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ELECTRICITY CONSUMPTION AND MANUFACTURING SECTOR OUTPUT IN NIGERIA: AN ARDL APPROACH

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ABSTRACT
Different factors have been adduced for Nigeria's poor manufacturing sector performance. One of the problems could be the economy's persistent poor electricity supply to the manufacturing sector over time. Therefore, this study examined the effect of electricity on the growth of manufacturing sector in Nigeria from 1981 to 2022. It employed the Auto Regressive Distributed Lag (ARDL) bounds testing approach to co-integration analysis to establish the long run relationship between the relevant time series data. The result revealed that manufacturing sector output and selected variables of manufacturing sector electricity consumption, electricity generation, electricity price proxied by consumer price index, carbon emission, exchange rate, and commercial bank credit to the manufacturing sector included in the models have a long run relationship with manufacturing sector output performance. It also showed that manufacturing sector electricity consumption, electricity generation and cost of electricity have inverse and significant effect on the growth of Nigeria manufacturing sector while commercial bank credit to the manufacturing sector has direct and significant effect on the growth of Nigeria manufacturing sector. The study recommended that more electric power supply should be generated by Electricity Generation Company to take care of electric power demand by the manufacturing sector and the regulatory bodies in the energy sector should set some energy capacity distribution standards with regards to energy preference to key sectors of the economy such as manufacturing sector.

Keywords: Electricity Consumption Index, Manufacturing Sector, Electricity.

1. INTRODUCTION

The manufacturing sector as a sub-sector of the industrial sector is concerned with the production of goods and services, the utilization of raw materials and other factors of production. Both in developed and developing countries, the manufacturing sector provides an opportunity for import substitution and export expansion, thereby creating foreign exchange earning capacity as well as generating employment for the teeming population and bring about an increase in per capita GDP. Furthermore, the manufacturing sector creates investment capital at a faster rate than any other sector of the economy while promoting wider and more effective linkages amongst different sectors (Ebele & Iorember, 2016).

Imoughele and Ismaila (2014) asserted that the manufacturing sector in Nigeria serves as an avenue for increasing productivity in relation to import replacement and export expansion, creating foreign exchange earning capacity, raising employment and per capita income level which help increase in consumption patterns. However, despite these laudable contributions of the manufacturing sector to economic growth, the Nigerian manufacturing sector has been experiencing decline in terms of output in recent times, although the government has embarked on several strategies aimed at improving the trodden industrial production and capacity utilization in the sector. For instance, the average contribution of the manufacturing sector to GDP between 1986 and 1992 was 24.10 per cent. It decreased to an average of 11.14 per cent and 4.98 per cent between 1993 and 1999 and from 2000 to 2006 respectively and further contributed an insignificant output of 1.21 per cent between 2007 and 2016 (CBN, 2016). According to Charles (2012) the unimpressive performance of the sector in Nigeria is mainly due to massive importation of finished goods and inadequate financial support for the manufacturing sector, which ultimately has contributed to the reduction in capacity utilization of the sector in the country.

Odior (2013) asserted that the Nigerian manufacturing sector continues to experience challenges with regard to access to credit from the banking sector, which in turn affects the importation of raw materials. Others include the epileptic supply of electricity and the increases in the pump price of diesel and fuel used to run generators to provide private electricity supply, this poor manufacturing performance has been attributed to high production cost as a result of high cost of foreign exchange procurement, high interest rates, poor demand for made in Nigeria products, insufficient raw materials supply need for production, inadequate working capital and frequent machine break downs. All these coupled with inadequate finance snow-ball into low manufacturing sector productivity.

The classical economists considered energy as an intermediate input in production, facilitating factors of production but Alam (2006) however argues that it serves as factor input in certain production circumstances. Beaudreau (2005) saw that the transformation of steam, fossil fuel and hydraulic power sources into a more usable form of energy such as electricity as a way forward for greater increase in speed, efficiency and consequently, productivity in the manufacturing industry. Increase in the amount of electricity consumed by the manufacturing sector indicates increase in the speed of operation in manufacturing process which eventually leads to increase in output. In a similar vein, Riker (2011) concluded that improvement in the efficiency of electricity use significantly increases an industry's output. Chinedum and Nnadi (2016) noted that the relationship between electricity and production in machine-driven industry cannot be disentangled, if higher output is to be achieved.

Nigeria has recorded a great history of unstable and inadequate electric power supply (Adenikinju, 2003). This problem became more severe in manufacturing sector as the number of manufacturing firms leaving the country and shutting down became more pronounced. Chinedum and Nnadi (2016) revealed that over 800 companies including multinationals have been estimated to have relocated all or part of their manufacturing facilities outside Nigeria where they can get access to a more reliable power supply. The problem of erratic power supply in Nigeria has virtually affected all the major sectors of the economy and particularly devastated the manufacturing sector. Report shows that Nigeria needed 40,000MW supply of electricity but only 4,600MW is made available. The current demand for electricity in the manufacturing sector is 2,500 Megawatt (MW) while the electricity distribution Company of Nigeria is only capable of supplying 267 MW, amounting to a short fall of 2,233 MW. The installed capacity of the manufacturing firms' personal power generating plants is cumulatively 597 MW which can still not cover up for the short fall, instead, increase the cost of production and still have a short fall of 1,636 MW (Adenikinju, 2003). Yahaya, Salisu and Uma (2015) found that 93.9% of the firms described electricity as their major problem while 97.4% of the firms have their private generators. They also showed that the high cost of operating on generators caused about 800 firms to shut down between 2009 and 2011.

Therefore, the lingering electricity problem in the country may be affecting the overall growth of the economy particularly the manufacturing sector. In addition, available statistics indicate that the industrial sector seems to be experiencing slow growth and one of the factors responsible to a considerable extent for this slow growth despite the policies and incentives is poor energy consumption (Ogunjobi, 2015). The manufacturing sector has always emphasized the need to improve various infrastructures, particularly, electricity which is the primary form of energy required for production. Therefore, this study empirically evaluates the impact of electricity supply on the Nigerian manufacturing sector productivity.

Poor access to electricity in Nigeria has been a major impediment to Nigeria's economic growth generally. Manufacturing sector has been adjudged as the engine of economic growth but its performance is grossly dismal due to inadequate power supply. Researchers have identified the increase in energy use as a vital component of emerging economies; economic growth of the South Asia Association for Regional Cooperation (SAARC) countries – comprising Bangladesh, India, Pakistan and Sri Lanka is closely related to its energy consumption which is an impediment for enhancing export values, increasing remittances receipts from manpower supply Sheriff (2002). Whether African economies, most especially Nigeria are ready for developmental take-off should be based on its readiness to ensure adequate and regular power supply, which represent a crucial factor that supports economic growth in developing countries.

Industries are shutting down in Nigeria. The manufacturing sector is suffering from acute shortage of power supply. This has reduced their contributions to government revenues, GDP and export earnings. Some manufacturing outfits in Nigeria have relocated to neighbouring countries like Ghana, Benin republic and South Africa where the cost of running their business concerns is relatively low. Some others that have managed to remain are operating at less than optimal capacity, largely depending on the off-grid supply using diesel/gas/petrol-powered electric generators, thereby running at huge overhead costs and contributing to greenhouse gas pollution among other harmful environmental problems (Olaoyel, Ajilore , Akinluwade, Omole, & Adetunji, 2016).

The Council for Renewable Energy of Nigeria estimates that power outages brought about a loss of 126 billion naira 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 cost of living, and grave deterioration in living conditions. Energy Information Administration (2007) discovered that only 40% of Nigerians have access to electricity. In Nigeria presently, the total installed capacity of the generating stations have not equated the energy demand of the people due to poor infrastructure and policies despite the government's increasing investments in this sector. At present, the Nigeria's current energy demand is estimated to be between 10,000MW and 15,000MW. However, existing power stations and their installed capacities are about 6000MW. Meanwhile, the country manages to generate only a meager (of more or less) 4000 MW of electricity (Atser, 2006). Furthermore, electricity supply is adjudged as one of the major significant factor that determine manufacturing sector productivity in Nigeria.

Studies have traced the collapse of Nigeria's manufacturing sector development, small and medium scale businesses, and economic standstill to the inadequate and erratic state of the country's energy policy. However, most researchers focused on disaggregate energy consumption-economic growth nexus (Ogunleye and Ayeni, 2012; Akinlo, 2009). This implies energy consumption from various subsectors like natural gas, coal, diesel and several others. While some of the studies centered on aggregate energy-supply to industrial sector which were problems oriented e.g., (Nwosa and Akinbobola, 2012; Liew, Nathan and Wong, 2012; Omisakin, 2008). Using the Ordinary Least Squares Error Correction Modelling (ECM), a vector Error Correction Modelling (VECM), most of the studies focused on the effect of energy consumption and generation on other sectors; ignoring manufacturing sector in Nigeria (Ogunjobi 2015; Nwajinka, Essien and Igweonu, 2014; Jiburum, 2014, Akekere and Yousuo 2013). Therefore, this study seeks to fill this significant gap by examining the effects of manufacturing sector electricity consumption, generation and cost of electricity on manufacturing sector productivity in Nigeria.

Research Hypotheses

The following research hypotheses were formulated and tested in the study:

H_{01}: Electricity consumption has no significant effect on manufacturing sector output in Nigeria.

H_{02}: Electricity generation has no significant contribution to manufacturing sector output in Nigeria.

H_{03}: Electricity price has no relationship with manufacturing sector output in Nigeria.

H_{04}: Electricity generator carbon emission has no significant impact on manufacturing sector output in Nigeria.

2. LITERATURE REVIEW

The Theory of the Firm Production and Costs states that to produce a good or a service a firm needs factors of production. The factors of production used by a firm in the production of a good or a service are generally referred to as inputs. What a firm produces is called output. A firm has to pay for the inputs it needs. Meanwhile, inputs on the other hand generate cost which generates output. The relationship between inputs and the output is called "productions function" while the relationship between the output and costs is referred to as cost function (Alam, 2006). As cited by Olawale, Ilo and Lawal (2017) in response to the inadequacies of the managerial limit theory, optimal firm size hypotheses postulate that firm size is strongly dependent on a number of considerations. Such factors include the market structure in which the firm operates, in other words whether it operates in a perfectly competitive market or an imperfectly competitive one (e.g. monopoly, oligopoly or monopolistic competition). The major conclusion of the optimal firm size theory is that small companies grow faster than larger companies until they reach the Minimum Efficient Scale (MES) point of production. Similarly, if firms have market power (i.e. where there is imperfect competition), their optimal size may deviate from this optimal cost position and if there are economies of scale such deviations may be more noticeable. However, in this situation, a firm’s ability to grow depends on it innovations, in other words, the limits to a firm’s potential growth are largely determined by the demand for its unique product rather than by cost considerations.

There are vast empirical literatures on the relationship between electricity and its effect on the economic activities. However this study narrows its focus on the relationship it has on the manufacturing sector development. Agbede (2018) examined disaggregate energy supply and industrial output growth in Nigeria using time series data from 1981-2014. Data were sourced from the Central Bank of Nigeria, Statistical Bulletin and the National Bureau of Statistics. The study employed Ordinary Least Square method, Granger Causality and Johansen Co-integration test to carry out the empirical analysis. The findings show that electricity generated and premium motor spirit have a positive impact on industrial output growth in Nigeria but with high cost of production. Government capital expenditure signed positive, while gas consumption and automated gas oil (diesel) have negative signs from the result.

Osabase and Bakare (2014) examined the relationship between electricity generation/supply and the manufacturing-sectors performance, using time-series data from 1975-2011. The variables utilised included: index of manufacturing production, electricity-generation, government's capital expenditure, inflation rate, exchange rate, and capacity-utilisation. The study employed correlation analysis, the Granger Causality test and Johansen Co-integration test. The correlation result revealed a weak positive nexus between electricity generation and index of manufacturing production in Nigeria. The Granger Causality test showed a unidirectional causality between electricity generation and index of manufacturing-sector's production.

Chinedum and Nnadi (2016) examined the relationship between electricity supply and the output of the Nigerian manufacturing sector. The major objective is to critically determine the impact of electricity supply on the manufacturing output in Nigeria. The study explores the relationship between electricity supply and manufacturing sector's output in Nigeria. Time series data spanning the period between 1981 and 2013 were analyzed using Johansen Cointegration and Vector Autoregression tests. The results revealed that there exists a long run relationship between electricity and manufacturing output in Nigeria. It also identified that electricity supply has an insignificant relationship with the manufacturing sector in Nigeria.

Olufemi (2015) determined the relationship between electricity consumption and industrial growth in Nigeria. The study used time series data covering the period between 1980 and 2012. The data collected were analyzed using co-integration and error correction techniques to estimate the dynamics of the research models respectively. The result 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 rate while it showed a negative relationship between industrial growth and capital input (proxied by gross capital formation).

Also, Ogunjobi (2015) studied the effects of electricity consumption on industrial growth in Nigeria. It was found that there exist co-integration relationship between electricity consumption and industrial growth in Nigeria. The study further established positive relationship between industrial growth and labour employment, electricity generation, electricity consumption and foreign exchange rate in the long-run while it had a negative relationship with capital input. Nwosa and Akinbobola (2012) examined the nexus between aggregate energy consumption and sectoral output in Nigeria for the period 1980 to 2010. The study utilised unit root test, cointegration test and bi-variate Vector Auto-regressive causality test. The study observed a bi-directional causality between aggregate energy consumption and agricultural output while a unidirectional causality was found from service output to aggregate energy consumption.

Enu (2014) determined the conditions that influence electric power consumption in Ghana and also estimate the extent to which electric power consumption impact on the various sectors of the Ghanaian economy. The ordinary least squares method of data estimation technique was used. The study revealed that the major factors that influence electricity consumption in Ghana are population, the size of the Ghanaian economy, foreign inflows, the general price level, and trade.

The study also revealed that electric power consumption affected agricultural production in Ghana negatively and the margin of the decrease was 0.0284186. More so, the study identified that electricity consumption had a positive effect on manufacturing sector of the Ghanaian economy though its value was statistically insignificant.

Furthermore, Braimah and Amponsah (2012) examined the causes and effects of the frequent and unannounced electricity blackouts on the operations of micro and small scale industries in Kumasi, Ghana. Data from a sample of 320 micro and small-scale industries selected from three industrial clusters in the Kumasi metropolis, revealed that the frequent and unannounced blackouts have caused a deficit of about 5.3% in the quantity of electricity required for continuous operations. The blackout hours were estimated to last for an average of 10.3 hours per month. As a consequence of the blackouts, about 44% of the micro and small scale industries spent this duration in redundancy because of lack of alternative sources of electricity but maintained the same labour cost. The remaining 56% of the micro and small scale industries obtained power from alternative sources which required an average of GH¢15.5 per month to run. The paper concludes that uninterrupted electricity supply is vital for the effectiveness of the micro and small scale industries.

Kouakou (2011) examined the causal relationship between economic growth and electricity consumption in Cote d'Ivoire from 1971 to 2008. The method used was ARDL granger causality test. The study identified bi-directional causality between electricity consumption and GDP. Also, a unidirectional causality from electricity consumption to industry value added in the short-run was identified by the study. Jamil and Ahmad (2010) examined the relationship between electricity consumption, electricity price and GDP in Pakistan from 1960 to 2008. The study employed Johansen cointegration, and VECM Granger Causality. The study revealed that GDP causes electricity consumption while growth in output in commercial, manufacturing and agricultural sectors tends to increase electricity consumption in Pakistan.

Ogundipe and Apata (2013) examined the relationship between electricity consumption and economic growth in Nigeria using the Johansen and Juselius Co-integration technique based on the Cobb-Douglas growth model covering the period 1980-2008. The study adopted Vector Error Correction Modelling and the Pairwise Granger Causality test in order to empirically ascertain the error correction adjustment and direction of causality between electricity consumption and economic growth. The study found the existence of a unique co-integrating relationship among the variables in the model with the indicator of electricity consumption impacting significantly on growth. Also, the study shows an evidence of bi-directional causal relationship between electricity consumption and economic growth.

Aguegboh and Madueme (2013) examined the nexus between energy consumption and economic growth with evidence from Nigeria. The vector auto regression model and the co integration technique were adopted. Their study contradicts other studies on energy consumption and economic growth in Nigeria. A unidirectional causality was observed between petroleum consumption to GDP, gas consumption to GDP and capital to GDP. Also, the impulse response result shows that energy consumption do not contribute to economic growth in Nigeria. On the contrary, capital formation contributes to economic growth as opposed to labour force that does not contribute to GDP in Nigeria. Bamidele and Mathew (2013) examined energy consumption and economic growth nexus in Nigeria. The error correction mechanism was used to analyse the influence of total energy consumption, consumer price index, monetary policy rate, credit available to private sector on economic growth in Nigeria. The result of the study revealed that all the explanatory variables significantly influence output growth in the short run.

Osobase (2014) investigated the relationship between electricity generation, supply and manufacturing sector performance in Nigeria. This study is based on secondary data from 1975 to 2011. Government capital expenditure, inflation rate, exchange rate, capacity utilization, electricity generation and index of manufacturing production variables were studied. Correlation and Johnson co-integration techniques were used for analysis of data. Results indicated that there is positive relationship between index of manufacturing production and electricity generation and unidirectional relationship between electricity generation and index of manufacturing production.

This study (Osobase's work) did not over electricity consumption but focused majorly on electricity distribution and supply. The outcome could be limited in policy decision because electricity supplied is seemingly not the same as is distributed and consumed. Further, manufacturing firms largely consume electricity for their daily productive engagement. Therefore ignoring electricity consumption constitute some inadequate for policy formulation. This study seeks to address the challenge.

Theoretical Framework

The theoretical framework of this study is hinged on the neoclassical traditional production function following the empirical studies by Beaudreau, 1995; Enang, 2011; Enang, 2010 and Enang 2011. The neoclassical production function, particularly Cobb and Douglas (1928) expresses the technical relationship between given level of output and a given quantity of physical inputs. A change in output is as a result of variation in the physical inputs. The production function has only two factor inputs in production, but with the emergence of empirical evidence identifying energy or electricity as an independent and primary factor input in production process, there is departure from the neoclassical thinking of production function to that which includes energy as an independent factor of production (Alam, 2006). To this extent, our model for manufacturing sector's output constitutes an explicit inclusion of electricity supply as primary and independent factor of production.

$$M_t = f\ (E^{y}K^{\theta}L^{\sigma}) \qquad (1)$$

Where:

M	=	Manufacturing sector output
E	=	Electricity sector
K	=	Gross fixed capital formation
L	=	Labour force
f	=	Functional operator

y, θ and σ are the respective contributions of E, K and L to manufacturing sector's output (M). Labour and capital are treated as additional variable to avoid the possible biased findings as a result of exclusion of relevant variables (Wolde-Rufael, 2010). The production function in equation 1 is an exponential function, there is need to log the data in order to linearly express the equation. The estimation of time series properties can best be done through VAR model expressed in log – linear form with time trend or intercept (Pesaran, Shin, & Smith, 2001). Thus, taking the log of equation

1 and transforming it to econometric regression model to be estimated, we have equation 2.

$$LOG(M_t) = \beta_0 + yLOG(E_t) + \beta_1 LOG(K_t) + \beta_2 LOG(L_t) + u_t \quad (2)$$

Where

$LOG(M_t)$ = Natural log of Manufacturing output at time t
$LOG(E_t)$ = Natural log of Electricity supply at time t
$LOG(K_t)$ = Natural log of Gross fixed capital formation at time t
$LOG(L_t)$ = Natural log of Labour force at time t
u_t = Error term or residual term
y, β_1 and β_2 are the respective coefficients of $LOG(E_t)$, $LOG(K_t)$ and $LOG(L_t)$

Model Specification

The study adopted the model used by Theophilus, Christophe and Paul (2016) with examined variables of the model

INDP = (ELEC, IQ, GFCF, HCD, TOP, TGAP) (3)
INDP = Industrial Output
ELEC = Electricity Consumption
IQ = Institutional Quality
GFCF = Gross Fixed Capital Formation
HCD = Human Capital Development
TOP = Trade Openness
TGAP = Technological Gap.

In order to reflect the peculiarities of this study, this model is modified by adding the aforementioned variables and re-specified as follows;

MAO = f(CMB, ECP, ELEC, EXR, ELG) (4)
Where:
MAO = Manufacturing sector Output
CBM = Commercial bank credit to the manufacturing sector
CEM = Carbon Emission
ECP = Electric Price
ELEC = Manufacturing sector Electricity Consumption
EXR = Exchange Rate
ELG = Electricity generation

Equation four is written in log linear form except exchange rate;

$$MAO = \beta_0 + \beta_1 LOGCBMt + \beta_2 LOGCEM_t + \beta_3 LOGECP_t + \beta_4 LOGELEC_t + \beta_5 EXR + \beta_6 LOGELG_t + U_t \quad (5)$$

a priori expectations are $\beta_1>0$, $\beta_2>0$, $\beta_3>0$, $\beta_4<0$, $\beta_5>0$, $\beta_6>0$
t = time trend is the time trend
β_0 =intercept
$\beta_1 - \beta_6$ are parameters
U_t = error term also known as the white noise random element

Sources of Data

Given the nature of the model, it became expedient for this study to make use of time-series data which are basically secondary data. The data for electricity consumption in manufacturing sector of Nigeria were obtained from Central Bank of Nigeria (CBN) Statistical Bulletin while, the other variables were sourced from the publications of International Monetary Fund (IMF), United Nations (U.N) and the National Bureau for Statistics (NBS).

3. METHOD OF DATA ANALYSIS

The study adopts the Bounds testing cointegration procedure to estimate the long run and short run relationships and dynamic interaction among the variables of interest. Pesaran, Shin and Smith (2001) proposed the Auto-Regressive Distributed Lag (ARDL) bounds testing approach to investigating the existence of cointegration relationship among variables. The choice of this modeling approach is based on the following considerations. First, it circumvents the problem of the order of integration associated with the Johansen likelihood approach (Johansen & Juselius, 1990). Second, unlike most of the conventional multivariate cointegration procedures, which are valid for large sample size, the Bounds test approach is suitable for small sample size study (Pesaran, Shin & Smith, 2001).

Third, it provides unbiased estimates of the long run model and valid t-statistics even when some of the regressors are endogenous (Harris & Sollis, 2003). Fourth, the bound test does not impose a restrictive assumption that all variables under study must be integrated of the same order. Also, it is unnecessary that the order of integration of the underlying regressors be ascertained prior to testing the existence of a level relationship between the variables (Pesaran, Shin & Smith, 2001). However, to ensure that the variables are not integrated of higher order 1(2), therefore it is necessary to test the unit root. Fifth, it estimates the short and long run components of the model simultaneously, removing problems of omitted variables and autocorrelation.

The following ARDL model is estimated in order to test the cointegration relationship between the variables: manufacturing sector output, manufacturing sector electricity consumption, electricity generation, electricity price proxied by consumer price index, carbon emission, exchange rate and commercial bank credit to the manufacturing sector. The Auto-Regressive Distributed Lag (ARDL) specification of equation 5 is presented below as equation 6.

$$\Delta LOG(MAO)_t = \alpha_0 + \sum_{i=1}^{p}\alpha_1\Delta LOG(MAO)_{t-i} + \sum_{i=0}^{p}\alpha_2\Delta LOG(CBM)_{t-i} + \sum_{i=0}^{p}\alpha_3\Delta LOG(CEM)_{t-i}$$

$$+ \sum_{i=0}^{p}\alpha_4\Delta LOG(ECP)_{t-i} + \sum_{i=0}^{p}\alpha_5\Delta LOG(ELEC)_{t-i} + \sum_{i=0}^{p}\alpha_6\Delta(EXR)_{t-i} + \delta_1 LOG(MAO)_{t-1} + \delta_2 LOG(CBM)_{t-1}$$

$$+ \delta_3 LOG(CEM)_{t-1} + \delta_4 LOG(ECP)_{t-1} + \delta_5 LOG(ELEC)_{t-1} + \delta_6 (EXR)_{t-1} + \upsilon_t \text{--------------} (6)$$

Where δi is the long run multipliers, α_0 is the intercept and υ_t are white noise errors. The first step in the ARDL bounds testing approach is to estimate equation 6 by Ordinary Least Squares (OLS) in order to test for the existence of a long run relationship among the variables by conducting an F-test for the joint significance of the coefficients of the lagged levels of the variables, that is: H_0: $\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = \alpha_5 = 0$ $\alpha_6 = 0$ against the alternative H_1: $\alpha_1 \neq \alpha_2 \neq \alpha_3 \neq \alpha_4 \neq \alpha_5 \neq 0$ $\alpha_6 \neq 0$. The functions which normalises the tests are denoted by MAO = f(MEC, ELG, ECP, CEM, CBM, EXR).

Two asymptotic critical value bounds provide a test for cointegration when the independent variables are I(d) [where 0≤d≤1]: a lower value assuming the regressors are I(0) and an upper value assuming purely I(1) regressors. If the F- statistic is above the upper critical value, the null hypothesis of no long run relationship can be rejected irrespective of the orders of integration for the time series. Conversely, if the test statistic falls below the lower critical value, the null hypothesis cannot be rejected. Finally, if the statistic falls between the lower and upper critical values, the result is inconclusive. The approximate critical values for the F-statistic test were obtained from Pesaran, Shin and Smith (2001). Once cointegration is established the conditional ARDL (α_1, α_2, α_3, α_4, α_5, α_6) long run model for MAO_t can be estimated as:

$$\Delta LOG(MAO)_t = \alpha_0 + \sum_{i=1}^{p} \alpha_1 \Delta LOG(MAO)_{t-i} + \sum_{i=0}^{p} \alpha_2 \Delta LOG(CBM)_{t-i} + \sum_{i=0}^{p} \alpha_3 \Delta LOG(CEM)_{t-i}$$

$$+ \sum_{i=0}^{p} \alpha_4 \Delta LOG(ECP)_{t-i} + \sum_{i=0}^{p} \alpha_5 \Delta LOG(ELEC)_{t-i} + \sum_{i=0}^{p} \alpha_6 \Delta (EXR)_{t-i} + \beta ECM_{t-1} + \upsilon_t ---------- (8)$$

All coefficients of short-run equations are coefficients relating to the short run dynamics of the model's convergence to equilibrium and β represent the speed of adjustment and ECM is the Error Correction term that is derived from the estimated equilibrium relation of equation (7).

The lag length selection criterion was determined to know the number of lag to include in the estimation because an appropriate lag selection will be able to identify the dynamics of a model (Isedu, 2013). Furthermore, post estimation analyses are carried out to examine the usefulness, robustness and reliability of the estimated models by conducting diagnostic tests. The structural stability test is conducted by employing the Cumulative Sum (CUSUM) and Cumulative Sum of Square (CUSUM Q) of residual of the ARDL model. The existence of parameter instability is established if the Cumulative Sum of the residual goes outside the area between the critical (dotted bounded) lines. It is estimated at 5 percent critical level.

4. RESULTS

Prior to the testing of ARDL Bound test, we conducted a test of order of integration for each variable using Augmented Dickey-Fuller (ADF). Even though the ARDL framework does not require pre-testing variables to be done, the Unit Root Test could convince us whether or not the ARDL model should be used. This is to ensure that the variables are not I(2) stationary so as to avoid spurious results. The results of the ADF group unit root test is presented in Table 4.1

Table 1: Augmented – Dickey Fuller (ADF) Test Result

Variable	ADF T-statistic at level	ADF T-statistic at 1st Difference	5% critical value	Order of Integration
LOG(MAO)	-0.558694	-5.810862	-2.948404	I(1)
LOG(CBM)	-0.025910	-5.418334	-2.948404	I (1)
LOG(CEM)	-3.233823	-	-2.945842	I (0)
LOG(ECP)	-3.298618	-	-2.945842	I (0)
LOG(ELEC)	-3.425537	-	-2.945842	I (0)

LOG(ELG)	-1.373583	-6.662144	-2.948404	I (1)
EXR	-2.238120	-3.303323	-2.948404	I (1)

Sources: Author's Regression Output

From Table 1, Time series of manufacturing sector output, exchange rate and commercial bank credit to the manufacturing sector are stationary at first difference *I*(1) since the ADF value of each of the variables at first difference is greater than the McKinnon 5% critical values while manufacturing sector electricity consumption, electricity generation, electricity price proxied by consumer price index and carbon emission are stationary at level 1(0). Therefore, unit test show that there is a mixture of I(1) and I(0) of underlying regressors and therefore, the ARDL testing could be proceeded.

The lag-length selection criteria such as sequential modified LR test statistic (LR), Final Prediction Error (FPE), Akaike Information Criterion (AIC), Schwarz Information Criterion (SC), and Hannan-Quinn information criterion (HQ) were employed to determine the appropriate lag length of the model. The test result of the different lag selection methods is reported in Table 2. After a meticulous examination of the different lag lengths by estimating the VAR at each lag length and diagnosing the whiteness of resulting residuals, three (3) lag lengths, as recommended by Aikaike Information Criteria AIC statistic was selected.

Table 2: Lag Order Selection Criteria

Lag Order Selection Criteria
Endogenous variables: LOG(CBM) LOG(CEM) LOG(ECP) LOG(ELEC) LOG(ELG) EXR LOG(MAO)

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-222.7292	NA	0.001744	13.51348	13.82773	13.62065
1	-20.82309	308.7976	2.30e-07	4.519005	7.033011	5.376353
2	47.40592	76.25595	1.10e-07	3.387887	8.101648	4.995415
3	159.2632	78.95805*	9.71e-09*	-0.309598*	6.603918*	2.048109*

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Bounds Test for Co-Integration

The next step after determining the order of integration and lag length of the variables was to apply the bound F-test in order to establish the existences or otherwise of long-run relationship among the variables. The results of the bounds test for cointegration alongside with critical values are reported in Table 3. The Computed F-Statistic from bound test is 7.5035. This value exceeds the upper bounds critical value of 3.28 at the 5% significance level. This implies that the alternate hypothesis of the existence of a unique cointegration (long run) relationship between manufacturing sector output and exchange rate, commercial bank credit to the manufacturing sector, manufacturing sector electricity consumption, electricity generation, electricity Price Proxied by Consumer Price Index and carbon emission is upheld. This means that the null hypothesis of no co-integration is rejected.

Table 3: ARDL Bound Test Result

Test statistic	Computed F-statistic	Lag	Significance level	Bound Critical values	
				Lower Bounds I(0)	Upper Bounds I(1)
F-statistic	7.0089	3	5%	2.39	3.38

Variables	Coefficient	Std error	T- statistics	Pro-value
LOG(CBM)	0.9656*	0.0414	23.3374	0.0000
LOG(CEM)	0.2100	0.1087	1.9320	0.0795
LOG(ECP)	-0.1679*	0.0610	-2.7521	0.0188
LOG(ELEC)	-0.5355*	0.1997	-2.6818	0.0213
LOG(ELG)	-0.1945*	0.0864	-2.2511	0.0458
EXR	-0.0008	0.0008	-0.9828	0.3468
C	5.9701	1.2343	4.8369	0.0005

Note*: * Coefficient is significant at 5% level of significance.*
Dependent variable: LOG(MAO)
Source: Authors Regression output

From Table 3, it could be observed that none of the variable except Commercial bank credit to the manufacturing sector and carbon emission have their expected sign. Commercial bank credit to the manufacturing sector LOG(CBM) has direct and significant impact on manufacturing sector output. One percent increase in LOG(CBM) leads to 0.9656 unit increase in Nigeria's manufacturing sector output. This is consistent with the apriori expectation. This result supports the fact that in the long run increasing commercial bank credit to the manufacturing sector enhanced the growth performance of the manufacturing sector output. This finding is in line with Osmond, Egbulonu and Mmaduabuchi's (2015) position which holds that commercial bank credit contributes massively to the growth of the manufacturing sector.

The result further revealed that the coefficient of carbon emission has direct but insignificant effect on the growth of Nigeria's manufacturing sector such that one unit increase in LOG(CEM) leads to 0.2100 percent increase in Nigeria manufacturing sector. This implies that increase in number generator enhance manufacturing sector productivity which is consistent with the apriori expectation and the insignificant of this variable is due to cost of running generator in the manufacturing sector. Electricity price proxied by consumer price index has an indirect and significant impact on the growth of the Nigeria manufacturing sector suggesting that its contribution to industrial manufacturing output is low. This also implies that electricity demand is normal goods.

The coefficient of manufacturing sector electricity consumption LOG(ELEC) shows an inverse and significant relationship with Nigeria manufacturing sector output. One unit increase in LOG(ELEC) leads to about 0.5354 unit increase in Nigeria manufacturing sector output. This is

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not consistent with apriori expectation. This result showed that electricity demand and supply has not enhanced manufacturing sector output in the Nigerian economy. Furthermore electricity generation has an indirect and significant relationship with growth of the Nigeria manufacturing sector such that one percent increase in LOG(ELG) lead to -0.1945 percent decreases in Nigeria manufacturing sector output. The inverse and significant nature of these variables could be explained by the underdeveloped nature of the Nigerian electric power generation and distribution which does not stimulate the growth of the real sector of the economy such as the manufacturing sector.

The coefficient of exchange rate shows an inverse and insignificant relationship with Nigeria's manufacturing sector output. One unit increase in exchange rate leads to 0.0008 percent decrease in Nigeria manufacturing sector output. This is not consistent with the apriori expectation. This result suggests that exchange rate depreciation has not contributed to the growth of the Nigeria manufacturing sector in long run. Furthermore, the insignificance of this variable is that the use of depreciation as a mechanism for promoting the growth of the manufacturing sector in Nigeria has not enhances the sector productivity but this is not in line with Adekoya and Fagbohun (2015) and Lawal (2016) who revealed that exchange rate has a positive relationship with manufacturing sector output but not significant. Therefore, there is the need for the review of the current exchange rate policy towards appreciation of the naira.

ARDL Short Run Estimation

In order to capture the short run deviations that might have occurred in estimating the long run co-integration equation, a dynamic error correction estimate is reported in Table 4.

Table 4: Error Correction Estimate for Selected of ARDL Model (3, 3, 1, 2, 3, 3, 1)

Variable	Coefficient	Std. Error	T-statistic	Prob.
DLOG(MAO(-1))	-1.9257*	0.2475	-7.7819	0.0000
DLOG(MAO(-2))	-1.0829*	0.2053	-5.2741	0.0003
DLOG(CBM)	-0.4172*	0.1297	-3.2170	0.0082
DLOG(CBM(-1))	0.4138*	0.1427	2.8988	0.0145
DLOG(CBM(-2))	-0.4217*	0.1106	-3.8117	0.0029
DLOG(CEM)	0.0672	0.0510	1.3177	0.2144
DLOG(ECP)	0.1918*	0.0276	6.9697	0.0000
DLOG(ECP(-1))	-0.0823*	0.0216	-3.8085	0.0029
DLOG(ELEC)	0.5935*	0.1641	3.6179	0.0040
DLOG(ELEC(-1))	-0.5499*	0.1736	-3.1665	0.0090
DLOG(ELEC(-2))	-0.5949*	0.1526	-3.8984	0.0025
DLOG(ELG)	-0.9122*	0.1747	-5.2218	0.0003

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DLOG(ELG(-1))	-1.3374*	0.2131	-6.2749	0.0001
DLOG(ELG(-2))	-0.1978	0.1498	-1.3202	0.2136
D(EXR)	0.0036*	0.0009	4.0329	0.0020
ECM(-1)	-0.7604*	0.0833	-9.1332	0.0000

R-Squared = 0.8689 Adjusted R^2 = 0.7596 DW = 2.5015

Source: *Author's Regression Output*

Note: * *Coefficient is significant at 5% level of significance respectively.*

Dependent variable: DLOG(MAO)

Table 5 indicated that the coefficient of ECM(-1) is found to be statistically significant at 5% level. This confirms the existence of a long run relationship between the variables. The coefficient of ECM term is -0.7604. This indicates that about 76 percent disequilibria in the manufacturing sector in the previous one year are corrected in the current year. Also, the result previous manufacturing sector output at lag one and two have an inverse but significant impact on manufacturing sector output. The estimation of the coefficients of DLOG(CBM), DLOG(CBM(-1)) and DLOG(CBM(-2)) are all statistically significant but DLOG(CBM) and DLOG(CBM(-2)) have inverse and significant impact on the manufacturing sector output. This implies that continuous credit supply to the manufacturing sector has the tendency to induce the performance of the sector in the short run.

The difference in carbon emission DLOG(CEM) has direct but insignificant impact on the manufacturing sector output on the short run. The results also shows that the difference in electricity price DLOG(ECP) has direct and significant impact on the manufacturing sector output on the short run but the variables DLOG(ECP(-1)) has an inverse but significant effect on the growth of manufacturing sector output. The results also shows that the difference in manufacturing sector electricity consumption DLOG(ELEC) has direct and significant impact on the manufacturing sector output on the short run. This indicate that adequate power supply to the manufacturing company has the tendency to induce the growth of the sector but the variables DLOG(ELEC(-1)) and DLOG(ELEC(-2)) have inverse and significant effect on the manufacturing sector output.

The difference in electricity generation DLOG(ELG), at lag one of it DLOG(ELG(-1)) and at lag two of it DLOG(ELG(-2)) have an inverse but significant impact on the manufacturing sector output on the shortrun. This implies that electricity generation has not improved the growth of manufacturing sector in Nigeria. The adjusted R^2 of 0.7596 indicates that 76 percent of the variations in the manufacturing sector output are explained by variations in the independent variables and the Durbin Watson statistic of 2.5015 suggests that the model is free from serial autocorrelation.

Diagnostic Tests

To confirm whether any of the assumptions of the Autoregressive Distributed Lagged framework was violated; some diagnostic tests were performed. This is to ensure that the model is satisfactory for policy formulation. Table 6 shows the test for serial autocorrelation, test for Heteroskedasticity, Ramsey test of model specification fitness and Jarque-bera test of normality.

Table 6: Summary of Diagnostic test on the Model

Breusch-Godfrey Serial Correlation LM Test	
F-statistic = 0.979	Prob. F(1,17) = 0.335
Obs*R-squared = 1.405	Prob. Chi-Square(1) = 0.190
Heteroskedasticity Test: Breusch-Pagan-Godfrey	
F-statistic = 1.544	Prob. F(14,20) = 0.182
Obs*R-squared = 18.184	Prob. Chi-Square(14) = 0199
Scaled explained SS = 7.677	Prob. Chi-Square(14) = 0.906
Ramsey (RESET) test of model specification fitness	
F-statistic = 1.5546	Prob. F(6,22) = 0.09412
Likelihood ratio = 3.2005	Prob. Likelihood ratio(6) = 0.2346
Jarque-Bera test of Normality	
Jarque-Bera 4.267	Prob = 0.1184

Source: Author's Regression Output

The summary of the diagnostic test result in Table 6 indicated that the residual generated from the long-run estimates used as error correction term (ECT) in the short-run model estimates are not serially correlated, the variance of the error term are homoscedastic, there is no model specification error and the residuals are normally distributed. The Breusch-Godfrey Serial Correlation LM Test was used to check hypothesis about the fact that no serial correlation exist between the short run and long run period. The test has the null hypothesis of no serial correlation; hence, its rejection requires that the probability value exceeds appropriate threshold or level of significance at which the test is carried out e.g 0.05 (or 5%). Since the F-statistic of the Breusch-Godfrey Serial Correlation LM Test is not statistically significant (p>0.05); hence, the null hypotheses is retained. The Breusch Pagan statistic tests for homoscedasticity with the null hypothesis that homoscedasticity exist. Since the test statistic (F-statistic of the Breusch-Pagan-Godfrey) has a p-value greater than the appropriate threshold (p>0.05), the null hypothesis of homoscedasticity is thereby retained. In addition to this, the coefficients of Ramsey RESET (regression equation specification error test) and Jarque-Bera were not statistically significant (p>0.05). Hence, we cannot reject the null hypotheses of none existence of model error specification and normality of residual distribution respectively. This indicates that the model is well specified and the residuals are normally distributed.

5. IMPLICATIONS OF THE RESULT

The result shows that manufacturing sector electricity consumption and electricity generation has an inverse and significant effect on the growth of the Nigeria manufacturing sector both in the short-run and long-run. By implication, this shows that increased electricity consumption decreases output in the manufacturing sector. The reason for the inverse relationship could be due to high electricity (utility) bill incurred by manufacturing firms without commensurate increase in electricity distribution and consumption. This accounts for the reason many micro and small scale manufacturing firms, expend so much money to maintain their generators, solar power and biogas; which serve as ready alternatives to power their machines and production plants. Furthermore, the negative sign of the coefficient could be due to high cost of doing business and maintaining power plants which may be adversely affecting business profit for most firms.

The direct relationship between commercial bank credit and manufacturing output is an indication that increasing commercial bank credit to the private sector will bring about increase in the Nigeria manufacturing sector both on the long run and short run. This implies that increase in domestic credit is pertinent in reducing the cost of borrowing for entrepreneurs who want to invest in the manufacturing industry. In conclusion, the results from the empirical analysis showed that, manufacturing sector electricity consumption, electricity generation and cost of electricity have inverse and significant effect on the growth of Nigeria manufacturing sector.

6. RECOMMENDATIONS

Based on the findings of this study, the following recommendations are made:

a) More electric power supply should be generated to take care of electric power demand by the manufacturing sector. This can be done by investing massively into the energy sector of the Nigerian economy by the authorities in charge of affairs to ensure continuous electric power supply to all the sectors of the Nigerian economy.
b) The regulatory bodies in the energy sector should set some energy capacity distribution standards with regards to energy preference to key sectors of the economy such as manufacturing sector.
c) Government privatization policy of the electricity sub-sector should be highly monitored to provide enough electricity generation and consumption to encourage mass employment of a skilled and unskilled labour in the Nigeria manufacturing sector.

REFERENCES

Adenikinju, O. (2005). Analysis of the cost of infrastructure failure in a developing economy: The case of electricity sector in Nigeria. *AERC Research paper* , 148.

Agbede, M. O. (2018). Disaggregate energy supply and industrial output in Nigeria. *International Journal of Economics, Business and Management Research*, 2(2): 154-172

Aguegboh, S.E & Mudueme, S.I. (2013). Energy consumption and economic growth nexus: empirical evidence from Nigeria. Proceedings of the 2013 *NAEE/IAEE* conference on energy resource management in a federal system, challenges, constraint and strategies. 305-332.

Akekere, J. & Yousuo, P.O. (2010). Empirical analysis of change in income on private consumption expenditure in Nigeria from 1981- 2010. *International Journal of Academic Research in Business and Social Sciences*, 2(11).

Akinlo, A. E. (2009). Electricity consumption and economic Growth in Nigeria: Evidence from co-integration and co-feature analysis. *Journal of Policy Modelling*, 31, 681-693.

Alam, I. (2006). Customer co-creation in hotel service innovation: an interpretive structural modelling in structural and MICMAC analysis approach. *An International Journal*. 25(1); 55-61.

Atser, G. (2006). Power shortage takes toll on economy. *The Punch*, June 8, 2006 p. 28.

Bamidele, P. A. & Mathew, A.D. (2013). "Energy consumption and economic growth nexus: Empirical evidence from Nigeria". Proceedings of the NAEE/AEE conference on energy resource management in a federal system, challenges, constraint, and strategies, Nigeria. Pp 241 257.

Beaudreau, B. C. (2005). Engineering and economic growth. *Structural Change and Economic Dynamics*, 16(2), 211–220.

Braimah, I. and Amponsah, O. (2012). Causes and effects of frequent and unannounced electricity blackouts on the operations of micro and small scale industries in Kumasi. *Journal of Sustainable Development*, 5(2): 17-26.

Charles .A.N (2012). Investigating the performance of monetary policy on manufacturing sector in Nigeria: 1980-2009. *Arabian Journal of Business and Management Review (OMAN Chapter)*, 2(1), 12-25.

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.

Cobb, C.W. & Dougals, P.H. (928). A theory of production. *American Economic Review*, 187, 139-165.

Ebele, E. J., & Iorember, P. T. (2016). Commercial bank credit and manufacturing sector output in Nigeria. *Journal of Economics and Sustainable Development*, 7(16), 1-8

Enang, B. (2010). Industrial development, electricity crisis and economic performance in Nigeria. *European Journal of Economics, Finance and Administrative Sciences*, 18(18), 106 – 121.

Enang, B. (2011). Energy crises, stabilization policies and economic performance in Nigeria: An empirical investigation. *Interdisciplinary Journal of Research in Business*, 1(9), 27–37.

Enu, P. (2014). Sectoral estimation of the impact of electricity consumption on real output in Ghana. *International Journal of Economics, Commerce and Management*, 2, 1–18

Imoughele, L. E. and Ismaila, M. (2014). Empirical investigation of the impact of monetary policy on manufacturing sector performance in Nigeria (1986-2012). *International Journal of*

Education and Research, 2(1), 87-106.

Kouakou, A. K., (2011). Economic growth and electricity consumption in Cote d'Ivoire: Evidence from time series analysis. *Energy Policy*, *Elsevier*, 39(6): 3638-3644

Liew, V. K., Nathan, T. M. & Wong, W. (2012) Are sectoral outputs in Pakistan led by energy Consumption? *Economic Bulletin*, 32(3), 2326-2331

Nwosa, P. & Akinbobola, T. (2012). Aggregate energy consumption and sectoral output in Nigeria. *An International Multidisciplinary Journal*, *Ethiopia*, 6(4) 206-215.

Odior, S.E. (2013). Macroeconomic variables and the productivity of the manufacturing sector in Nigeria: A static analysis approach. *Journal of Emerging Issues in Economics*, *Finance and Banking (JEIEFB)*, 1(5), 362-380

Ogundipe, A. A. & Apata, A. (2013). Electricity consumption and economic growth in Nigeria. *Journal of Business Management and Applied Economics*, 2, 1–14

Ogunjobi, J.O. (2015). The effects of electricity consumption on industrial growth in Nigeria. *Journal of Economics and Sustainable Development*, 6(13): 54-59

Ogunleye, E. O. & Ayeni, R. K. (2012). Energy demand in Nigeria: A disaggregates analysis. *International Research Journal of Finance and Economics*, 86, 52-62.

Olaoye, T., Ajilore , T., Akinluwade, K., Omole, F. and Adetunji, A. (2016). Energy crisis in Nigeria: Need for renewable energy mix. *American Journal of Electrical and Electronic Engineering*, *4(1): 1-8.*

Olawale, L.S. Ilo, B.M. & Lawal, F. K. (2017). The effect of firm size on performance of firms in Nigeria. *The IEB International Journal of Finance.*15: 2-21

Olufemi, O. J. (2015). The effects of electricity consumption on industrial growth in Nigeria. *Energy*, 6(13): 54-59

Omisakin, O. A. (2008). Energy consumption and economic growth in Nigeria: A bounds testing co-integration approach. *Journal of Economic Theory*, 2(4), 18-123.

Osobase, A. O. & Bakare, T. A. (2014). The Nexus between electricity generation, supply and sanufacturing Sector performance in Nigeria (1975-2011). *International Journal of Management Sciences and Humanities*, 2(2), 184-207

Riker, D. (2011). Electricity efficiency and U.S. manufacturing exports. *The Electricity Journal*, *Elsevier*, 25(1), 84 – 92.

Theophilus I. U., Christopher K. D. & Paul O. E. (2016). Electricity Consumption and Industrial Production in Nigeria. *Journal of Policy and Development Studies*. 10 (2), 8-19

Yahaya, Y., Salisu, B. & Umar, B. (2015). Electricity supply and manufacturing output in Nigeria: Autoregressive distributed lag (ARDL) bound testing approach. *Journal of Economics and Sustainable Development,* 6(17): 7-17.