Journal of Economics and Sustainable Development www.iiste.org
ISSN 2222-1700 (Paper) ISSN 2222-2855 (Online)
Vol.6, No.17, 2015

Electricity Supply and Manufacturing Output in Nigeria: Autoregressive Distributed Lag (ARDL) Bound Testing Approach

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Abstract
Electricity has been identified as primary and independent factor of production in modern production process. Hence, this study explore the relationship between electricity supply and manufacturing sector's output in Nigeria using time series data from 1971 to 2010. It adopts Autoregressive Distributed Lag (ARDL) bounds testing approach to cointegration. Our findings reveal long run relationship between the variables, and shows significant and negative error correction term. Manufacturing output is found to be positively dependent on electricity in both short run and long run, but only significant in the long run.The policy implication of these findings is that electricity supply must be increased if the productive capacity of the manufacturing sector is to be improved. More importantly, this is a prove that if the country is to achieve its economic vision of being among the 20 World industrialized economies in the year 2020, adequate and stable increase in electricity supply, particularly to the manufacturing sector, must remain an uncompromising policy.
Keywords: Electricity Supply, Manufacturing Sector, Factors of Production, Output

1. Introduction

Manufacturing sector is the aspect of an economy that engages in the production of real goods by transforming raw materials through production process. Manufacturing is therefore the life force for sustainable economic growth; is a catalyst to the transformation of an economy from a raw material base into a more active and productive economy (Okonjo-Iweala & Osafo-kwaako, 2007). For an economy to achieve sustainable growth, it is imperative to have a sound manufacturing sector. A vibrant and well-efficient manufacturing sector is a necessary impetus for rapid and favourable economic growth. In modern economy where industrialization is taking pace and mass production is needed for domestic consumption and exports, electricity is regarded as primary factor that facilitates the efficiency and productivity of other factors of production, particularly labour and capital.

Though classical economists considered energy as an intermediate input in production, facilitating factors of production, Alam (2006) however argues that it serves as factor input in certain production circumstances[1]. Beaudreau (1998) sees 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. 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) concludes that improvement in the efficiency of electricity use significantly increases an industry's export. Thus, the relationship between electricity supply and production in machine-driven industry cannot be disentangled, if higher output is to be achieved.

The Nigerian manufacturing sector formally came into existence as a sub-sector of the economy in 1960. Okere and Fidelis (2012) observe that in the 1960s and 1970s, after the country's independence, the manufacturing sector developed positively as a result of Foreign Direct Investment (FDI). This continued hitherto 1980, and thereafter, the sector recorded low growth and development. Adenikinju and Chete (2002) reveal the same observation. The study reveals that the performance of the manufacturing sector from 1970 to 1980 was satisfactory, afterward, declining trend was observed. Dipak and Ata (2003) revealed 25% decline in the real output of manufacturing sector from 1982 to 1986.

This moribund trend persisted and became worsen as the power sector deteriorates by each day in the country; this declining scenario is depicted in table 1.1 where manufacturing sector's contribution to the Gross Domestic Products (GDP) keeps declining from 1980 to 2009. The situation became more noticeable in the 1990s and 2000s with more than 800 firms shut down and about one million workers rendered unemployed (Adenikinju, 2002). One of the major factors responsible for this trend is the inadequate and poor power supply which makes cost of production unbearable to remain in business. This is notable from the Word Bank's Ease of Doing Business survey[2] (2012) where Nigeria ranks 176th in getting electricity as shown in figure 1.1.

[1] Alam argued analogically that, in an economy whose mainstay is flour milling, using windmills to grind wheat into flour, change in climate increases the wind speed and hence productivity. Thus, increase in productivity in such a situation is solely as a result of increase in energy.
[2] Ease of Doing Business (EDB)(2012):http://www.doingbusiness.org/ranking

Table 1.1: Percentage Contributions of Different Sectors to GDP in Nigeria

Sectors	1960-1970	1971-1980	1981-1990	1991-2000	2001-2009
Agriculture	55.8%	28.4%	32.3%	34.2%	40.3%
Industry	11.3%	29.1%	41.0%	38.6%	28.4%
Manufacturing	6.6%	7.3%	6.1%	4.9%	3.9%
Building & Construction	4.8%	8.3%	2.3%	1.8%	1.8%
Wholesale & Retail Trade	12.8%	17.6%	14.5%	13.8%	14.0%
Services	15.3%	16.5%	9.8%	11.5%	15.5%
Total value Added	100%	100%	100%	100%	100%
Diversification Index	0.2	0.4	0.4	0.4	0.3

Source: Adopted from National Bureau of Statistics (NBS)

Figure 1.1 was an extract from the World Bank's survey in 2012 on Ease of Doing Business (EOD) in 183 countries of the World. Nigeria was ranked 176th out of 183 countries and even among African and developing countries, Nigeria features the worse situation reflected in the red part of its bar.

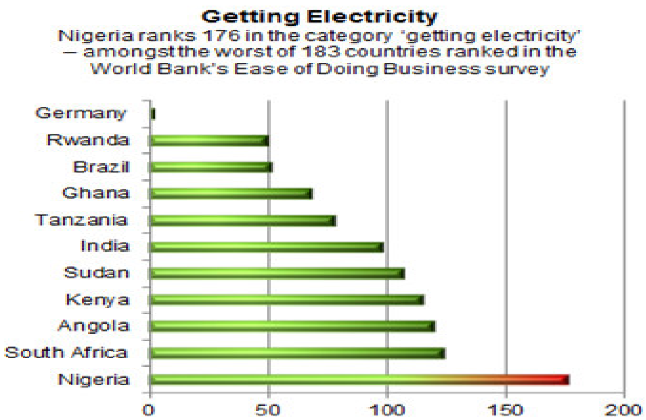


Figure 1.1: Nigeria rank in Ease of Doing Business
Source: Adopted from frontierstrategygroup.com

In an attempt to explore the area of the impact of electricity, numerous literatures only reveal the relationship between economic growth and electricity, with little empirical attention on the effect of electricity on the various sectors of the economy. This could lead to fallacy of decomposition because economic growth is a function of the performance of different sectors which certainly differ in their need for electricity. In response to this perceived gap, this study explores the relationship between electricity supply and manufacturing sector's output in Nigeria.

1.1 Manufacturing and Electricity in Nigeria

Nigeria has recorded a great history of unstable and inadequate electric power supply. This problem became more acute in manufacturing sector as the number of manufacturing firms leaving the country and shutting down became more pronounced. 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 (Adenikinju, 2002). The problem of erratic power supply in Nigeria has virtually affected all the major sectors of the economy and particularly devastated the manufacturing sector. The current demand for electricity in the manufacturing sector is 2,500 Megawatt (MW) while the Power Holding Company of Nigeria (PHCN) 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, 2002).
The manufacturing sector as a whole operates on more than 70% of energy it generates using generators; and operating these generators greatly increases the cost of manufacturing goods in the country[1]. This high cost of production makes it practically impossible for the firms to compete with their foreign counterparts whose goods

[1] Nigerian Association of Chambers of Commerce, Industry, Mines and Agriculture (NACCIMA)(2012): http://www.naccima.com

are produced and imported into the country at comparatively less cost. The proportion of electricity cost in manufacturing production cost in Nigeria is 30% to 35% as compared to other countries which is 5% to 10% (MAN Survey, 2009)[1]. This implies that even when the electricity supply is relatively stable, manufacturing production is still relatively costly because of the electricity problem in the country.

Manufacturing production cost in Nigeria costs nine times more the production cost of the same item in China, four times in Europe and South Africa, and two times in Ghana (Adenikinju, 2002). This implies that goods produce in Nigeria cannot compete for market with the same goods produce in these countries. Thus, manufacturing firms in Nigeria can neither gain market domestically nor internationally. In a survey conducted by Marchat et. al. (2002) on Nigerian firms, it was found that 93.9% of the firms described electricity as their major problem while 97.4% of the firms have their private generators. The high cost of operating on generators caused about 800 firms to shut down only between 2009 and 2011[2].

Therefore, the lingering electricity problem in the country is undoubtedly affecting the overall growth in the economy as well as the manufacturing sector. Hence the need to empirically reveal the relationship between manufacturing sector's output and electricity supply in Nigeria. Does this relationship exist and continue over a period of time? How significant is this relationship? To provide details for policy direction, this study attempts to answer these questions.

2. Literature Review

Overwhelmingly, electricity consumption is found to promote economic growth in the world. Figure 2.1 depicts how energy and the World economic growth (GDP) relate. It indicates that fluctuation in energy triggers corresponding fluctuation in World GDP growth.

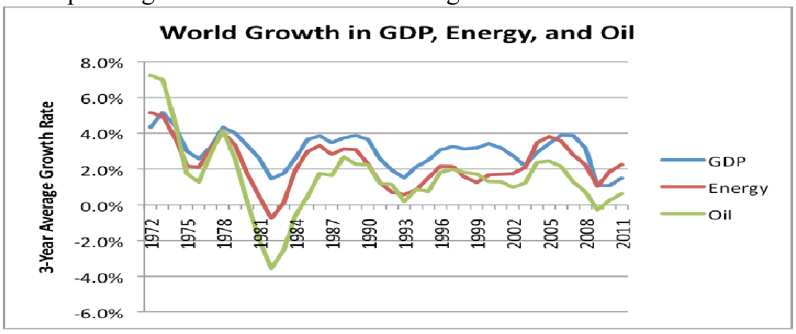


Figure 2.1: Energy and the World GDP Growth Rate, Source: ourfiniteworld.com

Ferguson, Wilkinson & Hill (2000) in a study of over one hundred countries that represent over 90% of the World economy, reveal strong correlation between the amount of electricity use and GDP per capita at general level. When the countries were disaggregated, the correlation was found to be stronger and more pronounced in rich countries compared to poor countries. It is apparent that the rich countries in the World are mostly industrialized countries that use capital intensive production method, hence consume much electricity in their growth process; while the poor countries are basically agrarian or raw material producing economy. Electricity is therefore an indispensable factor that promotes growth in an industrialized economy; hence, any country that pursues industrialization must ensure stable and adequate supply of electricity.

Adenikinju (1998) in a study of 667 firms over the period of 1988 to 1990 found that the contribution of energy consumption (electricity) to the growth of manufacturing firms in Nigeria is not significant. However, the firms displayed mixed coefficient signs, but on the overall, the manufacturing sector coefficient is positive. However, in a later survey - based study among 162 firms on the costs of electric infrastructure failure on manufacturing firms in Nigeria by the same author, Adenikinju (2003), it reveals that the firms use between more than 20% of their capital in the procurement of private electricity generation equipments to facilitate the supply of electricity for their production activities. Akinlo (2008) studied 11 sub-Saharan African countries including Nigeria from 1980 to 2003. With the use of Autoregressive Distributed Lag (ARDL) and Vector Error Correction Model (VECM), the study reveals the existence of cointegration between the use of energy and economic growth in seven of the countries, bi-directional causality in three countries and unidirectional from GDP to energy consumption in two countries. Neither long run relationship nor causality between the energy consumption and economic growth was identified in Nigeria. However, using an improved sample period from 1980 to 2006 and VECM technique for Nigeria by the same author, Akinlo (2009), long run relationship and unidirectional causality from electricity consumption to GDP per capita was found. A similar study was also conducted in China with the same techniques and sample size, by Yuan, Zhao, Yu, & Hu (2007), and reveals the

[1] Manufacturers Association of Nigeria (MAN) Survey (2009): http://www.manufacturersnigeria.org/survey
[2] (see 3)

same results with Akinlo (2009).

Enang (2010), studied the relationship between economic development, electricity supply and industrialization in Nigeria over the period of 1970 to 2008, and reveals the existence of long run relationship between the variables. Similar significance of electricity supply on growth was established by the same author, Enang (2011). In a related study by Ekpo, Chuku, & Effiong (2011), using ARDL bound testing over the period of 1970 to 2008 on real GDP per capita, population, electricity consumption and industrial output; it was found that all the variables are significant in influencing GDP per capita. Similarly, Odularu & Okonkwo (2009) reveal the existence of cointegration between economic growth, labour stock, capital stock and use of energy in Nigeria.

This relationship was also investigated in Malaysia by Tang (2008) from the period of 1972 to 2003, the results reveal no long run relationship while bidirectional causality was identified between the variables. Chandran, Sharma, & Madhavan (2010) also show the existence of long run relationship between electricity consumption and economic growth, and causality from electricity to economic growth from 1971 to 2003.

Kouakou (2011) employs ARDL bounds testing techniques and studies electricity consumption, industrial output and economic growth in Cote d' Ivoire over the period of 1971 to 2008. The study reveals the existence of cointegration between the variables. A test of granger causality identified short run bi-directional causality between economic growth and electricity consumption while causality only runs from electricity consumption to growth in the long run. Shahbaz & Lean (2012) undertook a related study in Pakistan on electricity consumption and economic growth from 1972 to 2009. Employing similar analytical techniques used by Kouakou (2011), the variables were found to relate in the long run with electricity consumption having positive impact on growth. The causality result shows the existence of feedback causality between the variables. Pakistan and Cote d' Ivoire therefore share the same scenario which supports the link between electricity and economic growth.

Squalli (2007) investigates the link between electricity consumption and economic growth in the Organization of Petroleum Exporting Countries (OPEC) from 1980 to 2003. Using the ARDL bounds testing technique, long run relationship was found to exist between the variables in all the countries including Nigeria. Employing the MWALD test for causality, feedback or unidirectional causality was revealed in all the countries with exception of Algeria, Iraq and Libya. Similarly, Wolde-Rufael (2006) studies seventeen African countries within 1971 and 2001 and reveals long run relationship in nine countries and causality in twelve countries. This result shows that African scenario also exhibit relationship between electricity and economic growth, though the relationship might not be strong as obtainable in developed countries. – see Ferguson et al. (2000)

Welle-Strand, Ball, Hval, & Vlaicu (2012) studied the effect of power sector on economic growth and development, using panel data approach in seventy seven countries, developed and developing countries, within the period of 1980 to 2005. The study uses the Solow growth model (1957) by including electricity, explicitly, as an independent variable. Estimating the model without electricity gave 57% power of the explanatory variables while the inclusion of electricity extended it to 76%, indicating the contribution of electricity to growth in the countries at 19%. The study further revealed positive coefficient for electricity at 0.47, thus, a 10% increase in electricity supply leads to 4.7% positive change in growth. The number of countries involve in this study presents global picture of the linkage between electricity and economic growth as well as corroborating Ferguson et al. (2000).

The South American countries also do not evade the pervasive relationship between electricity and economic growth. In a study by Yoo & Kwak (2010) in seven countries of this region over annual data from 1975 to 2006, the causality test of Granger (1969) reveals causality from electricity consumption to economic growth in five of the countries – Argentina, Brazil, Chile, Columbia and Ecuador. Bidirectional causality was identified in Venezuela while no causality link was established in Peru. The result for Peru probably needs to be subjected to a more rigorous study, considering its high growth and prudency in managing resources compared to Ecuador. However, the region generally displays correlation between electricity consumption and economic growth.

3. Methodology

This study employs secondary annual time series data. Time series data is advantageous because it captures a country's specific behaviours and devoid of endogeneity, thus providing an in depth policy implication (Forbes, 2000). Data on gross fixed capital formation and labour force from 1971 to 2005 were adopted from Odularu & Okonkwo (2009), while from 2006 to 2010 are from the National Bureau of statistics, Nigeria (NBS)[1]. Data on manufacturing output and electricity supply are sourced from Central Bank of Nigeria Statistical Bulletin (2010)[2] and World Bank's World Development Indicators[3] Data respectively. The combination of data from different

[1] National Bureau of Statistics (NBS)(2011): http://www.nigerianstat.gov.ng
[2] www.cbn.gov.ng
[3] www.worldbank.org

source is apparently due to lack of consistency in data flow in the country, which is a peculiar feature of most developing countries.

3.1 Statistical Tool

The study adopts Autoregressive Distributed Lag (ARDL) approach to cointegration developed by Pesaran (1997) and subsequently redeveloped bounds testing approach by Pesaran, Shin, & Smith (1999, 2001). The study chooses ARDL approach due to its comparative advantages over other cointegration approaches such as the Engle & Granger (1987), Johansen & Juselius (1990, 1992) and Johansen (1995). While these approaches require variables to be integrated at first difference order, I (1) and must assume equal lag length in the model, ARDL method was developed to circumvent these requirements due to the unreliability of the existing unit roots tests use in determining the integration order of the variables (Duasa, 2007).

ARDL approach has been proven to be robust in small sample, estimating and testing hypothesis of long run coefficients of underlying variables irrespective of whether they are all integrated at level, I(0), at first difference, I(1) or mixed (Pesaran, 1997), it therefore devoid of pretesting problem. It is applicable to small sample size ranging from 30 to 80 observations (Narayan, 2004 & 2005) and (Wolde-Rufael, 2010). The approach therefore becomes suitable to our study considering our sample size of 40 observations. This approach has been widely used in research studies and in some studies related to ours, such as Wolde-rufael (2005, 2006, 2010), Ekpo, Chuku & Effiong (2011), Tang (2008), Chandran, Sharma & Madhavan (2010), Kouakou (2011), Shahbaz & Lean (2012), Squalli (2007) and Akinlo (2008).

The ARDL bounds testing approach to cointegration determines the long run level relationship between variables and further derive the error correction representation model for the estimation of short run coefficients of the variables if long run relationship exists among them. F-statistic of the joint significance test (Wald test) is used to determine whether the lagged levels of the variables are significant and cointegrated in first difference regression of the model (Conditional Error Correction Model Specification). The F-statistic is compared with the two asymptotically sets of critical values developed by Pesaran et al. (2001), applicable for large sample studies, and further reformulated by Narayan (2004, 2005) to accommodate small sample studies of observations ranging from 30 to 80. The critical values constitute the lower bound and upper bound for I (0) and I (1) respectively, depending on whether the model includes a deterministic trend or not. If the F-statistics falls above or greater the upper bound, long run level relationship is said to exist among the variables; if falls below or less than lower bound, long run level relationship among the variables exists not. The decision whether there exists cointegration among the variables remains inconclusive if the F-statistics falls in between the upper and the lower bounds (Pesaran et al., 1999, 2001).

The Conditional Error Correction Model (Long Run ARDL Model) is built on the assumption of uncorrelated residual terms. It is therefore necessary to appropriately determined the optimal lag length for the underlying ARDL model in which the .disturbance terms are not serially correlated (Wolde-Rufael, 2010) and (Pesaran et al., 2001). In determining the optimal lag length, we employ Akaike Information Criterion, AIC (Akaike, 1974), Schwarz Bayesian (or Information) Criterion, SBC (Schwarz, 1978) and Hannan-Qiunn Criterion, HQC (Hannan & Quinn, 1979) methods. The lag length at which the values of these methods are minimized is the optimal lag (Pesaran et al., 2001). The popularly use ones are AIC and SBC, but SBC is more parsimonious. However, Al-jammal (2010) found AIC to be preferred in a simulation study between AIC and SBC, and if the difference between the minimum AIC and another AIC of a model is less than two (2), rule of thumb suggests substantial evidence for the model at both AICs.

3.2 Model Specification

Following the empirical studies such as Beaudreau, (1995, 2005), Wolde-Rufael (2004, 2006, 2009, 2010), Akinlo (2008, 2009) and Enang (2010, 2011), we adopt the neoclassical traditional production function. The neoclassical production function, particularly Cobb & Douglas (1928) expresses the technical relationship between given level of output and a given quantity of physical inputs. A variation in output is a resultant effect 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 inputs 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). Hence our model for manufacturing sector’s output in equation 1 constitutes an explicit inclusion of electricity supply as primary and independent factor of production.

$$M = f(E^{\gamma}\ K^{\theta}\ L^{\sigma}) \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (1)$$

Where;
M = Manufacturing sectors output
E = Electricity supply

K = Gross fixed capital formation
L = Labour force
f = Function

γ, θ and σ are the respective contributions of E, K and L to manufacturing sector's output. 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 et al., 2001). Thus, taking the log of equation 1 and transforming it to econometric regression model to be estimated, we have equation 2.

$$lnM_t = \alpha + \gamma lnE_t + \theta lnK_t + \sigma lnL_t + \mu_t \dots\dots\dots\dots\dots\dots\dots\dots\dots (2)$$

Where;

$lnM_t =$ Natural log of manufacturing output at time t

$lnE_t =$ Natural log of electricity supply at time t

$lnK_t =$ Natural log of capital at time t

$lnL_t =$ Natural log of labour at time t

$\mu_t =$ Error term or residual term

γ, θ and σ are the respective coefficients of lnE_t, lnK_t and lnL_t

3.3 ARDL Models

Equation 2 can be expressed as conditional error correction model or unrestricted error correction regression, an ARDL equation for testing the existence long run level relationship among the variables (Pesaran et al., 1999, 2001; Wolde-Rufael, 2010). We therefore have the following UREC regression equations. Equation 3 tests for the long run level relationship.

$$\Delta lnM_t = \alpha_0 + \sum_{i=1}^{\rho} \beta_i \Delta lnM_{t-i} + \sum_{i=m}^{\rho} \gamma_i \Delta\, lnE_{t-i} + \sum_{i=m}^{\rho} \theta_i\, \Delta lnK_{t-i} + \sum_{i=m}^{\rho} \sigma_i\, \Delta lnL_{t-i} + \omega_{1M} lnM_{t-1} + \omega_{2M} lnE_{t-1} + \omega_{3M} lnK_{t-1} + \omega_{4M} lnL_{t-1} + \mu_t \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (3)$$

$$H_0: \omega_{1M} = \omega_{2M} = \omega_{3M} = \omega_{4M} = 0$$

$$H_1: \omega_{1M} \neq \omega_{2M} \neq \omega_{3M} \neq \omega_{4M} \neq 0$$

Where;

H_0 is null hypothesis (no long run relationship)
H_1 is alternative hypothesis (long run relationship exists)
If cointegration is identified by the rejection of H_0, the long run and short run coefficients of the variables are estimated in equation 3.1 and 3.2 respectively (Pesaran et al., 2001; Wolde-Rufael, 2010)

$$lnM_t = \alpha_1 + \sum_{i=1}^{\rho} \beta_{1i} lnM_{t-i} + \sum_{i=m}^{\rho} \gamma_{1i}\, lnE_{t-i} + \sum_{i=m}^{\rho} \theta_{1i}\, lnK_{t-i} + \sum_{i=m}^{\rho} \sigma_{1i}\, lnL_{t-i} + \mu_{1t} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots . (3.1)$$

$$\Delta lnM_t = \alpha_2 + \sum_{i=1}^{\rho} \beta_{2i}\, \Delta lnM_{t-i} + \sum_{i=m}^{\rho} \gamma_{2i}\, \Delta lnE_{t-i} + \sum_{i=m}^{\rho} \theta_{2i}\, \Delta lnK_{t-i} + \sum_{i=m}^{\rho} \sigma_{2i}\, \Delta lnL_{t-i} + \lambda\, ECM_{t-1} + \mu_{2t} \dots\dots\dots\dots\dots\dots (3.2)$$

Equation 3.1 gives the coefficients of the level variables in the long run at ρ optimal lag. It shows the impact of the level variables up to ρ in the long run. Equation 3.2 is the ARDL short run specification; it is derived through the construction of an error correction model (ECM). λ in 3.2 is the coefficient of the ECM, it represents the speed of adjustment or re-equilibration to equilibrium position whenever there is deviation as a result of shocks, thus it must be negative and significant. The ECM is therefore the error correction term and is lagged by one period to show the percentage of its speed of adjustment from a shock in the previous period to equilibrium in the current period. All coefficients in equation 3.2 reveals the short run impact of the independent variables on ΔlnM_t , hence, the first difference operator, Δ. Equation 3.3 represents the ECM showing its speed of recovering from deviation.

$$ECM_t = lnM_t - \alpha_1 - \sum_{i=1}^{\rho} \beta_{1i}\, lnM_{t-i} - \sum_{i=m}^{\rho} \gamma_{1i}\, lnE_{t-i} - \sum_{i=m}^{\rho} \theta_{1i}\, lnK_{t-i} - \sum_{i=m}^{\rho} \sigma_{1i}\, lnL_{t-i} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3.3)$$

3.4 Diagnostic Tests

These are the tests for the Classical Linear Regression Model (CLRM) assumptions. For valid inference and reliable conclusion with regard to coefficients in a model (betas), the model must fulfill the classical regression model assumptions. Pesaran (1974) concludes that for a model can only be taken as a true model once it satisfies all the assumptions of the CLRM. However, if no serious deviation from the CLRM assumptions, a model can still be used (Wolde-rufael, 2010).

The major and important CLRM assumptions is independence of the error terms, implying that the residuals of the response variables must be uncorrelated. Homoscedasticity assumes that the variance of residual of the response variables are constant, hence no heteroscedasticity. Others are normality of the distribution, stability and specification of the model. Though the ARDL is only based on the assumption of serially uncorrelated residuals, this study tests for other assumptions such as no heteroscedasticity, normal distribution, misspecification and stability of the model to confirm how close is our model to the true model for reliable and valid inferences.

4. ARDL Bound Testing Approach Results and Analysis

4.1 Stationarity Tests

Though the ARDL approach to cointegration does not require unit roots pre testing, determining the maximum order of integration of the variables is necessary because a variable that is stationary at second difference, I(2), can not fit in the bounds testing. The critical values are only available for a maximum of I(1) variables. To identify the order of integration of our variables, we employ two test approaches, the Augmented-Fuller (ADF) test (Dickey & Fuller, 1979) and Kwiatkowski, Phillips, Schmidt and Shin (KPSS) test (Kwiatkowski, Phillips, Sshmidt, & Shin, 1992), due to the lack power of the unit root tests (Sj, 2008) and (Toda & Yamamoto, 1995). Table 4.1 and 4.2 show the results of ADF and KPSS respectively. The ADF in table 4.1 shows the integration of all the variables at first difference. The ADF null hypothesis of non stationary is rejected for all the variables at 1% significance level, both at constant, constant and trend.

Table 4.1: Augmented Dickey-Fuller (ADF)

Series	Constant	Constant and Trend
lnM_t	-3.175791**	-2.408883
lnE_t	-2.751961*	-2.339312
lnK_t	-1.782007	-2.045613
lnL_t	-0.258493	-1.357550
ΔlnM_t	-4.212591***	-4.835494***
ΔlnE_t	-4.224029***	-5.025062***
ΔlnK_t	-4.742761***	-4.673089***
ΔlnL_t	-4.282347***	-4.538711***

Note: The critical values for constant (and trend) at 1%, 5% and 10% level of significance are -3.621023 (-4.226815), -2.943427 (-3.536601) and -2.610263 (-3.200320) respectively. ***, ** and * denote significance at 1%, 5% and 10% respectively. ADF test the null hypothesis of 'not stationary' against the alternative of 'stationary'.

The KPSS test outcome is given in table 4.2. Unlike the ADF, KPSS tests the null hypothesis of stationary against the alternative of non stationary. Hence, if the t – statistic is significant means that the variable is not stationary. KPSS rejects stationarity in all the variables at both constant, and constant and trend at level, at

1% significance level. But they are all integrated at first difference, at 1% significance level.

Table 4.2: Kwiatkowski-Phillips-Schmidt-Shin (KPSS)

Series	Constant	Constant and Trend
lnM	2.844059***	0.737269***
lnE	3.491888***	0.783962***
lnK	1.273816***	0.358249***
lnL	1.862787***	0.581365***
ΔlnM	0.452229*	0.111150
ΔlnE	0.520949**	0.083076
ΔlnK	0.052949	0.053603
ΔlnL	0.226970	0.054104

Note: In contrast to ADF and PP, KPSS unit root test has the null hypothesis of 'stationarity' against the alternative, 'not stationary'. Critical values for constant (with trend) are 0.739000 (0.216000), 0.463000 (0.146000) and 0.347000 (0.119000) at 1%, 5% and 10% respectively. ***, ** and * represent 1%, 5% and 10% level of significance respectively.

The unit roots tests confirmed all our process to be integrated at first difference and at 1% level of significance. The virtual similarity in both tests made robust our conclusion that all our variables are I(1).

4.2 Optimal Lag Selection

ARDL bound testing approach to long run level relationship among the variables requires the determination of the optimal lag for the cointegrating equation based on the assumption of serially uncorrelated residual. We employed the popularly used model selection criteria – Akaike Information Criterion (AIC) and Schwarz Bayesian Criterion (SBC). The lag length that minimizes the value of the AIC and SBC and at which the model does not have autocorrelation is the optimal lag. Since we are dealing with time series data, inclusion of time trend in our equations can produce better approximated results (Pesaran et al., 2001). Hence, we estimate equation 3 with and without time trend separately from lag 1 to 3 and compared their AICs and SBCs as well as the serially uncorrelated assumption to chose the optimal lag for each equation. We limit the estimations to lag 3 because increase in lag increases the possibility of serially uncorrelated residuals; however, it has to be done parsimoniously to avoid over-parameterization problem (Narayan, 2005; Pesaran et al., 2001; Wolde-Rufael, 2010).

Table 4.3a and 4.3b show the AIC and SBC, and the residual autocorrelation test for first difference regression of equation 3 with trend and without trend respectively. The rationale for LM test at different order is to check if change in lag affects the outcome of the test. In both tables, AIC minimizes its value at lag 2 while SBC does at lag 3. Though both lags do not suffer from serial autocorrelation at the different order, the study chooses lag 2 as the optimal lag because as the lag increases from 2, SBC continuously minimizes its value while AIC increases its value. This means that SBC cannot provide minimum value until more number of lags is taken which may lead to over parameterization. Hence, we use AIC to choose the optimal lag for equation 3 with trend and without trend. Though Pesaran et al. (2001) see SBC to be more consistent and parsimonious, and recommended its use; Al-jammal (2010) in simulation study, has found a model chosen by AIC to be more preferred in terms of robustness.

Table 4.3a: Lag Selection for Equation 3 with Trend

Lags	SBC	AIC	LM [1]	LM [3]
1	-12.6276	-7.7149	0.031[0.860]	3.402[0.334]
2[g]	-15.1017	**-7.8526**	**0.127[0.721]**	**2.017[0.569]**
3	**-15.8875**	-6.3864	0.141[0.707]	3.538[0.316]

Note: [g] denotes optimal lag chosen, SBC and AIC are Schwarz Information Criterion and Akaike Information Criterion respectively. LM [1] and LM [3] denote Langrange Multiplier test of residual autocorrelation at order 1 and 3 respectively.

Table 4.3b: Lag Selection for Equation 3 without Trend

Lags	SBC	AIC	LM [1]	LM [3]
1	-11.7439	-7.6499	1.151[0.283]	6.922[0.074]*
2[g]	-13.3045	**-6.8608**	**0.063[0.802]**	**1.926[0.588]**
3	**-14.1017**	-5.3924	0.128[0.720]	3.563[0.313]

Note: * and [g] denote significance at 10% and optimal lag chosen respectively, SBC and AIC are Schwarz Information Criterion and Akaike Information Criterion respectively. LM [1] and LM [2] denote Langrange Multiplier test of residual autocorrelation at order 1 and 3 respectively.

4.3 Bounds Testing for Long Run Level Relationship

Haven determined the order of integration of the process and optimal lag for the ARDL cointegrating equation, we estimate Unrestricted Error Correction (UREC) by testing the joint significance of the lagged levels of the variables in first difference regression and compare the F – Statistic with the critical values – lower and upper bounds for I(0) and I(1) respectively - formulated for small sample size by Narayan (2004, 2005). The critical values depends on whether estimated equation is with intercept and trend or intercept and no trend, number of regressors (K) and the order of integration of the process – I(1), I(0) or mixture of both. Table 4.4 provides an extract of the critical values from Narayan (2004) according to the need of our study.

Table 4.4: Critical Values for Bounds Test (n = 40)

	Intercept with Trend K=3		Intercept and no Trend K=3	
1% Level	I (0) 5.018	I (1) 6.610	I (0) 4.310	I (1) 5.544
5% Level	I (0) 3.548	I (1) 4.803	I (0) 3.100	I (1) 4.088
10% Level	I (0) 2.933	I (1) 4.020	I (0) 2.592	I (1) 3.454

Note: n is the number of observation while K is the number of regressors. I (0) and I (1) represent the lower and upper boundary respectively. If the value of F-statistic falls above the upper boundary, long run relationship exists, however, it does not exist if it falls below the lower boundary. If the F-statistic is in between the lower and the upper boundaries, the long run relationship is inconclusive.

Table 4.5 shows the F–Statistics of the joint significance test or zero restriction hypothesis tests of the lagged levels of the variables in the first difference regression estimated at different lags. The F–Statistic of equation 3 at the optimal lag when trend is included is above the upper bound of the critical values at 5% level of significance, indicating that all the variables in the equation associate together in the long run. In other words, these variables namely, manufacturing output, electricity supply, capital and labour will relate together over a long period. Hence, manufacturing output is dependent on labour, capital and electricity supply. However, when trend is not captured in the equation, the F – Statistic falls in between the critical values, hence, inconclusive decision. This shows the significance of time trend in the relationship among the variables.

Table 4.5: F–Statistic Test for Long Run Relationship

Test	Lags 1	2	3
Equation 3 (WT)	5.2292	5.8646**+ u	3.4558
Equation 3 (NT)	3.2886	3.3779** + b	2.0175

Note: [u] and [b] indicate above upper boundary and between lower and upper boundaries of the critical values respectively. *, ** and *** show significance level at 10%, 5% and 1% respectively, while + denotes optimal lag length. WT and NT refer to “with trend” and “no trend” respectively.

Results in table 4.5 show overwhelming support for inclusion of time trend in our equation, thus, long run and short run coefficients were estimated with time trend component.

Table 4.6 presents estimates of the short run coefficients, long run coefficients and error correction representation model (ECRM) of the selected ARDL model (1,0,0,1). The short run coefficients shows positive but insignificant impact of electricity supply on manufacturing output in the current period, but one period lag of both manufacturing output and electricity supply were positive and significant at 1% and 5% respectively in influencing the current output of the manufacturing sector. Hence, the dependence of manufacturers on electricity supply for their activities reveals rational expectation hypothesis – output decision was based on previous electricity supply.

Table 4.6: Estimates of Short run Coefficients, Long run Coefficients and Error Correction Representation Model (ECRM)

	Dependent Variables : lnM		
Regressors	Short run coefficients	Long run coefficients	ECRM
$Constant_t$	-23.576[0.055]*	-62.533[0.008]***	-23.576[0.054]*
$Trend_t$	-0.098[0.117]	-0.261[0.091]*	-0.098[0.117]
lnE_t	0.048[0.907]	2.175[0.000]***	0.048[0.907]
lnK_t	0.088[0.387]	0.233[0.457]	0.088[0.387]
lnL_t	2.603[0.166]	6.905[0.145]	2.603[0.166]
$lnM_{(t-1)}$	0.623[0.000]***		
$lnE_{(t-1)}$	0.772[0.048]**		
ECT			-0.377[0.010]***
LM	0.063[0.802]		
ARCH	0.001[0.972]		
RR	0.903[0.374]		
JB	126.2[0.000]***		
R – Square	0.957		

Note: ***, ** and * denote level of significance at 1%, 5% and 10% respectively. LM: Langrange Multiplier Test of Residual Correlation, ARCH: Autoregressive Conditional Heteroscedasticity Test of Residuals, RR: Ramsey's RESET: Misspecification Test based on square of fitted values, JB: Jarque – Bera Test of Normality Based on Skewness and Kurtosis of Residuals, ECT: Error Correction Term

Similarly, previous output in the sector signal more firms to produce in the current period, hoping the same electricity supply level will be maintained.

The long run coefficients show that electricity supply has positive and significant effect on manufacturing at 1% significance level. Specifically, a 10% increase in electricity supply increases manufacturing output by 21.75%; this indicates that manufacturing is positively elastic towards changes in electricity supply in the long run. Therefore, the need of electricity for the growth of the manufacturing in Nigeria cannot be overemphasized. For any policy design to achieve growth in the manufacturing sector, adequate and stable electricity supply must be incorporated.

According to Pesaran & Shin (1996), establishing long run relationship through cointegration analysis could be misleading if the speed or percentage at which the relationship or system recover from disequilibrium once shock is experienced is not determined. In the ECRM, ECT was found to be significant, negative and less than one, showing the speed of adjustment and reversal ability of our model to return back to equilibrium after shock. Our ECT of -0.337 and significant at 1% shows that the speed of adjustment in one period is 37.7%, 3 years for the model to adjust back to equilibrium after shock.

4.4 Diagnostic Tests for ARDL Model

The estimated ARDL cointegration equation does not show serious deviation from the true mode referred to by Pesaran (1974). Though the ARDL cointegration equation is based only on the assumption of serially uncorrelated residuals; our equation passed all the diagnostic tests except for Jaque-Bera normality test

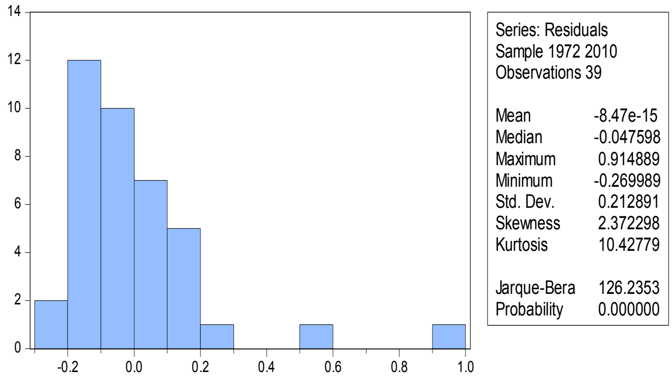
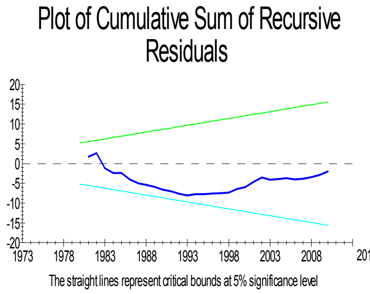


Figure 4.1: Jarque-Bera Normality Test



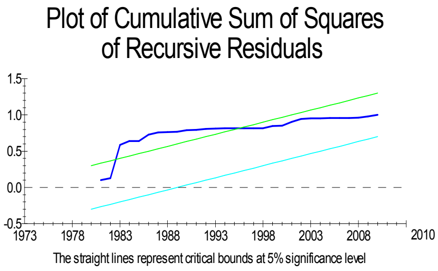


Figure 4.2a: CUSUM Figure 4.2b: CUSUMSQ

The Cumulative Sum of Recursive Residuals (CUSUM) and Cumulative Sum of Squares of Recursive Residuals (CUSUMSQ) stability tests in figure 4.2a and 4.2b show the relative stability of our model within the study period at 5% significance level. The result in CUSUM test could be due to the lack of power of test to capture some important break in the process (Pesaran et al., 1999, 2001). The R-square in table 4.6 shows that more than 90% of the variation in the dependent variable is explained by the independent variables in the model.

5. CONCLUSION

Based on the outcome of this study, we empirically conclude that there exists long run relationship between electricity and manufacturing output in Nigeria. The study identifies electricity supply as a significant factor in the growth of the manufacturing sector in Nigeria. The growth of the Nigerian manufacturing industry is heavily anchored on adequate and stable electricity supply. Manufacturing output proves to be very elastic to changes in electricity supply, 10% increase in electricity leads to 21.75% increase in manufacturing output in the long run. For the Nigerian manufacturing sector to serve as a catalyst for the transformation of the Nigerian economy as identify by Okonjo-Iweala & Osafo-kwaako (2007), we emphatically recommend that adequate and stable electricity supply must be a policy focus.

With the presently weak manufacturing sector, the country’s visionary policy of being among the 20 industrialized economies in the world by the year 2020 is certainly a mirage. If the country must achieve this vision, this study recommends that more attention should be given to the electricity sector in the country in order to galvanize the manufacturing sector. This will not only spur the manufacturing sector but create employments and reduce poverty.

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