East African Scholars Journal of Economics, Business and Management
Abbreviated Key Title: East African Scholars J Econ Bus Manag
ISSN 2617-4464 (Print) | ISSN 2617-7269 (Online)
Published By East African Scholars Publisher, Kenya

OPEN ACCESS

Volume-3 | Issue-5 | May-2020 |

DOI: 10.36349/EASJEBM.2020.v03i05.056

Research Article

Energy and Industrial Productivity in Nigeria: An Insight from ARDL Approach

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Article History
Received: 18.04.2020
Accepted: 09.05.2020
Published: 11.05.2020

Journal homepage:
https://www.easpublisher.com/easjebm

Quick Response Code

Abstract: This paper analyzed and estimated the impact of energy on industrial productivity in Nigeria for the sample period of 1980 – 2018. The Autoregressive Distributed Lag model (ARDL) estimated with the Ordinary Least Square technique was used to examine the relationship among the variables. Findings from the model revealed that there was a direct and significant relationship between gross capital formation, gas consumption, electricity consumption and petroleum products consumption on industrial productivity in the long run. There was a direct and significant relationship between the independent variables and industrial productivity in the short run with the exception of electricity consumption that indicated negative and insignificant impact. The study therefore recommended investments in alternative energy sources and harnessing the abundance of natural gas in Nigeria' energy mix.

Keywords: Oil production, environmental degradation, economic development, ARDL,externalities. Jel classification: O_{11}, Q_{22}, Q_{28}.

INTRODUCTION

Energy is vital to economic growth and development of nations. It helps in poverty eradication and provides a form of security. Energy is an important factor in all the sectors of any country's economy. Energy fuels productive activities including agriculture, commerce, manufacturing, industry and mining. Conversely, a lack of access to energy contributes to poverty, deprivation and economics decline. Energy and poverty reduction are not only closely related to each other but are also related with socio-economic development (Nnaji et. al 2010). The Council for Renewable Energy of Nigeria (2009) estimated that power outages brought about a loss of N126 billion annually. It has also resulted in health hazards due to exposure to carbon emissions caused by generators in households and business premises. Security, climate change and public health are closely related with energy (Raid, 2004). Raid (2014) opined that the recent world's energy crisis is due to rapid population growth and the increase in the standard of living of societies. The per capita energy consumption is a measure of the per capita income as well as a measure of the prosperity of a nation (Ramehandra, 2011).

The Nigerian power sector has been in comatose for over four decades. In the context of power generation, transmission and distribution it had been one problem or the other. The enormity of the problem is under stored by the fact that Nigeria is the largest purchase of standby electricity generating plants in the word (Braimoh and Okedeyi, 2010). A significant part of today's prosperity in the global arena rests on secure and stable access to energy. In the absence of functional energy infrastructure modern production grinds to a halt as witnessed in many developing countries, Nigeria inclusive. Most of the rich countries with few exceptions have become rich through industrialization though some of them are now focusing on services. Compared with agriculture and services, industrial production is relatively more energy intensive. The implication of this is that industrialization increases demand for energy thus a need for adequate energy supply. The most direct role of energy is that of an input production. In fact a world without energy amounts to non-mechanized production.

The secondary sector of the Nigerian economy has been bedeviled by a plethora of problems. A major part of the problem is inadequate energy supply. The government is not unaware of the benefits of industrialization for employment generation, poverty reduction, inequality reduction and improving standard of living generally. Successive governments in Nigeria have adopted various policies, schemes and incentives toward realization of a virile secondary sector that is competitive. Some of the policies adopted included but not limited to import substitution in the 60s, indigenization policy of 1972, the Structural Adjustment Programme (SAP) 1986, the Bank of Industry and Small and Medium Equity Investment Scheme (2002), the Electricity Power Sector Reform Act (EPSRA) of 2005 and the National Integrated Industrial Development (NIID) blue print 2007 (Ugoke, Dike and Ekewa, 2016). In spite of these policies, available data indicated that only 10% of manufacturing firms in Nigeria could operate at 48.8%. installed capacity, 60% of the companies were barely able to cover their average variable costs while 30% had to shut down completely due to inadequately supply of electricity (Okafor 2008; Ogunjobi 2015). Against this background, the objective of the study is to analyze and estimate the role of energy in industrial productivity in Nigeria. By estimating the relationship between disaggregated energy supply and industrial productivity will position policy makers well to address the problems of unemployment, poverty, inequality and low standard of living with sound professional. The remainder of this paper is planned as follows: section 2 provides review of literature while method of study is presented in section 3. Section 4 presents the empirical estimations of results for the paper and while section 5 discloses the findings and concludes the study.

LITERATURE REVIEW

Empirical Literature

This paper is on the role of energy in industrial productivity in Nigeria therefore literature review was focused on the relationship between energy and industrial productivity. Empirical studies on the link between energy consumption and economic growth are more in abundance than on the relationship between energy and industrial productivity. We proceed by reviewing studies done in other parts of the world and then narrow down to the studies done on the Nigerian economy. In a study on the relationship between disaggregated energy consumption and industrial output and employment in the United States (Sari, Ewing and Soytas, 2008) employed the autoregressive distributed lag approach over a period of 2001:1-2003:6. The results of the industrial production equation showed that neither employment nor local energy consumption has a significant long-run impact on real output. The short run relationship indicated a statistically significant relationship between employment, industrial production and conventional hydroelectric wind energy.

Knetsh and Molzahn (2009) examined the impact of energy price likes on the short term supply of industrial goods and transport services as well as their effect on income distribution in the two sectors in Germany, employing annual time series data from 1970-2008. The results showed that industrial production was more severely affected by the oil price shocks of the late 70s than those of the early 1970s and 2004-2008 periods. Estimates from the energy demand equation indicated that the elasticity of substitution between capital and energy is higher (0.9) in the industry than in transportation (0.3) meaning that the output responses to energy price impulses are stronger in industry than in transportation. Also, the study found that the persistent rise in the relative price of energy use alters the optimal-energy combination, making it costly to operate energy-intensive machines.

In a study carried out in Pakistan (Qazi, Ahmed and Mudassar, 2012) empirically examined the relationship between disaggregate energy consumption and industrial output employing annual time series data from 1972 to 2010. The study used the Johansen co-integration task to examine the long run relationship between the variables while the vector error correction Models (VECMs) which are also known as restricted VAR models were employed to obtain short run coefficients. The results indicated a long-run relationship between the variables in the model. The long run coefficients of the model showed that disaggregated energy consumption has positive and significant effect on industrial output in Pakistan. The short run causality test indicated bidirectional causality between oil consumption and industrial output. The joint significance test conducted by aggregating all disaggregated energy sources confirm a unidirectional causality running from energy usage to output growth.

Studies on energy consumption and economic growth in Nigeria abound in economic literature, however, there are very few studies on energy and industrial productivity. In a study carried out in Nigeria (Elija and Nsikak, 2013) examined the relationship between energy requirements and industrial growth using the autoregressive distributed lag approach (ARDL). The results of the long run estimates indicated that physical capital, exchange rate, coal and petroleum products consumption have positive relationship with industrial output in Nigeria. The results from the short run estimates showed that changes in the previous (one lagged) period of industrial output, physical capital and petroleum products have positive impact on industrial output while the remaining variables have negative impacts. The study recommended that policy makers should look into exploring solar, wind and other renewable energy sources. The efficient use of natural gas was recommended too.

Olarinde and Omoyolaibi (2014) examined electricity consumption, institutions and economic growth in Nigeria for the period 1980-2011. The study tested for causality using the ARDL and Wald test approach and found a positive and significant relationship between institutions, electricity consumption and economic growth. Agbede (2018) examined disaggregate energy supply and industrial output in Nigeria using the error correction model (ECM) on time series data from 1981-2014. The study found that electricity generated and premium motor spirit have a positive impact on industrial output growth in Nigeria while gas consumption and automated gas oil (Diesel) have negative impact. The study recommended that the power sector should be given more attention for growth of the economy through the means of guided private sector initiative.

Aladejare (2014) examined the relationship between energy, growth and economic development using descriptive and statistical techniques of analysis. The study found that implementing a good energy mix is germane for economic development in the country. The study recommended implementation of renewable energy and energy efficiency programs.

Danmaraya and Hassan (2016) examined the relationship between electricity consumption and manufacturing productivity in Nigeria using the autoregressive distributed long run a time series data set from 1980-2013. The results indicated a long-term relationship between electricity consumption and industrial productivity. Also, there was an indication of unidirectional causality relationship electricity consumption and manufacturing productivity. The study recommended policies that will enhance electricity supply.

From the literature reviewed above it can be deduced that there are contradicting findings on either the existence or the direction of causality between energy and economic growth. This study reinvestigates the relationship between energy and industrial productivity with the aim of filling this gap in the literature thereby contributing to the debate.

Overview of the Manufacturing Sector in Nigeria: Some Stylized Facts

The structure of the Nigerian economy depicts a typical underdeveloped framework. Available data from the stable of the Manufactures Association of Nigeria (MAN) revealed that more than 50% of the Gross Domestic Product (GDP) is accounted for by the primary sector with agriculture contribution about (20%). The oil and gas sector contributed 14.8 and 13.8% to GDP in 2011 and 2012 respectively. The industrial sector (comprising manufacturing, mining and utilities) accounted for 6% of GDP while the manufacturing sector contributed only 4% to GDP in 2011. In spite of policy efforts over the last 5 decades that have attempted to facilitate industrialization, the secondary sector is still very weak. The manufacturing sector contribution to the RGDP has been low over the years due to inability of the country to revive the sector through putting in place appropriate investment to encourage production. Since the 2016 recession that crippled business activities and brought the economy to its knees, the manufacturing sector (which is the most prominent sub-sector in the industrial sector) has continually recorded inconsistent movement. The sector oscillates between modest growth and contracting amplitude. The sector got a facelift after it limped 1.36% in the first quarter of 2017. After picking up in the first two quarters of 2017, the sector plunged into a negative trajectory recording -2.85% growth.

In Q4 2017, growth in the manufacturing sector was positive at a 0.14% as economic activities gradually return to normal. For the first time since the 4th quarter of 2017, the sector contracted by -0.13% year on year, lower than the corresponding quarter of 2018 and Q1 of 2019. This shows that it was not the best of times for manufacturing companies as the sector faces a number of challenges. The growth rate of the sector, on a quarter-on-quarter basis stood at -4.41%. the contribution to real GDP in Q2 2019 was 9.10%, which is lower than 9.29% recorded in the previous year and 9.79 recorded in the first quarter of 2019. The manufacturers Association of Nigeria (MAN) released the 2019 manufacturers CEOs Confidence Index. 400 Chief Executives made clear their position about the Nigeria economy. The challenges identified as inhibiting the sector included lack of access to bank credit, high interest rate that ranges between 20-35% per annum, delay in clearing raw materials and machinery which often result in demurrages which increase production cost and slow down manufacturing operations. Other important impediments included inadequate space inside the ports, poor road network and the association gridlock, inefficient port infrastructure and inadequate electricity supply.

Theoretical Framework

The role of energy in the economy is not accorded a prominent place by traditional growth models. The mainstream production theory considers capital, labour and land to a lesser extent, as the basic (primary) factors of production, while inputs such as energy and raw materials are considered intermediate factors. This over-concentration of growth theories on these primary inputs has led to lesser treatment of energy as a factor in the production function.

For instance, the neoclassical growth theory developed by Solow (1957) specified a production function of the form;

$$\mathbf{Y = f(K, L, A)} \text{ ------------- } \mathbf{(2.1)}$$

Where; Y is output, K is capital, L is labour and A is an index of technology. The basic assumption of the neoclassical model is that output increases at a decreasing rate as the amount of capital employed increases. The model also assumes that labour and the level of technology grow at exogenous exponential rates. Following from the second assumption, the neoclassical growth model holds that the only cause of continuing economic growth is technological progress. According to neoclassical growth theory, if there is no technological progress, growth in this model will eventually come to a halt. By intuition, the model states that increases in the state of technological knowledge raise the rate of return to capital; thereby offsetting the diminishing returns to capital that would otherwise means a halt in growth (Stern, 2012).

The endogenous growth model, on the other hand was developed as a response to the failures of the neoclassical theory. The model states that growth can be achieved endogenously rather than exogenously. The endogenous growth model attempts to endogenize technological change by explaining technological progress within the model rather than outside the model. Within the endogenous growth model, the relationship between capital and output can be expressed as;

Y = AK -------------------------------(2.2)

The endogenous growth theorists defined K more broadly than in the case of exogenous growth model to include a composite of productive and knowledge base capital. Also, from the model above, endogenous growth theorists have been able to show that under reasonable assumptions, the A term in the model above is a constant so that growth can continue indefinitely as capital is accumulated. The technological knowledge in turn can be thought of as a form of capital which is accumulated through research and development (R & D) and other knowledge creating process such as education and training. Thus, in an endogenous growth model, the economy can sustain a constant growth rate in which the diminishing returns to manufactured capital are exactly offset by the technological growth external effect so that growth rate is permanently influenced by the saving rate; a higher savings rate increases the economy's growth rate, not merely its equilibrium level of income (Stern, 2012).

The traditional growth models as presented above do not capture the role of energy in their respective models. However, ecological economists have held strongly the role of energy in the production process. Building on the second law of thermodynamics which state that a minimum quantity of energy is required to carry out the transformation of matter. Therefore there must be limits to the substitution of other factors of production of energy (Stern, 2012). And since all production involves the transformation of inputs into output in some way, it therefore means that all such transformations require energy. In this way, ecological economists also consider energy as an essential factor of production. To buttress their point, they employed the frequently used Cobb Douglas growth theory to demonstrate the essentiality of energy in production. Given the Cobb-Douglas production function;

$Y = AK^{\alpha}L^{\beta}$-------------- (3.1)

Where: K is the stock of capital, L is the stock of labour and A is technological progress. And since A is endogenously determined in the new growth model, it is thought to relate to energy in some way. This is because the amount of technology per unit of time requires some level of energy to work. Technology in this regard refers to plants, machinery and equipment and without adequate supply of energy; this technological stock will be obsolete. This is justified through the law of thermodynamics which holds that no production can occur without conversion of energy. Thus, from the theoretical perspective of the endogenous growth model, energy can enter the equation as one of the factors of production. Based on this theoretical framework, the empirical model for this study can be specified as follows:

Y = f(K, L, E)

Where: Y = total output, K=Capital stock, L=labour stock, E=Index of energy infrastructure. However, since the specific objective of this study is to examine the relationship between energy consumption and industrial growth, the empirical model in (1) is modified slightly with industrial output replacing total output and human capital replacing labour stock. We used human caital instead of labour because human capital reflects the extent to which labour force (L) is capable of using available stock of knowledge and skills in operating more complicated tasks and producing output. The energy index (E) is disaggregated into various sources (electricity, natural gas, coal and petroleum products) and used as independent variables alongside capital stock and human capital. In addition to the above variables, we also include exchange rate to capture the extent of international competiveness. Thus, exchange rates together with physical and human capitals serve as controlled variables to the energy variables.

METHOD OF STUDY

The Data

Annual time series data covering 1980-2018 were collected and employed for the analysis of this paper. The data were sourced from National Bureau of Statistic (NBS) Annual Abstract of Statistics (Various issues). National Bureau of Statistics (NBS) quarterly Reports, CBN Statistical Bulletin (various volumes) and (BN Annual Accounts and Reports (various years).

Model Specification

In this study, industrial output is the dependent variable while the independent variables are physical capital, represented by gross fixed capital formation, proxy by government expenditure in health and education as % of GDP, electricity consumption, natural gas consumption, petroleum product consumption are used as the independent variables.

To measure the effect of energy on industrial productivity, we specify:

INDOUT = f (GCF, GAC, ELC, ELC, GEH, PEP)-----(3.1)

Where
INDO = Industrial output

GCF = Physical capital, represented by gross fixed capital formation
GAC = Natural gas consumption
ELC = Electricity consumption
GEH = Government expenditure in health and education as % of GDP
PPC = Petroleum products consumption.

The model in its econometric linear form can be expressed as;

$$\mathbf{INDOUT = \alpha_0 + \alpha_1 GCF + \alpha_2 GAC + \alpha_3 ELC + \alpha_4 GEH + \alpha_5 PPC + U_t} \quad \text{-----------------------} \quad \mathbf{(3.2)}$$

Where α_0 to α_7 = the parameters to be estimated and U_t = the error term.

The theoretical expectations about the signs of the coefficients of the parameters are as follows;

$\alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5 > 0$

Estimation technique

The study adopts the Autoregressive Distributed Lag (ARDL) bounds testing approach developed by Pesaran, Shin and Smith (2001) in the estimation and analysis of the relevant models. This approach is applied irrespective of whether the series is integrated of 1(0), 1(1) or mutually cointegrated. In this way the pre-testing problem associated with the standard cointegration test such as the classification of variables into I(0) and I(1) is avoided.

Following from Pesaran *et al*. (2001), the Error Correction Model (ECM) of the unrestricted Autoregressive Distributed Lag (ARDL) equation can be formed. based on (3.2) specified as follows;

Equation (3.2) is transformed into an Autoregressive Distributed Lag (ARDL) model as shown in equation (3.3).

$$\Delta INDO = \alpha_0 + \alpha_1 INDO_{t-1} + \alpha_2 GCF_{t-1} + \alpha_3 GAC_{t-1} + \alpha_4 ELC_{t-1} + \alpha_5 GEH_{t-1} + \alpha_6 PPC_{t-1} + \ldots + \ldots + \sum_{i=0}^{k} \beta 1 \Delta\, INDO_{t-1} + \sum_{i=0}^{k} \beta 2 \Delta\, GCF_{t-1} + \sum_{i=0}^{k} \beta 3 \Delta\, GAC_{t-1} + \sum_{i=0}^{k} \beta 4 \Delta\, ELC_{t-1} + \sum_{i=0}^{k} \beta 5 \Delta \ldots + GEH_{t-1} + \sum_{i=0}^{k} \beta 6 \Delta\, PPCt - 1 + U_t \quad (3.3)$$

Where: U_t is the white noise error term.

The first part of the right hand side of equation (4) with parameters α_1 to α_6 represents the long-run parameters of the model and the second part with parameters β_1 to β_6 represents the short-run dynamics of the model. The ARDL approach involves testing first for the co-integration relationship between the variables in the model. In specific term, the bounds test involves estimating equation 3.3 using the OLS method and then testing the null hypothesis (H_0) of no long run relationship against the alternative hypothesis (H_a) that there is a long-run relationship. That is

$\mathbf{H_0: \alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = \alpha_5 = 0}$ against the alternative hypothesis that

$\mathbf{H_a: \alpha_1 \neq \alpha_2 \neq \alpha_3 \neq \alpha_4 \neq \alpha_5} \neq 0$

The above hypotheses are tested by comparing the calculated F-statistics against the critical values given in Pesaran *et al*. (2001). If the computed F-statistics exceeds the upper critical value, the null hypothesis of no long-run relationship can be rejected. On the other hand, if the F-statistics falls below the lower critical value then the null hypothesis cannot be rejected. Lastly, if the F-statistics lies between the upper and lower critical values, the result is rendered inconclusive. In such circumstance, knowledge of the cointegration rank of the forcing variables is required to proceed further (Pesaran *et al*., 2001).

To establish the short run relationship among the variables, the following error correction model (ECM) is estimated.

$$\Delta INDO_t = \beta_0 + \sum_{i=1}^{k} \beta 1 \Delta\, INDO_{t-1} + \sum_{i=1}^{k} \beta 2 \Delta\, GCF_{t-1} + \sum_{i=1}^{k} \beta 3 \Delta\, GAC_{t-1} + \sum_{i=1}^{k} \beta 4 \Delta\, ELC_{t-1} + \ldots \ldots + \sum_{i=1}^{k} \beta 5 \Delta GAC_{t-1} + \sum_{i=1}^{k} \beta 6 \Delta\, PPCt - 1 + \theta EMC_{t-1} + U_t \quad (3.4)$$

Where: ECM is the error correcting factor and U_t is the white noise error term.

RESULT PRESENTATION AND ANALYSIS

Unit root test was carried out using Augmented Dickey Fuller (ADF) and Philips Peron (PP) to check the stationarity of the variables of the model. The result is as shown in the Table 4.1.

Table 4.1: Summary of Unit Root Test

Variables	ADF	PP	Decision
INDOUT	4.49*	4.93*	I(0)
GCF	2.37	3.06	
D(GCF)	12.16*	17.88*	I(1)
GAC	6.28*	6.89*	I(0)
EC	6.24*	6.36*	I(0)
GEH	2.79	2.65	
GEH/{D(GEH)}	7.52*	14.36*	I(1)
PPC	3.01	3.06	
D(PPC)	5.33*	5.41*	I(1)

Source: Researchers' computation using Eviews

Note: (i) Critical values: ADF and PP at 1% (5%) are 4.24 (3.54) respectively. (ii) D is the first difference operator. (iii) * means significant at 1%. (iv) All values were presented in their absolute terms.

Within the framework of ADF and PP, some variables of the model were stationary at level {I(0)}, while others were stationary at first difference {I(0)}. Specifically, the growth rate of industrial output (INDOUT), gas consumption (GAC) and electricity consumption (ELC) were stationary at I(0). On the other hand, gross capital formation (GCF), government expenditure in health and education as a percentage of GDP (EH), and population growth rate (POPR) became stationary after their first difference were taken. With the combination of I(0) and I(1) data in the model, the use of Auto-regressive Distributed Lag Model (ARDL) is justified. The study adopted ARDL with Cointegrating Bounds. With this approach, a generic ARDL model was first estimated, and from it, coefficient diagnostic was conducted to check for the existence of long-run equilibrium relationship among the variables of the model. The result of the Bound test is presented in table 4.2

Table 4.2: Summary of Bound Test

	1 % Critical Value		**5% Critical Value**	
F-statistic	Upper Bound	Lower Bound	Upper Bound	Lower Bound
4.98	4.15	3.06	3.38	2.29

Source: Researchers' computation using Eviews

With the F-statistic of 4.98, which is higher than the upper bound of the two critical values (1% and 5%), there exist a long-run equilibrium relationship among the variables of the model. Further coefficient diagnostic tests for error correction (long-run), which has automated variable inclusion mechanism and short-run estimates were conducted and the results are as presented in Table 4.3 and Table 4.4 respectively

Table 4.3: Long-run Estimate

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GCF	0.557472	0.137924	4.041890	0.0016
PPC	-96.57849	22.23945	-4.342666	0.0010
GC	0.082355	0.089177	0.923496	0.3739
ELC	0.572078	0.323677	1.767437	0.1026
EH	2.314189	0.501942	4.610474	0.0006
C	291.3653	55.71118	5.229925	0.0002

Source: Researchers computation using Eviews

In the long run, gross capital formation, and government expenditure on education and health as a percentage of GDP have positive significant impact on the performance of the industrial sector. The multiplier effect of a unit change in gross capital formation and government expenditure on education and health are 0.55 and 2.33 respectively. Furthermore, gas consumption has a positive insignificant impact on the performance of the industrial sector in the long-run. A unit change in it can induce 0.08 change in the performance of the sector.

Table 4.3: Short-run Estimate (ECM)

Dependent Variable: INDR

Variable	Coefficient	Std. Error	t-Statistic	Prob.
1D(INDR(-1))	0.894608	0.217306	4.116811	0.0014
D(INDR(-2))	0.484338	0.164926	2.936705	0.0124
D(GCF)	0.130620	0.156960	0.832187	0.4216
D(GCF(-1))	1.489162	0.247777	6.010081	0.0001
D(GCF(-2))	1.181741	0.236114	5.004960	0.0003
D(GCF(-3))	0.870515	0.241604	3.603069	0.0036
D(GC)	0.216389	0.074185	2.916883	0.0129
D(GC(-1))	0.149031	0.075190	1.982063	0.0708
D(EC)	-0.544255	0.333704	-1.630951	0.1288
D(EC(-1))	-1.320403	0.301436	-4.380367	0.0009
D(EC(-2))	-0.812819	0.225676	-3.601704	0.0036
D(EH)	1.633280	1.022592	1.597196	0.1362
D(EH(-1))	3.480313	1.217077	2.859568	0.0144
D(EH(-2))	5.925971	1.444112	4.103539	0.0015
D(EH(-3))	2.943130	1.192848	2.467314	0.0296
D(PPC)	0.67758	0.005563	12.179828	0.0000
D(PPC(-1)	0.040617	0.012617	3.219362	0.0067
D(PPC(-2)	0.526595	0.040172	13.10847	0.0000
CointEq(-1)*	-2.472641	0.341791	-7.234360	0.0000

R^2 = 87%, DW = 2.42

The lagged values of the growth rate of industrial output have positive significant impact on the performance of the industrial sector. 1% change in the one period lag of industrial output can induce 0.89% change in the performance of the sector. Over time, this magnitude of change declined to 0.48 for the second period lag. The current level of gross capital formation has positive insignificant impact on the performance of the sector. This is not out of place as capital investment does not transform to automatic output increase, some timeframe may be required. This assertion is justified by the positive significant impact of the lagged values of gross capital formation on the performance of the sector. A unit change in the lagged values of gross capital formation can have a multiplier effect of 1.49 on the performance of the sector. However, this multiplier effect declined to 0.87 over the third period lag. The current period rate of gas consumption exerted positive significant impact on the performance of the sector. However, its one period has exerted a positive insignificant impact. The multiplier effect of a unit change in gas consumption was 0.22 for the current value and 0.14 for the one period lag. For electricity consumption, its impact on the performance of the industrial sector is negative; insignificant for its current value, while the lagged values are significant. This is in line with (Ugwoke, Dike and Elekwa 2016) but contrary to (Sari et. al 2008; Ozturk and Acaravci, 2010). The magnitude of its multiplier effect is such that a unit change in the current value of electricity consumption can induce 0.54 change in the performance of the sector. However this magnitude of change is higher for the lagged values, as a unit change in its one period lag can induce 1.32 change in the performance of the sector. Current expenditure on education and health as a percentage of GDP exerts insignificant positive impact on the performance of the sector while the impact of its lagged values are positive and significant. With respect to the magnitude of this variable, a unit change in its current value, one period lag, second period lag, and third period lag can induce 1.63, 3.48, 5.92, and 2.94 respectively on the performance of the industrial sector. The negative and significant value of the error correction term {CointEq(-1)*} is satisfactory. Its value of 2.47 indicates over 200% speed of adjustment to equilibrium in the event of any distortion in the model. R^2 of 0.87 indicates that 87% change in the dependent variables is accounted for by change in the independent variables taken together. Stability tests indicate that the variables of the model are normally distributed (see Appendix I) and free from the problems of serial correlation and heteroscedasticity (see Appendix II and III). Furthermore, the stability tests indicate that the model is stable and free from the problem of misspecification (see Appendix IV and V). The implication of these stability tests is that the model can be relied on for policy making and implementation.

CONCLUSION

The study has analyzed and estimated the impact of energy on industrial productivity in Nigeria for the period 1970 to 2018. Specifically, the study adopts a disaggregated analysis by looking at the effect of four sources of energy consumption on industrial output in Nigeria. The energy sources captured in the study included electricity consumption, natural gas consumption and petroleum products consumption. The analysis was carried out using the Autoregressive Distributed Lag (ARDL) model developed by Pesaran *et al*. (2001).

The result of the cointegration test based on the bounds testing approach showed that the variables are mutually co-integrated which suggested a long-run relationship between them. The results of the long-run estimates showed that all the regressors had positive and significant long-run relationship with industrial productivity. The results of the short-run impact on industrial productivity indicated that all the regressors had positive and significant relationship with industrial productivity except electricity consumption that was negative and insignificant. We conclude that industrial productivity is highly responsive to changes in gross capital formation, gas consumption, electricity consumption and petroleum products both in the short and long runs.

Recommendations

Based on the results obtained, the study recommended the following:

1. Policy makers should begin to think about investing on alternative energy sources such as solar, wind and other renewable energy sources. The negative effects of electricity consumption on industrial output also calls for concerted efforts to be intensified in ensuring that the power sector is make to work more efficiently. The current efforts at building new power generating stations and upgrading distribution channels will go along to put the industrial sector on sound footing.
2. There is need to harness and utilize the abundance of natural gas available in the country rather than flaring it. This is because natural gas is one of the cheaper and cleaner sources of energy available for industrial use in the country.
3. There is a need to further improve investment on the education and health sector of the economy.

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