capital formation impacted negatively on industrial performance in Nigeria. This result connotes a deficiency of capital infrastructural development in Nigeria, especially in industrial development. This finding agrees with the study of Okonkwo (2010) that low capital accumulation is the main obstacle faced in achieving the goal of sustained economic growth in Nigeria. This finding shows that there is still a lot to be done by the government to effect industrial growth in the power sector of the Nigerian economy in order to compete favourably with developed countries. Also, the World Bank (2004) reports that the nation's difficult business environment has largely been caused by inadequate power supply, which serves as the most severe constraint for industrial development in Nigeria.

Also, gross domestic product has a negative relationship with industrial output over the examined period; hence, it is not statistically significant. This result suggests an inverse relationship between the economic growth rate and industrial performance in Nigeria. The indicator revealed that a 1 percent rise in gross domestic product reduces industrial performance by 0.020 percent. This result is in line with the research work of Obioma, Uchenria, and Alexanda (2015), which states that the influence of industrial output on economic growth is not statistically significant. This implies that inefficiency in the power sector has weakened industrial performance, resulting in low productivity and retarded economic growth in Nigeria, with high operational costs that have significantly undermined the efforts of the Nigerian government in sustaining its economic performance.

Moreover, the exchange rate has a positive relationship with industrial output growth and is statistically significant. The results revealed that a unit rise in the exchange rate brings about a 44% rise in industrial output. This finding affirmed the study of Ehinomen and Oladipo (2012) that exchange appreciation has a significant relationship with domestic output, which promotes industrial output growth. Finally, capacity utilisation has a direct relationship with industrial output, as expected, but it is not significant. The findings showed that low capacity utilisation is due to shortages in electricity supply as well as other energy supplies to the industrial sector in Nigeria.

The value of the R-Square (R^2) for the model is pegged at 0.649125 or 64%, which implies that industrial electricity consumption, gross fixed capital formation, gross domestic product, exchange rate, and capacity utilisation explained about 64% of the systematic variation in industrial output in Nigeria over the observed years, while the remaining 36% of the variation is explained by other variables outside the model.

The t-test statistics confirm the standard error test. Testing at the 5% level, the variables fall within the acceptance region to confirm the alternative hypothesis that industrial electricity consumption and exchange rate are statistically significant. In other words, they do contribute significantly to industrial output in Nigeria. However, the t-statistics for gross fixed capital formation, gross domestic product, and capacity utilisation were not significant. The result implies that gross fixed capital formation, gross domestic product, and capacity utilisation are not statistically significant in explaining industrial output over the study period.

The standard error test revealed that industrial electricity consumption and exchange rate are significant when compared to half of each coefficient with its standard error; it was

found that the values of the standard errors were less than half of the coefficients. In another way, gross fixed capital formation, gross domestic product, and capacity utilisation were not significant in the estimated model. Lastly, the long-run variance for the model stood at 572.2824. The implication of this result connotes that the recommended Bartlett Kernel bandwidth of 4.0 implies that the model is free from the problem of heteroskedasticity.

5. Conclusion

The study investigated the effects of electricity consumption on industrial performance in Nigeria from 1983 to 2023. Descriptive statistics, unit root, and co-integration tests were conducted on the time series data selected for the study. The results of the descriptive statistics revealed that industrial electricity consumption is high due to the provision and maintenance of expensive energy back-up to minimise the expected outage from the national grid. Also, the findings revealed underutilisation of the installed capacity level of industrial production and inadequate infrastructural development in Nigeria. The unit root test confirmed that gross fixed capital formation, gross domestic product, exchange rate, and capacity utilisation were stationary at the level, while industrial output and industrial electricity consumption became stationary at the first difference. The Johansen co-integration test established a relationship among gross fixed capital formation, gross domestic product, exchange rate, and capacity utilisation.

The empirical result of the fully modified least squares method showed that industrial electricity consumption and exchange rate have a direct and significant positive relationship with industrial output in Nigeria. The finding confirmed that electricity consumption is one of the major determinants of industrial output growth in Nigeria. However, gross fixed capital formation and gross domestic product have a negative relationship with industrial output and were not significant in the model over the study period. Capacity utilisation has a dire relationship with industrial output, as expected, but is not significant. The non-significant capacity utilisation is due to shortages in electricity consumption from the national grid, as well as other energy supplies to the industrial sector in Nigeria.

One major finding of the paper is that inadequate energy supply accounts for adverse effects and a decline in productivity in the industrial sector. The gap between energy supply and demand has brought about the acquisition of expensive power backup in the form of diesel generator plants, inverters, and other alternative backups, which increase

the cost of production. To this end, there is a need for a comprehensive energy mix option through government policies to complement the existing energy sources available in Nigeria, as well as other renewable energy resources for the industrial sector and domestic use. Past expenditures on the electricity sub-sector infrastructure should be investigated to determine whether the substantial funds invested were actually used or diverted. There is a need for more commitment by the government to monitor the use of allocated funds in the sector for effective and efficient utilisation.

Economic growth rises when productivity increases; the government should encourage and accelerate other factors that affect productivity in the country, especially manpower and skills, to improve economic performance. Sound economic policies that will stabilise the exchange rate and encourage optimal utilisation of installed productive capacity should be prioritised to make industrial goods competitive in the global market.

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