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Electric Power Deficit and Economic Growth in Nigeria: A Sectoral Analysis

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ABSTRACT

In addition to capital and labour, electricity supply is another important factor that promotes economic growth in an economy. Often times, economic resources are used to generate electricity for domestic consumption by different sectors of an economy. In Nigeria however, the generated KWh is far higher than what eventually gets to the final consumers due to technical inefficiencies associated with electric power transmission and distribution in the supply chain resulting in huge losses. Thus, this study investigated the effect of electric power deficit proxied by electric power transmission and distribution losses on economic growth (disaggregated into agricultural and industrial RGDP) in Nigeria. This study employed the Autoregressive Distributed Lag (ARDL) model and time series data from 1981 to 2017. The hypotheses tested in this study were done at 5 and 10% levels of significance. The result obtain revealed that a 1 percent increase in electric power transmission and distribution losses will decrease agricultural output by 3% in the long run but insignificant in the short run. Similarly, electric power transmission and distribution losses do not have significant effect on industrial output. It was therefore recommended that the government should construct energy farms to muster and store the electricity that is produced before they are transmitted to the final consumers.

Keywords: Technical Inefficiencies, Electric Power Deficit, Economic growth, Energy Farms
JEL Classifications: C12, C13, C30, F43, L70, Q19, Q43

1. INTRODUCTION

One of the aims of Sustaining Development Goals (SDGs) is to ensure access to affordable, reliable, sustainable and modern energy for all especially to people in low middle-income countries like Nigeria. In addition to labour and capital, electric power supply is another important factor that is capable of influencing the economic growth of any country. Rehman and Deyuan (2018) opined that electricity is considered the source of energy that supports different sectors of an economy. Nigeria is blessed with enormous energy resources like crude oil, solar, hydro, coal, lignite, geothermal, wind, biomass, wood fuel, and tide. Out of these much, only crude oil, hydro, natural gas and coal are used in their processed form while others like solar and wood fuel are used in their crude forms for cooking, lighting, and heating (Ogundipe, 2013). Under usage of all these energy potentials in addition to distribution losses results in electric power deficit.

Conceptually, electric power deficit in this context means a situation where the effective demand for electricity exceeds its actual supply. This occurs when there are losses in transmission between sources of supply and points of distribution and in the distribution to consumers including pilferages. This assertion is particularly true for Nigeria which has the potentialities to generate 7000 megawatts (MW) of electric power from existing hydro (12.5%) and fossil (gas) thermal (87.5%) plants, but most times only generate 4600 MW (Nkalo and Agwu, 2018) which is inadequate to meet the energy requirement of over 200 million Nigerians. Based on the exposition above, it is crystal clear that the Nigerian power sector is operating below capacity with a high frequency of significant technical and nontechnical energy loss through the power supply value chain. In 2014 as reported by World Bank, the annual consumption of electricity per capita for Nigeria is estimated to be 144 kWh which is among the lowest in Africa compared to 4197 kWh for South Africa, 1683 kWh for Egypt, 351 kWh for Ghana, 275 kWh for Cameroon. According to the Renewable Energy World Report (2017), the demand for electric power in Nigeria has been increasing rapidly in the last two decades due to industrialization demand, improved standard of living and population growth without a corresponding increase in supply. The inadequate and unstable electricity supply has made many firms, businesses and households to depend on diesel and petrol generators as a more reliable primary or backup source of electricity (Uyigue et al., 2015).

Careful observation of Nigeria's net electricity generation from 2000 to 2017 showed that a good percentage of energy is lost between the point of generation and distribution to the final consumers. This is depicted in the Table 1 below:

Table 1: Total electricity net generation and transmission and distribution losses

Year	Total Electricity Net Generation (Billion Kilowatt-hours)	Transmission and distribution losses (Percentage of Total Generated)
2000	14.14	38.14762
2001	14.84	38.71427
2002	20.68	37.53075
2003	19.36	33.39279
2004	23.24	31.08136
2005	22.53	23.70534
2006	22.05	31.07313
2007	21.92	11.53277
2008	20.14	9.422075
2009	18.83	5.865399
2010	24.89	17.21603
2011	25.72	9.547237
2012	27.3	8.656727
2013	27.48	15.11962
2014	30.63	16.10727
2015	30.83	17.09492
2016	30.23	18.08258
2017	30.62	19.07023

Source: Knoema and World Development Indicator, 2018

From Table 1, the total electricity net generation is the amount of gross electricity generated less the electrical energy consumed at the generation stations for station services and auxiliaries (Knoewa, 2018). From the annual net generated electricity, percentage is lost between transmission and distribution including energy theft by Nigerians.

It is no doubt that electric power can play an important role in attracting investment and influencing growth in all the sectors of the Nigerian economy. The electricity supply usually consolidates economic activities and provides essential services required to direct the production activities in the agricultural and industrial sectors (Onakoya et al., 2013). Prior to 2001, successive governments have attempted to tackle Nigeria's electric power deficit problem by maintaining a monopoly in power provision and spending an average of 2 billion U.S dollars annually. Although Nigeria generated electricity relatively in commercial quantities within these periods but power supply remained grossly inadequate.

In 2001, the Nigerian government launched a far reaching set of power sector reforms which culminated into the unbundling and privatization of electricity generation and distribution (in 2013) to tackle the challenges associated with government monopoly in power generation, transmission and distribution. However, it seems privatization only changed the dimension of the challenges and power supply remains largely inadequate and unreliable in the country. To the best of our knowledge, no study has looked at the effect of electric power deficit on economic growth. Hence, this study seeks to investigate the effect of electric power deficit on economic growth in Nigeria.

The rest of this paper is structured as 2.0 literature review, 3.0 methods and data, 4.0 analysis and results, and 5.0 conclusion and recommendation.

2. EMPIRICAL REVIEW

Adequate electricity power supply is necessary to drive growth in different sectors of an economy. However, whether the losses in transmission between sources of supply and points of distribution affect economic growth in the various sectors of an economy is not yet known. There are myriads of literature on the relationship between electricity or energy consumption and economic growth in and outside Nigeria. Some of these studies have interesting findings but sometimes mixed and ambiguous conclusions. In China, Shengfeng et al. (2012) examined the short and long term causal relationship between electricity consumption and real GDP from 1953 to 2009. The study used Vector Error Correction Model (VECM) as its estimation technique. The VECM result revealed that there is cointegration between real GDP and electricity consumption and the presence of unidirectional causality from electricity consumption to economic growth in the short and long run. the study therefore suggested that China should modulate the supply structure of electric power and pick up speed to adjust industry structure.

In Turkey, Nazlioglu et al. (2014) examined the causal relationship between electricity consumption and economic growth using the bounds testing cointegration, the linear granger causality and non-linear granger causality test from 1967 to 2007. The cointegration result showed that electricity consumption and economic growth are cointegrated in the long-run. The linear granger causality result based on the error correction model revealed that there is bidirectional causality in both the short and long run between electricity consumption and economic growth. On the contrary, Gokten and karatepe (2016) used a bivariate Vector Autoregressive (VAR) causality test to investigate the relationship between electricity consumption and economic growth from 1950 to 2010. The result revealed that there is a unidirectional causal relationship running from electricity consumption to economic growth.

In Ghana, Patrick and Emmanuel (2014) used Vector Error Correction Model (VECM) and Granger Causality test to critically examine the influence of electricity consumption on economic growth. The result obtain revealed that a 100% increase in electricity power consumption will cause real gross domestic product per capita to increase by approximately 52% in the long run. In the short run, the result showed that electricity consumption negatively affect real gross domestic product per capita. The study also showed that there is unidirectional causality running from electricity consumption to economic growth. It was recommended that the Ghanaian government should invest massively into the existing electricity infrastructure and conservation measures to meet the needs of the various sectors of the economy.

Similarly, Muhammad (2015) used Ordinary Least Square (OLS) to investigate the impact of electricity shortage on sectoral GDP (agriculture, industrial, and service sectors) in Pakistan from 1991 to 2013. The result revealed that electricity shortage is inversely linked with agriculture sector output. Industrial sector output is negatively affected by electricity shortage and electricity load-shedding deteriorates service sector output. The study recommended that unnecessary energy usage should be discouraged and adoption of electricity saving devices and responsiveness should be encouraged.

Khobai et al. (2017) used a multivariate framework that included trade openness, electricity price, capital and employment as intermittent variables to investigate the causal relationship between electricity supply and economic growth in South Africa from 1985 to 2014. The study employed ARDL bound test and Vector Error Correction Model (VECM) as it estimation technique. The result obtained revealed that there is a long-run relationship among the variables and that bidirectional causality exists between electricity supply and economic growth.

In Nigeria, Odularo and Okonkwo (2009) investigated the relationship between energy consumption and the Nigerian economy using cointegration technique on data from 1970 to 2005. The result showed that there exists positive relationship between current period energy consumption and economic growth. The result also revealed that a negative relationship was observed for lagged values of energy consumption and economic growth. The study recommended that the energy sector should be given more attention by exploiting the opportunities laden in the sector to increase economic growth.

Onakoya et al. (2013) evaluated the causal nexus between energy consumption and economic growth using time series data from 1975 to 2010. The study employed cointegration and ordinary least square techniques to analyze the data obtained. The result showed that there is a long run relationship among the variables and that total energy consumption had a similar movement with economic growth except for coal consumption. The result further revealed that petroleum, electricity and the aggregate energy consumption have significant and positive relationship with economic growth in Nigeria. While gas consumption showed positive but non-significant impact on growth, coal consumption was negative and statistically significant. The study recommended that the government should diversify its power generating portfolio.

Using Cobb-Douglas growth model, Ogundipe (2013) examined the relationship between electricity consumption and economic growth in Nigeria from 1980 to 2008. The study used Vector Error Correction Model (VECM) and Pairwise Granger Causality test. The result revealed that there electricity consumption has significant impact on economic growth. More so, the result showed a bidirectional causal relationship between electricity consumption and economic growth. The study therefore emphasized the need to strengthen the effectiveness of energy generating agencies by ensuring periodic replacement of worn-out equipments.

Muse (2014) examined the causal relationship between economic growth and energy consumption in Nigeria from 1980 to 2012 using Ordinary Least Squares (OLS), Error Correction Model (ECM) and Pairwise granger causality technique. The result revealed that electricity consumption enhances economic growth enormously in Nigeria. Similarly, the causality result showed bidirectional causality between total energy consumption and economic growth in the long run. The study therefore recommended that government should improve the power sector so as to harness the potential of electricity in growing the economy.

Okoligwe and Ihugba (2014) examined the causal relationship between electricity consumption and economic growth in Nigeria using data from 1971 to 2012. The study used Error Correction Model (ECM) and Granger Causality test. The result showed that there is no causality between electricity consumption and economic during the period. It was therefore recommended that the government should place priority on building electricity generating capacity and infrastructure in the power sector so to force sustainable economic growth.

Ogbonna et al. (2016) examined the impact of power generation capacity on economic growth in Nigeria from 1980 to 2015. The model developed for this study expressed real gross domestic product as a function of power generation capacity in kilowatt, gross capital formation and unemployment. The study employed cointegration, vector error correction mechanism and grange causality as it estimation technique. The result revealed that there is a stable long-run relationship between the dependent and explanatory variables in the model. The result also showed that power generating capacity has no significant relationship with economic growth and no causal relationship between them in Nigeria. The study therefore recommended that the government must ensure that there is transparency in the overall implementation of the power sector policy and its attendant reforms.

Contrary to the study of Ogbonna et al. (2016), Okorie and Manu (2016) evaluated the causal relationship between electricity consumption and economic growth in Nigeria from 1980 to 2014. The study employed Johansen cointegration and VAR-based techniques. The result showed that a long run relationship exists among the variables used in the model. The result also revealed that in the long run, electricity consumption has similar movement with economic growth. The causality result showed that there is unidirectional causality electricity consumption and economic growth. The study recommended that the government should increase daily generation of power to meet up with the increasing demand for power.

From extant literature, it is obvious that most of the studies only concentrated on the relationship between electricity consumption and economic growth. None of them looked at the effect of electric power losses that occur between the sources of supply and points of distribution and in the distribution to consumers including energy theft. Thus, this study added to existing literature on the relationship between electric power and economic growth by investigating the effect of electric power deficit on economic growth in Nigeria from 1981 to 2017.

3. METHODS AND DATA

3.1. Model Specification

To empirically investigate the impact of electric power deficit on economic growth in Nigeria, this study adopted descriptive research design. This is appropriate for this study because it is theory-based created by gathering, analyzing and presenting the results of data collected. The theory that underpins this study is the David Stern Model propounded in 2004. This theory is a neoclassical model that provides linkage between energy and economic growth. The model adopted the neoclassical standpoint of the Cobb-Douglas production function to examine the factors that could decrease or reinforce the linkage between energy use and economic activities overtime and depicted that there has been a decoupling of economic output and resources (Stern, 2004). This therefore denotes that the constraints to economic growth are not restrictive as other neoclassical growth theories.

According to Ogbonna et al. (2016), a general form of the David Stern's model can be presented as:

$$(Q_i., Q_m) = f(A, X_i., X_n, E_k., E_p) \quad (1)$$

Where Q_i are various outputs of different sectors of an economy (agriculture and industrial sector), X_i are various factor inputs (capital, labour among others), E_k are the different energy inputs (gas, hydro, coal, etc), and A is the level of technological development as defined by the total factor productivity indicator. Stern (2004) opined that the relationship between energy and gross domestic product (GDP) is affected by substitution between energy and outputs, technological change, shifts in the composition of the energy input, and shifts in the composition of output. Thus, this study adopted the model used in the study of Ogbonna et al. (2016) where real GDP is expressed as a function of power generation capacity in kilowatts hour, gross capital formation, and unemployment.

$$RGDP = f(PGCKWH, GCF, UNEM) \quad (2)$$

In this study, real gross domestic product (RGDP) is disaggregated into the various constituent sectors (agriculture and industrial). This is important because it shows how electric power deficits affect the real gross domestic product (RGDP) of the individual sector. Obviously the effect might vary from sector to sector. Similarly, power generation capacity in kilowatts is replaced with electric power transmission and distribution losses proxy for electric power deficit. This is because power generation capacity is assumed and not proportionate to the actual electricity production. Thus, shifts in the composition of energy output as emphasized by Stern (2004) constitute electric power transmission and distribution losses. Gross fixed capital formation is used to replace gross capital formation (GCF) as proxy for technological progress while population growth rate is used as a proxy for labour since there are no complete data on labour force employment in Nigeria for the time frame (1981 to 2017). The model that guided this study becomes:

$$RGDP = f(EPD, GFCF, PGR) \quad (3)$$

However, disaggregating RGDP proxy for economic growth into the various constituent sectors (agriculture and industrial), the model became:

Equation 1: Agricultural Sector RGDP and Electric Power Deficit

$$lnAGRICRGDP_t = \alpha_0 + \alpha_1 EPD_t + \alpha_2 lnGFCF_t + \alpha_3 PGR_t + \varepsilon_t \quad (4)$$

Where $lnAGRICRGDP_t$ is the log of agricultural sector RGDP at time t, EPD_t is electric power deficit at time t, $lnGFCF_t$ is the log of gross fixed capital formation at time t, PGR_t is population growth rate at time t, α_0 to α_3 are parameters to be estimated, and ε_t is the error term at time t.

Equation 2: Industrial Sector RGDP and Electric Power Deficit

$$lnINDRGDP_t = \beta_0 + \beta_1 EPD_t + \beta_2 lnGFCF_t + \beta_3 PGR_t + \epsilon_t \quad (5)$$

Where $lnINDRGDP_t$ is the log of industrial sector RGDP at time t, EPD_t is electric power deficit at time t, $lnGFCF_t$ is the log of gross fixed capital formation at time t, PGR_t is population growth rate at time t, β_0 to β_3 are parameters to be estimated, and ϵ_t is the error term at time t.

3.2. Data

This study used annual time series data from 1981 to 2017 to examine the effect of electric power deficit on economic growth in Nigeria. This period was chosen due to the availability of data and the electric power reform (in 2005) that took place within this period. Thus, the duration of the data employed in this study is enough to avoid micronumerosity and give a reliable result. Description of variables, sources and a priori expectations are presented in Table 2.

3.3. Estimation Techniques

Estimating the effect of electric power deficit and economic growth in Nigeria, this study employed the Autoregressive Distributed Lag (ARDL) bounds test approach to cointegration developed by Pesaran and Shin in 1999 and further elaborated by Pesaran et al., 2001. To do this, three fundamental steps are required: test for stationarity of the data to ensure that none of the variable is integrated at order I(2), conduct bounds test for cointegration, and finally, the short (Error Correction Model) and long run estimates. However, before conducting the unit root tests, this

Table 2: Description of variables, sources and a priori expectation

Variable	Description	Source	A priori expectation
Agricultural Sector RDGP (AGRICRGDP)	Total agricultural sector (crop production, livestock, forestry, and fishing) gross domestic at 2010 constant basic prices in millions of naira	Central Bank of Nigeria Statistical Bulletin (2018)	Dependent Variable
Industrial Sector RGDP (INDRGDP	Total industrial sector (crude petroleum and Natural gas, solid minerals and manufacturing) gross domestic product at 2010 constant basic prices in millions of naira	Central Bank of Nigeria Statistical Bulletin (2018)	Dependent Variable
Electric Power Deficit (EPD)	This is proxied by electric power transmission and distribution losses include losses in transmission between sources of supply and points of distribution and in the distribution to consumers, including pilferage as percentage of output	World Bank, World Development Indicators (2018)	Negative
Gross fixed Capital Formation (GFCF)	Gross fixed capital formation includes land improvements, plant, machinery and equipment purchases, and construction in millions of constant local currency.	World Bank, World Development Indicators (2018)	Positive
Population Growth Rate (PGR)	This is the proxy for labor force. Annual population growth rate for year t is the exponential rate of growth of midyear population from year t-1 to t, expressed as a percentage.	World Bank, World Development Indicators (2018)	Positive

Source: Compiled by the Author

study conducted a correlation test in order to have a first impression about the relationship between electric power deficit and economic growth in Nigeria.

3.3.1. Unit root test

The unit root test procedure employed for this study is the Augmented Dickey-Fuller (ADF) test developed by Dickey and Fuller (1979; 1981). The ADF test requires rejecting a null hypothesis of unit root, that is, the series are non-stationary in favour of the alternative hypotheses of stationarity (Omoke, 2010). The tests were conducted without a deterministic trend for each of the series. The general form of the ADF test is stated as:

$$\Delta y_t = \alpha_0 + \alpha_1 y_{t-1} + \sum\nolimits_{i=1}^{n} \alpha \Delta y_{t-i} + \varepsilon_t \quad (6)$$

Where: y is a time series, t is a linear time trend, Δ is the difference operator, α_0 is a constant, n is the optimum number of lags in the dependent variable and ε_t is the error term at time t.

3.3.3. Autoregressive distributed lag (ARDL)

This model is an ordinary least square (OLS) based model which can be used for both non-stationary data as well as for data with mixed order of integration. This technique used sufficient numbers of lags to capture the data generating process in a general-to-specific modeling framework (Shrestha and Bhatta, 2018). The dynamic error correction model (ECM) can be obtained from the ARDL model through a simple linear transformation. Similarly, the ECM combines both the short run dynamics with the long run equilibrium relationship. According to Akpan and Akpan (2012), the statistic underlying this test is the Wald or F-statistic in a generalized Dickey-Fuller type regression, which is used to test the significance of lagged levels of the variables under consideration in a conditional unrestricted equilibrium correction model (UECM).

The general form of the Autoregressive Distributed Lag (ARDL) bounds testing model is presented as follow:

$$y_t = \alpha + \beta x_t + \delta z_t + e_t \quad (7)$$

The error correction version of the Autoregressive Distributed Lag (ARDL) bounds testing model is expressed as:

$$\Delta y_t = \alpha_0 + \sum\nolimits_{i=1}^{p} \beta_i \Delta y_{t-i} + \sum\nolimits_{i=1}^{p} \delta_i \Delta x_{t-i} + \sum\nolimits_{i=1}^{p} \varepsilon_i \Delta z_{t-i} + \lambda_1 y_{t-1} + \lambda_2 x_{t-1} + \lambda_3 z_{t-1} + u_t \quad (8)$$

The first part of equation (8) with β, δ and ϵ denotes short run dynamics of the model while the second part with λs represents long run relationship. The null hypothesis that guides the ARDL approach is $\lambda 1 + \lambda 2 + \lambda 3 = 0$, which implies non-existence of long run relationship.

4. ANALYSIS AND RESULTS

Before testing the stationarity property of the variables, the study subjected them to a correlation test in order to have a first impression about sign of the relationship that exists among them.

4.1. Correlation Matrix

The correlation result in Table 3 revealed that there is a strong negative relationship between agricultural output (AGRICRDGP) and electric power deficit (EPD) proxy for electric transmission and distribution losses. This is because the coefficient −0.765030 for electric power deficit is negatively related with agricultural output within the period of study. The coefficients of gross fixed capital formation (GFCF) and population growth rate (PGR) showed that they have positive relationship with agricultural output. This is because the correlation coefficients of 0.274151 and 0.587911 for GFCF and PGR respectively are positive.

Similarly, the correlation result in Table 4 revealed that there is a strong positive correlation between industrial output

(INDRDGP) and electric power deficit (EPD) proxy for electric transmission and distribution losses. This is because the coefficient −0.661283 for electric power deficit is negatively related with agricultural output within the period of study. The coefficients of gross fixed capital formation (GFCF) and population growth rate (PGR) also showed that they have weak positive correlation with industrial output. This is because the correlation coefficients of 0.223698 and 0.474056 for GFCF and PGR respectively are positive.

4.2. Unit Root Test of Stationarity

The unit root results presented in Table 5 showed that the variables are stationary after first difference except population growth rate (PGR) that was stationary at level. This implies that the test statistic at first difference is greater than the critical value at 5% and 10% levels of significance, thus, the variables are integrated of order I(0) and I(1). This is also evidence from the probability values obtained after differencing the variables. These values are all <0.05%. Thus, cointegration test of Engel-Granger (1987), Johansen (1988), and Johansen-Juselieus (1990) cannot be used to test for long run relationship among the variables in the two equations developed for this study. This is because PGR which appears in both equations is stationary at level and the cointegration tests highlighted above requires that all the variables must be stationary at first difference.

4.3. Agricultural Sector and Electric Power Deficit Equation

Having established the order of integration, the study proceeded to ascertain if there is long run relationship among the variables in model 1 using the ARDL bounds testing approach for cointegration. The result obtained is presented in Table 6.

Table 3: Correlation matrix for agricultural sector equation

Variable	AGRICRGDP	EPD	GFCF	PGR
AGRICRGDP	1.000000			
EPD	−0.765030	1.000000		
GFCF	0.274151	−0.114589	1.000000	
PGR	0.587911	−0.683920	0.399950	1.000000

Source: Compiled by Authors

Table 4: Correlation matrix for industrial sector equation

Variable	INDRGDP	EPD	GFCF	PGR
INDRGDP	1.000000			
EPD	−0.661283	1.000000		
GFCF	0.223698	−0.114589	1.000000	
PGR	0.474056	−0.683920	0.399950	1.000000

Source: Computed by Authors

Table 6 shows the result of the ARDL bounds test for cointegration for model 1 (Agriculture and Economic Growth Equation). The first step in this procedure is to compare the value of the calculated F-statistic with the Pesaran et al. (2001) critical value bounds. Accordingly, the estimated F-statistic of 5.593492 calculated at k=3 (number of explanatory variables) exceeds the upper critical bound at 5 and 10% levels of significance. Hence, the null hypothesis of no long run relationship among the variables in model 1 is rejected. This implies that there is a long-run relationship among the variables.

4.4. Industrial Sector and Electric Power Deficit Equation

Similarly, the study proceeded to ascertain if there is long run relationship among the variables in model 2 using the ARDL bounds testing approach for cointegration. The result obtained is presented in Table 7.

Table 7 shows the result of the ARDL bounds test for cointegration for model 1 (Agriculture and Economic Growth Equation). The first step in this procedure is to compare the value of the calculated F-statistic with the Pesaran et al. (2001) critical value bounds. Accordingly, the estimated F-statistic of 3.809024 calculated at k=3 (number of explanatory variables) exceeds the upper critical bound at 5 and 10% levels of significance. Hence, the null hypothesis of no long run relationship among the variables in model 2 is rejected. This implies that there is a long run relationship among the variables.

4.5. Dynamic ARDL Relationships

Having established that a long run relationship exists among the variables in the two models, the next step is to investigate the long-run and short-run marginal effects of electric power deficit on the on the various sectoral real gross domestic products (RGDP). The result is presented in Tables 8 and 9.

Using ARDL (4,3,4,4) model selected automatically based on Akaike Information Criterion (AIC), the estimated long-run effect obtained by normalizing on agricultural sector real gross domestic product (LNAGRICRGDP) are reported in Table 8. The long run coefficient of electric power deficit (EPD) is negative and statistically significant, while gross fixed capital formation (LNGFCF) is positive and statistically significant as shown by

Table 5: Augmented dickey-fuller (ADF) unit roots results

Variables	At Level	Prob.	At First Difference	Prob.	Order of Integration
LNAGRICRGDP	0.145295	0.9649	−5.796345	0.0000	I (1)
LNINDRGDP	−0.771044	0.8152	−5.464484	0.0001	I (1)
EPD	−2.455788	0.1345	−8.575445	0.0000	I (1)
LNGFCF	−2.613425	0.1002	−4.777258	0.0005	I (1)
PGR	−4.764387	0.0007	-----------	------------	I (0)
Critical Values 5% level	−2.945842		−2.948404		
10% Level	−2.611531		−2.612874		

Source: Computed by Authors

their t-statistic and probability values at 10% levels. However, the coefficient of population growth rate (PGR) proxy for labour force is positive and not statistically significant at 5% and 10% levels of significance. This could be due to the data used and even though over 70% of Nigerians are involve in agriculture and agricultural related activities, their contribution is still very minimal.

Table 6: ARDL Bounds Test for Cointegration (Agricultural Sector and Electric Power Deficit Equation)

Test Statistic	Value	K
F-statistic	5.593492**	3
	Critical Value Bounds	
Significance Level	I (0) Bound	I (1) Bound
5%	2.79	3.67
10%	2.37	3.2

Source: computed by Authors, ** indicates that the F-statistic falls above the upper bound values at 5% and 10% levels of significance

Table 7: ARDL Bounds Test for Cointegration (Industrial and Electric Power Deficit Equation)

Test Statistic	Value	K
F-statistic	3.809024**	3
	Critical Value Bounds	
Significance Level	I (0) Bound	I (1) Bound
5%	2.79	3.67
10%	2.37	3.2

Source: Computed by Authors. ** indicates that the F-statistic falls above the upper bound values at 5% and 10% level of significance

Table 8: Estimated Long-run Coefficients (Agriculture and Electric Power Deficit Equation)

ARDL (4, 3, 4, 4) Selected Automatically Based on Akaike Information Criterion Dependent Variable: D (LNAGRICRGDP)				
Variable	Coefficient	Std. Error	T-statistic	Probability
EPD	−0.032426	0.014435	−2.246369	0.0413*
LNGFCF	2.020585	0.716011	2.822004	0.0136*
PGR	0.352693	2.366718	0.149022	0.8837

Source: Computed by Authors. * indicates significance at 10% level of significance

The negative sign of the coefficient of electric power deficit (EPD) is in line with the a priori expectation of this study and the correlation matrix result. This implies that a 1% increase in electric power transmission and distribution losses will decrease agricultural output by 3% in the long run. This true because the agricultural sector in Nigeria still is underdeveloped and crude method of farming is practiced. Similarly, the positive sign of the coefficient of gross fixed capital formation (LNGFCF) conforms to the result of the correlation matrix and also the a priori expectation of this study. This also implies that a 1% increase in gross fixed capital formation will boost agricultural output by 20.2% in the long run. However, the coefficient of population growth rate (PGR) is positive but not statistically significant in the long run. The sign of the coefficient is also in conformity with the a priori expectation of this study. This is true for Nigeria because the over 70% population involve in agriculture are still operating at the subsistence level.

The short-run dynamic result in Table 9 shows that electric power deficit (EPD) is still negative as in the long run estimate but not statistically significant in the short run. This implies that electric power transmission and distribution losses do not have significant effect on agricultural output in the short run in Nigeria. Similarly, the coefficient of gross fixed capital formation that was positive and significant in the long run is now negative and not statistically significant. This implies that gross fixed capital formation which is a proxy for technological progress does not have effect on agricultural output in the short run. This could be due to crude technique of production and long gestation period associated with agricultural activities. The coefficient of population growth rate (PGR) proxy for labour force is still positive and not statistically significant at 10% level in the short run. This is in conformity with the result of the long run estimate.

Finally, the lagged coefficient of LNAGRICRGDP in the error correction model in Table 9 is the error correction term. This is in line with theoretical expectation that demands that it should be negative and statistically significant. Thus, the error correction coefficient of -0.315787 showed a weak speed of adjustment. This implies only 31.6% of short run disequilibrium in agricultural output is corrected in the long run. Similarly,

Table 9: Error Correction Model (Agriculture and Economic Growth Equation)

ARDL (4, 3, 4, 4) Selected Automatically Based on Akaike Information Criterion Dependent Variable: D (LNAGRICRGDP)				
Variable	Coefficient	Std. Error	t-statistic	Probability
D (EPD)	−0.003018	0.003575	−0.844247	0.4127
D (LNGFCF)	−0.185751	0.219635	−0.845725	0.4119
D (PGR)	8.034847	4.292930	1.871646	0.0823
LNAGRICRGDP (−1)	−0.315787	0.153985	2.050760	0.0595*
R-squared	0.996082	Mean dependent var	15.70895	R-squared
Adjusted R-squared	0.991044	S.D. dependent var	0.634359	Adjusted R-squared
S.E. of regression	0.060033	Akaike info criterion	−2.493768	S.E. of regression
Sum squared resid	0.050456	Schwarz criterion	−1.632143	Sum squared resid
Log likelihood	60.14718	Hannan-Quinn criter.	−2.203857	Log likelihood
F-statistic	197.7230	Durbin-Watson stat	2.073782	F-statistic
Prob (F-statistic)	0.000000			Prob (F-statistic)

Source: Computed by Authors. * indicates significance at 10% level of significance the R-squared and adjusted R-squared result revealed that 99% of the variation in agricultural output is explained by electric power deficit (EPD) gross fixed capital formation (GFCF) and population growth rate (PGR). The Durbin-Watson statistic value of 2.07 showed that there is no evidence of serial correlation in the model.

Using ARDL (1, 0, 0, 4) model selected automatically based on Akaike Information Criterion (AIC), the estimated long-run effect obtained by normalizing on industrial sector real gross domestic product (LNINDRGDP) are reported in Table 10. The long run coefficient of electric power deficit (EPD) and population growth rate (PGR) are positive and not statistically significant, while gross fixed capital formation (LNGFCF) is positive and statistically significant as shown by their t-statistic and probability values at 10% levels.

Contrary to result of the correlation matrix and a prior expectation of this study, sign of the coefficient of electric power deficit (EPD) positive. This could be due to the fact that Nigeria is still backward industrially and firms operating in Nigeria produce using personal sources of energy like generator among others. Similarly, the positive sign of the coefficient of gross fixed capital formation (LNGFCF) conforms to the result of the correlation matrix and also the a priori expectation of this study. This implies that a 1% increase in gross fixed capital formation proxy for technological progress will boost industrial output by 66.6% in the long run. However, the coefficient of population growth rate (PGR) is positive but not statistically significant in the long run. The sign of the coefficient is also in conformity with result of the correlation matrix and a priori expectation of this study. This is also true for Nigeria because even though the population of the country is increasing, unemployment rate is also in the increase.

Table 10: Estimated Long-run Coefficients (Industrial Sector RGDP and Electric Power Deficit Equation)

ARDL (1, 0, 0, 4) Selected Automatically Based on Akaike Information Criterion Dependent Variable: D (LNINDRGDP)				
Variable	**Coefficient**	**Std. Error**	**t-statistic**	**Probability**
EPD	0.001236	0.007922	0.156069	0.8773
LNGFCF	0.665817	0.263625	2.525616	0.0186*
PGR	1.572221	1.359326	1.156618	0.2588

Source: Computed by Authors. Note: * indicates significance at 10% level of significance

The short-run dynamic result in Table 11 shows that electric power deficit (EPD) is still positive and not statistically significant as in the long run estimate. This goes a long way to reemphasizing the importance of electricity in industrial productivity in Nigeria which is grossly inadequate. Electric power transmission and distribution losses do not have significant effect on industrial output in the short run in Nigeria. Similarly, the coefficient of gross fixed capital formation (GFCF) is still positive and not statistically significant as in the long run estimate. This implies that gross fixed capital formation which is a proxy for technological progress does not have effect on industrial output in the short run. This could be due to low level of technical progress in the country and even the available ones currently in use are either outdated or not working optimally. The coefficient of population growth rate (PGR) proxy for labour force is still positive and not statistically significant at 5 and 10% levels in the short run. This is in conformity with the result of the long run estimate.

Finally, the lagged coefficient of LNINDRGDP in the error correction model in Table 11 above is the error correction term. This is in line with theoretical expectation that demands that it should be negative and statistically significant. Thus, the error correction coefficient of −0.315052 also showed a weak speed of adjustment from short run disequilibrium to long run equilibrium. Thus, this implies that only 31.6% of short run disequilibrium in industrial output is corrected in the long run. Similarly, the R-squared and adjusted R-squared result revealed that 96 and 94 percents of the variation in industrial output is explained by electric power deficit (EPD) gross fixed capital formation (GFCF) and population growth rate (PGR). The Durbin-Watson statistic of about 2.05 showed that there is no evidence of serial correlation in the model

Table 11: Error Correction Model (Industrial Sector RGDP and Electric Deficit Equation)

ARDL (1,0,0,4) Selected Automatically Based on Akaike Information Criterion Dependent Variable: D (LNINDRGDP)				
Variable	**Coefficient**	**Std. Error**	**t-statistic**	**Probability**
D (EPD)	0.000390	0.002432	0.160196	0.8741
D (LNGFCF)	0.209767	0.122505	1.712308	0.0997
D (PGR)	3.700565	3.438405	1.076245	0.2925
LNINDRGDP(−1)	−0.315052	0.106822	−2.949324	0.0070**
R-squared	0.958390	Mean dependent var	16.06998	R-squared
Adjusted R-squared	0.944519	S.D. dependent var	0.245007	Adjusted R-squared
S.E. of regression	0.057710	Akaike info criterion	−2.639782	S.E. of regression
Sum squared resid	0.079930	Schwarz criterion	−2.231643	Sum squared resid
Log likelihood	52.55640	Hannan-Quinn criter.	−2.502456	Log likelihood
F-statistic	69.09737	Durbin-Watson stat	2.048056	F-statistic
Prob (F-statistic)	0.000000			Prob (F-statistic)

Source: Computed by Authors, ** indicates significance at 5% level of significance

5. CONCLUSION AND RECOMMENDATION

From the estimated dynamic Autoregressive Distributed Lag (ARDL) relationship above, it is obvious that electric power deficit proxy for electric power transmission and distribution losses have significant effect on agricultural productivity in Nigeria in the short run but not significant in the long run. Similarly, Electric power deficit do not have significant effect on industrial output but gross fixed capital formation does in the short run. this imply that the inadequate electricity supply in Nigeria boosted agricultural output within this period because the agricultural sector do not require much electricity to operate unlike the industrial sector that uses heavy machinery and equipments that requires high electricity. Thus, the marginal propensity to consume electricity is high in the industrial sector than the agricultural sector that requires moderate supply.

Thus, this study recommended that technical inefficiencies associated with electricity transmission and distribution resulting to electric power losses should be urgently attended to by adopting energy conservation policy through the construction of energy farms where electric power generated can be mustered and stored temporarily for onward transmission to the final users especially industries. This will go a long way in reducing energy wastage in the chain of electricity supply.

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