ENERGY CONSUMPTION - ECONOMIC GROWTH NEXUS IN NIGERIA: AN EMPIRICAL ASSESSMENT BASED ON ARDL BOUND TEST APPROACH

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Abstract

This study examines the impact of energy consumption on economic growth in Nigeria over the period 1980-2010. The short-run and long-run relationship between energy consumption variables and economic growth are estimated by using the newly developed autoregressive distributed lag (ARDL) approach to cointegration analysis. The results indicate a long-run relationship between economic growth and energy consumption variables. Although, the coefficient of coal consumption is positive but is statistically insignificant, while both petroleum consumption and electricity consumption have positive and are statistically significant on economic growth. Moreover, the coefficient of error correction model suggests that the speed of adjustment in the estimated model is relatively high and had the expected significant and negative sign.The study therefore recommends that government should strengthening the ongoing transformation agenda particularly on energy infrastructure to create sufficient energy supply. This can be done through service availability, affordability, and accessibility.

Keywords: Energy Consumption, Economic Growth, Nigeria

1. Introduction

Energy plays an important role in the economic growth of both developed and developing countries. The growth hypothesis suggests that energy consumption is an indispensable component in growth, directly or indirectly as a complement to capital and labour as an input in the production process (Mulegeta *et al*. 2010). Since production and consumption activities involve energy as an essential factor inputs, the relationship between energy consumption and economic growth has been a subject of greater inquiry as energy is considered to be one of the important driving force of economic growth in all economies (Abdulnasser and Manuchehr, 2005). The question as to whether energy consumption has positive, negative or neutral impact on economic activities has motivated the interest of economists and policy analysts hence the need to find out the impact and direction of causality between energy consumption and economic growth (Eddine, 2009).

According to National Energy Commission (2003), insufficient supply of energy affects all aspects of development, more specifically social, economic, environmental, and even quality of life. Improvements in standard of living are manifested in increased agricultural output, increased industrial output, the provision of efficient transportation, adequate shelter, healthcare and other human services and these will holistically require increased in energy consumption. Therefore, energy is considered as an important requirement for economic growth and is potentially an inhibiting factor to economic and social development.

Nigeria today is one of the developing countries in Sub-Sahara Africa which is highly endowed with abundant natural resources including renewable and non-renewable potential energy resources. However, increasing access to energy has proved to be not only a continuous challenge but also a pressing issue (Odularo and Okonkwo, 2009). The gloomy energy services provision in Nigeria have adversely affected living standards of the population and aggravated energy poverty in the economy, the energy consumption mix of the country in 2004 was dominated by oil (58%), natural gas (34%) and hydroelectricity (8%), the proportion of oil in Nigeria's energy mix between 1984 and 2004 decreased from 77 to 58% (Energy Information Administration, 2007).

Coal as an energy source is considered to be the oldest commercial fossil fuel used in Nigeria. However, Since the discovery of oil in commercial quantities in Nigeria, coal was given less relevance and became highly neglected, with a reserve of over 2 billion metric tonnes Nigeria produces not more than 600,000 thousand metric tonnes yearly (Odularo and Okonkwo, 2009).

Although relevant empirical studies in this area have been conducted in Nigeria (see Ebohon, 1996; Omotor, 2008; Olusegun, 2008; Odularo and Okwonkwo,2009). The weaknesses identified with these studies reiterate the need for further research in this area. For instance, one of the pioneering studies in this area, Ebohon (1996) investigated the causal relationship between energy consumption and economic growth nexus. This study is not country specific. Thus the problem of false generalization cannot be ruled out. As for Odularu and Okonkwo (2009) their study is limited to the long run relationship between the energy consumption and economic growth. Furthermore, studies by Omotor (2008) and Olusegun (2008) investigated the causality and long run relationship between energy consumption and economic growth, the work of Olusegun (2008) is particularly noteworthy as it is one of the first to apply the ARDL bounds test approach to cointegration. However, the author did not consider coal consumption as one of his respective independent variables. Therefore, this study intends to fill this gap in the literature.

Therefore, the major objective of this study is to empirically examine the impact of energy consumption on economic growth in Nigeria. In order to achieve this objective, the paper is organized into five sections including this introduction. The rest of the paper is organized as follows: Section two presents the literature review. In section three, the methodology adopted for this study is presented. Presentation of results is done in section four and conclusion is drawn in section five with policy implication.

2. Literature review

The empirical literature provides mixed and conflicting evidence with respect to the energy consumption-growth nexus (see Pradhan, 2011; Shuyun and Donghua, 2010; Ma *et al.*2011). This phenomenon can be attributed to a number of factors, including estimation techniques, choice of variables, study period, and level of development of the country being studied, among other things.

Empirical studies designed to test the causal relationship between energy consumption and economic growth is generally grouped into three testable hypotheses. The first hypothesis suggests that energy consumption is a precondition for economic growth given that energy is a direct input in the production process and also, energy is an indirect input that complements labour and capital inputs (see Odhiambo, 2009; Ebohon, 1996). The second hypothesis assumes that there is a bi-directional or feedback relationship between energy consumption and economic growth. The implication of the bi-directional relationship is that energy consumption and economic growth are complementary. This means that an increase in energy consumption will accelerate economic growth, and contrariwise, an increase in economic growth will stimulate energy consumption (Hou, 2009; Omotor, 2008). The third hypothesis which is neutral assumes that there is no causality between energy consumption and economic growth and thus policies that are aimed at conserving energy will not retard economic growth (George and Nickoloas, 2011; Ezatollah *et al.*, 2010).

In an attempt to justify the first hypothesis, Odhiambo (2009) applied the newly developed autoregressive distributed lag (ARDL) bounds test approach and Granger non-causality test for Tanzania for the 1971-2006 period. The results of the bounds test revealed a stable long-run relationship between energy consumption and economic growth. While, the results of Granger non-causality showed the evidence of unidirectional causality running from energy consumption to economic growth as well as from electricity consumption to economic growth. The results imply that energy conservation policies have damaging repercussions on economic growth for Tanzania. Contradicting the first hypothesis, Mehrara (2007) looked at the relationship between the per capita energy consumption and per capita GDP on the basis of panel data for 11 oil exporting countries for the period 1971-2002 and employing the panel cointegration technique and Granger causality test. The results showed a unidirectional causality from economic growth to energy consumption for all the countries. The results indicated that energy conservation policies have no damaging effect on economic growth for this group of countries.

Furthermore, Esso (2010) examines the long-run causality relationship between energy and economic growth for 7 sub-Sahara countries over the period 1970-2007 and applying bounds testing approach to cointegration, the findings suggest unidirectional relationship between GDP and energy consumption for all countries, while the result of causality indicates bidirectional relationship between energy consumption and real GDP in the case of Coted'Ivoire and unidirectional causality from real GDP to Congo. Justifying the first hypothesis on the basis of panel data from 158 countries for the period 1980-2004 and employing semi-parametric partially linear panel model, Von (2009) reports energy consumption leads to increase in economic growth and the effect of time trend is not significant.

In addition, Nondo and Kahsai (2009) and Chali *et al* (2010) apply the same techniques of panel unit root tests, panel cointegration and panel error correction model to estimate the causal relationship between energy consumption and economic growth for 19 COMESA countries for the period 1980-2005. Their analyses reveal that causation running from energy consumption to economic growth for low income COMESA countries. Another study conducted by Pradhan (2010) using the time series data from China for the period 1970-2007 and applying production function and causality approach, he finds unidirectional causality from economic growth to energy consumption with infrastructure and transport as additional variables which also reports unidirectional causality as well. Employing different methodology and different time period for China, Shunyun and Donghua (2011) examines the causality between energy consumption and economic growth for the period 1985-2007 within a multivariate framework by applying fully modified OLS (FMOLS), the results indicate the presence of bidirectional relationship and economic growth which contradicts the findings of Pradhan (2010). Similarly, Viahinic-Dizdarevic and Zikovic (2010) apply the technique of error correction model (ECM) to investigate the role of energy consumption in economic growth from Croatia for the period 1993-2006, their results support unidirectional hypothesis.

Moreover, Khan and Qayyum (2007) using time series data of South Asia for the period 1972- 2004 and applying autoregressive distributed lag (ARDL) technique, the results support the evidence of causality running from energy consumption to GDP in all countries in the long as well as in the short- run. A similar study by Zachariadis (2006) using panel data for the 5 OECD countries for the period 1965-2004 and applying different modern econometric methods (VEC, ARDL and VAR), discovers the aggregate energy use is granger caused by GDP. But differences in methods and datasets do not allow for a more in depth analysis. On the contrary, using the Leveraged Bootsrap Simulation technique on time series data from Sweden for the period 1965-2000, Abdulnasser and Manuchehr (2005) find that energy consumption does not cause economic activity but rather it is caused by economic activity. Erbaykal (2008) using time series data for the period 1970-2008 for Turkey and employing Bounds test approach, the findings suggest that in the short run both oil and electricity have positive and statistically significant effect on economic growth, however, in the long run oil consumption has positive effect on economic growth while electricity has negative effect.

In contrast to the first hypothesis, Sinha (2009) using panel data from 88 countries for the period 1975-2003 and applying dynamic panel Vector Error Correction Model (VECM) and causality tests, the results show that per capita GDP and per capita energy are cointegrated. The findings also suggest bidirectional short run, long run and strong causality between the growth of GDP and growth of energy consumption. Mallick (2007) using time series data for the period 1970-71 to 2004-5 and employing Granger causality test and variance decomposition analysis of autoregression (VAR) method, the result from the application of Granger causality test suggests that it is the economic growth which leads to demand for the natural gas and electricity and the overall energy consumption, and it is only coal consumption which has positive influence on growth. But variance decomposition analysis suggests that there could be bidirectional causality between electricity consumption and economic growth in the future and unidirectional relationship as observed in Granger causality test for natural gas and coal on India.

However, supporting second hypothesis, Mawuse and Nezan (2009) on the basis of panel data for 4 WAEMU countries for the period 1970-2005 and applying Cointegration test and Vector Error Correction Model (VECM), the findings suggest a bidirectional relationship for the panel as a whole, the findings reveal not only feedback between energy consumption-growth nexus but also support regional energy policies which must take account some countries specificities. Another study conducted using time series data for the period 1970-2009 and applying the techniques of Vector Autoregressive (VAR) and Vector Error Correction Model (VECM), Magazzino (2011) reports the long run bidirectional relationship between energy consumption and economic growth in Italy. Similarly, using time series data from Malaysia for the period 1971-2008 and applying ARDL bounds testing approach to Cointegration, Faridula e*t al* (2011) discovers long run bidirectional causality amount all series. This implies that GDP and energy consumption cause each other in both short and long run.

In addition, Chebbi and Boujelbene (2009) using time series data from Tunisia for the period 1971-2004 and employing Multivariate Cointegration, the combined results of Causality analysis and impulse response functions do not assume that energy and GDP are neutral with respect to each other in Tunisia but rather indicates a bidirectional causality between GDP and energy consumption in the long run implying that Tunisia is an energy dependent economy. But using different data set, Ansgar *et al* (2010) apply the techniques of panel unit root and Cointegration tests to investigate energy consumption and economic growth of 25 OECD countries for the period 1981-2007, they found a bidirectional causal relationship between energy consumption and economic growth.

However, Hou (2007) using time series data and applying Cointegration test and Error Correction Model (ECM) , discovers that economic development and energy consumption are cointegrated in the long run in Beijing, so does in the tertiary. The gross energy consumption increases 0.427% with the gross value added 1% growth. Hou (2009) also, investigates the causal relationship between energy consumption and economic growth in China. He uses time series data for the period 1953-2006 and applying the techniques of ADF, Cointegration and Hsiao's Granger causality, the results suggest economic growth granger causes energy consumption and energy consumption granger causes economic growth.

Furthermore, employing different technique from most of the studies, which is Wavelet analysis as a semi- parametric model for detecting multi- causality between energy consumption and economic growth on the time series data for the period 1968-2002, Chifter and Ozun (2007) find the feedback relationship between GDP and energy consumption, while in the long run GNP leads to energy consumption. The findings also indicates the magnitude of the Wavelet correlation changes based on time series for GNP and energy consumption and thus indicate that the GNP and energy consumption are fundamentally different in the long run. Hye and Mashkoor (2010) on the basis of time series data for Bangladesh for the period 1971-2008 and applying ARDL based causality test, the result confirms bidirectional causality in the long run.

Justifying the third hypothesis, Mulegeta *et al* (2010) using a panel of 40 Sub-Sahara Africa (SSA) countries for the period 1980-2007 and applying a panel cointegration approach to test the causal relationship between energy consumption and GDP, the findings support the neutrality hypothesis in the short run, except for middle income countries and a strong causation running in both directions is found in the long run. The different results for low and middle income countries provide evidence for the importance of income in the causal relationship. Similarly, using a sample of 18 EU countries for three census years (1980, 1990 and 2000) and applying non-parametric regressions, George and Nickoloas (2011) the results justified the neutrality of energy consumption on economic growth. Jobert and Karanfil (2007) using time series data for the period 1960-2003 and employing the notion of Granger causality and the notion of instantaneous causality, find no evidence of long run relationship between energy consumption and economic growth which is neutral with each other. The analysis also shows strong evidence of instantaneous causality between these variables. In addition, Aqeel and Butt (2001) using the time series for the period 1955-6 for Pakistan and applying the techniques of Cointegration and Hsiao's of Granger causality, the findings suggest economic growth is a pre-requisite to the growth in petroleum consumption, while gas consumption justified neutrality hypothesis. However, it has been observed that electricity consumption leads to economic growth without feedback. Olaniyan (2010) on the basis of panel data of 5 West African countries for the period 1970-2005 and employing Granger causality tests and cointegration analysis, the results show energy consumption does not cause economic growth suggesting that individual efforts may be inadequate; rather, regional cooperation to lower oil prices, increases access to cheaper renewable energy sources as well as increased intra-region energy trade should be encouraged.

Moreover, Tsani (2010) on the basis of time series data examines the causal relationship between energy consumption (both at aggregated and disaggregated levels) and economic growth for Greece for the period 1960-2006 and applying Toda and Yamamoto technique, the findings suggests unidirectional relationship between energy consumption and real GDP at aggregate levels while bidirectional relationship with exception of transport energy consumption at disaggregated levels. Another study conducted in India using time series data for the period 1971-2006 through the application of ARDL model and Toda and Yamamoto multivariate model, their findings indicates the evidence of bidirectional Granger causality between energy consumption and CO_2 emissions in the long run but neutral relationship between energy consumption and economic growth which invariably implying that India could pursue conservation policies without harming economic growth.

3. Methodology

3.1 Data

Annual time series data were collected on real GDP proxied for economic growth and energy consumption variables. The annual data covers the period 1980 to 2010. The choice of this period was guided by data availability considerations and also to abide by central limit theorem. The data were obtained from the Central Bank of Nigeria Statistical Bulletin and publication of International Energy Agency (IEA).

3.2 Method of Data Analysis

The study employed Autoregressive Distributed Lag (ARDL) bounds testing procedure to test the long run equilibrium relationship between economic growth and the explanatory variables of energy consumption. The ARDL has several advantages over other techniques of cointegration. First, it can be applied irrespective of whether the underlying variables are I(0), I(1) or a combination of both . Second, the model takes a sufficient number of lags to capture the data generating process in general to specific modeling frameworks. Third, the error correction model (ECM) can be derived from ARDL through a simple linear transformation, which integrates short run adjustments with long run equilibrium without losing long run information. Fourth, the small sample properties of the ARDL approach are far superior to those of the Johensen and Juselius cointegration technique. Fifth, endogeneity is less of a problem in the ARDL technique because it is free of residual correlation. As Pesaran and Shin (1999) demonstrate, the appropriate lags in the ARDL model are corrected for both serial correlation and endogeneity problems. Sixth, the ARDL method can distinguish between dependent and explanatory variables.

The ARDL approach to cointegration will be estimated using the following Unrestricted Error Correction Model (UECM) equations:

$$\Delta InRGDP_{t} = \alpha_0 + \alpha_1 InRGDP_{t-I} + \alpha_2 InPTRC_{t-I} + \alpha_3 InCOLC_{t-1} + \alpha_4 InELTC_{t-1} + \sum b_1 \Delta InRGDP_{t-I} + \sum b_2 \Delta InPTRC_{t-I} + \sum b_3 \Delta InCOLC_{t-1} + \sum b_4 \Delta InELTC + \mu_{1i} \ldots\ldots (1)$$

$$\Delta InPTRC_{t} = \alpha_0 + \alpha_1 InPTRCt_{-I}\ \alpha_2\ InRGDP_{t-I} + +\alpha_3 InCOLC_{t-1} + \alpha_4 InELTC_{t-1} + \sum b_1 \Delta InPTRC_{t-I}\ \sum b_2 \Delta InRGDP_{t-I} + +\sum b_3 \Delta InCOLC_{t-1} + \sum b_4 \Delta InELTC + \mu_{1i} \ldots\ldots (2).$$

$$\Delta InCOLC_{t} = \alpha_0 + \alpha_1 InCOLC_{t-1+} + \alpha_2\ InRGDP_{t-I}\ \alpha_3 InPTRCt_{-I} + \alpha_4 InELTC_{t-1} + \sum b_1 \Delta InCOLC_{t-1}\ \sum b_2 \Delta InRGDP_{t-I} + \sum_3 \Delta InPTRC_{t-I} + +\sum b_4 \Delta InELTC + \mu_{1i} \ldots\ldots (3)$$

$$\Delta InELTC_{t} = \alpha_{0+}\ \alpha_1 InELTC_{t-} +_{+}\ \alpha_2\ InRGDP_{t\ +}\ \alpha_3 InPTRCt_{-I\ -I} + \alpha_4 InCOLC_{t-1\ 1} + \sum b_1 \Delta InELTC + \sum b_2 \Delta InRGDP_{t-I} + \sum_3 \Delta InPTRC_{t-I} + \sum b_4 \Delta InCOLC_{t-1} + \mu_{1i} \ldots\ldots (4)$$

Where:

Δ represents the first difference operator, μ represents the white noise error term, lnRGDP denotes the nature logarithm of real RGDP, lnPTRC denotes the nature logarithm of petroleum consumption, lnCOLC denotes the nature logarithm of coal consumption and lnELTC denotes the nature logarithm of electricity consumption. The parameters b's are the short-run coefficients and α's are the corresponding long-run multipliers of the underlying ARDL model. The F-test is used to determine whether a conintegrating relationship exists among the variables through testing the significance of the lagged levels of the variables.

The null hypothesis in the equation is $H_0\ :\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = 0$. This indicates the existence of a long run relationship. The alternative hypothesis is $H\ 1 : \alpha_1 \neq \alpha_2 \neq \alpha_3 \neq \alpha_4 \neq 0$. The calculated F-statistics is compared with two sets of critical values suggested by Pesaran et al. (2001). One set assumes that all variables are I(0) and the other assumes they are I(1). If the calculated F-statistics exceed the upper critical value, the null hypothesis of no cointegration will be rejected irrespective of whether the variables are I(0) or I(1). If it is below the lower value, the null hypothesis of no cointegration cannot be rejected. If it falls inside the critical value band, the test is inconclusive.

4. Results and Analysis

Table 1: Results of Augmented Dickey-Fuller Unit Root Test

Variables	Level Value	Difference Value	Order of Integration
RGDP	-1.867466	-3.940960***	1(1)
PTRC	-2.003863	-6.035939***	1(1)
COLC	-2.277045	-8.153546***	1(1)
ELTC	-2.455933	-4.116103***	1(1)

Source: authors' calculation using EVIEWS

Note: *** indicates levels of significance at 1%

Interpretation of Augmented Dickey-Fuller Unit Root Test Results

Before performing the bound test, it is essential to check for the stationarity of the data series used. This is important to obtaining an unbiased estimation from the Granger causality tests, and also because the bound test is used only when variables are 1(0) or 1(1). The Augmented Dickey-Fuller (ADF) test was applied to test for the existence of unit root tests. Therefore, Table 4.1.2 presents the results of Augmented Dickey- Fuller unit root test on the variables at their level and difference values. The summary of the result reveals that all the variables are non-stationarity in the level data. However, the stationarity property is found after taking the first difference of the variables in 1% critical level. As stated earlier, it is necessary to first perform unit root tests on the variables in order to ensure that none of the variables is integrated of order two 1(2) or beyond. According Chigusiwa *et al*.(2011), in presence of 1(2) variables the computed F-statistics of the bounds test are rendered invalid because they are based on the assumption that the variables are 1(0) or 1(1) or mutually cointegrated.

Table 2: Bounds F-Test for Cointegration

Dependent variable	Function	F-Statistic
LRGDP	F_{LRGDP}(LRGDP|LPTRC,LCOLC,LELTC)	6.5240^{**}
LPTRC	F_{LPTRC}(LPTRC|LRGDP,LCOLC,LELTC)	2.6073
LCOLC	F_{COLC}(LCOLC|LRGDP,LPTRC,LELTC)	1.9065
LELTC	F_{LELTC}(LELTC|LRGDP,LPTRC,LCOLC)	2.0267
Asymptotic critical value	5%	10%
Lower bound	2.8142	2.2295
Upper bound	4.1558	3.3970

Source: Authors' calculation using MICROFIT software

Note: ** indicates the level of significance at 5%

Interpretation of the Bounds F-Test for Cointegration Results

The next step after determining the order of integration of the variable was to apply a bound F-test in order to establish a long-run relationship among the variables. The results of the bounds test for cointegration alongside with critical values are reported in Table 4.1.3 above. The bounds test indicates that cointegration is only present when natural logarithm of real GDP is the dependent variable and the long run forcing variables are natural logarithms of petroleum consumption, coal consumption and electricity consumption. This is because the computed F_{LRGDP}(LRGDP|LPTRC,LCOLC,LELTC) is 6.5240, which is higher than the upper bound critical value at 5% significance level. However, the bounds test indicates that when the natural logarithms of petroleum consumption, coal consumption and electricity consumption are dependent variables F_{LPTRC}(LPTRC|LRGDP,LCOLC,LELTC), F_{LCOLC}(LCOLC|LRGDP,LPTRC,LELTC) and F_{LELTC}(LELTC|LRGDP,LPTRC,LCOLC) are lower than the lower bound critical value at the 5% level. Therefore, there is no evidence of cointegration when these variables are treated as the dependent variables, meaning that there is one single long run relationship among the variables under study.

Table 4.1.4 Results of Estimated long-run Coefficients Using ARDL Approach

ARDL (1,0,0,1) Selected based on Akaike Information Criteria

Regressor	Coefficient	Standard error	T-ratio [p-value]

Dependent variable; LRGDP			
LPTRC	1.9178	0.95740	20.0318[0.000]
LCOLC	0.0074009	0.47755	0.15498[0.878]
LELTC	0.97791	0.20135	4.8567[0.000]

Source; authors' calculation using MICROFIT software

Interpretation of Results of Estimated Long run Coefficients based on ARDL (1,0,0,1)

Having determined the existence of long run equilibrium when real GDP serves as dependent variable, the long run coefficients and short run coefficients are estimated using the associated ARDL and ECM. The ARDL model is estimated by setting the maximum lag length to 2 and using Akaike information criteria in selecting the optimum lag order for the model. The specification finally selected is ARDL (1,0,0,1), the derived long run elasticities are presented in Table 4.1.4.

Based on Table 4.1.4 above, the results of the long run elasticities on the real GDP in Nigeria are generally positive as expected. The long run impact of petroleum consumption on real GDP is around 1.92 and statistically significant at 1 % level, meaning that a 1% increase in petroleum consumption will in 1.92% in real GDP. The long run impact of coal consumption and electricity consumption on real GDP is 0.01 and 0.98, respectively and the former is statistically significant at 1% level but the latter is not at the same level of percentage.

Table 4.1.5 Error Correction Representation for the Selected ARDL Model

ARDL (1,0,0,1) Selected Based on Akaike Information Criterion

Regressor	Coefficient	Standard Error	T-ratio	P-value
Dependent variable: ΔLRGDP				
ΔLPTRC	0.33106	0.094524	3..5024	0.002
ΔLCOLC	0.0012775	0.0083003	0.15392	0.879
ΔLELTC	0.12262	0.066824	3.9563	0.001
ecm(-1)	-0.17262	0.047090	-3.6658	0.001

ecm=LRGDP-1.9178 * LPRC-0.0074009 * LCOLC-0.97791* LELTC

Source: authors' calculation using MICROFIT software

Interpretation of Results of Error Correction Representation for the Selected ARDL

Model ARDL (1,0,0,1) Selected Based on Akaike Information Criterion

The results of the short run dynamic coefficients associated with the long run relationships obtained from the error correction model are presented in Table 4.1.5. The signs of the dynamic impacts are maintained to the long run. Again, the petroleum consumption and electricity consumption variables were statistically significant at the 1% level. However, coal consumption variable has a positive lower impact on economic growth in both the short run and long run compared to other variables. The error correction coefficient, estimated -0.17 (0.001) is highly significant, has the correct sign, and imply a fairly high speed of adjustment to equilibrium after a shock. Approximately 17% of disequilibria from the previous year's shock converge back to the long run equilibrium in the current year.

Table 4.1.6 Diagnostic Tests of Selected ARDL Model

LM Test Statistics	
Serial Correlation CHSQ .(1)=0.0044925[0.947]	Normality .CHSQ(2) = 1.2936[0.524]
Functional FormCHSQ .(1) = 0.79974[0.381]	Heteroscedasticity CHSQ(1) =0.50421[0.524]

Source: authors' calculation using MICROFIT software

Interpretation of Results of Selected ARDL Model Diagnostic Tests

In this study, the selected ARDL model passes the standard diagnostic test of serial correlation, functional form, normality and hetroscedasticity as presented in Table 4.1.6.

5. Conclusion and policy implications

The study has examines the impact of energy consumption on economic growth in Nigeria during the period 1980-2010. The ARDL bounds test and error correction model (ECM) are employed. From the cointegration test results, the study found that petroleum consumption, coal consumption, and electricity consumption have a long run relationship with the economic growth. Moreover, the results of error correction coefficients, which determine the speed of adjustment, had an expected and highly negative sign.

The study therefore recommends that government should strengthening the ongoing transformation agenda particularly on energy infrastructure to create sufficient energy supply. This can be done through service availability, affordability, and accessibility. Government should also dedicate a certain percentage of the nation's income to support training, research, development and technology acquisition in the energy sector so that to ensure stable energy supply and attract foreign direct investment into the economy.

The policy implication of the findings suggests that energy conservation policies would not be implemented without undermining long-run economic growth Nigeria. It is therefore necessary for the government to have an integrated energy policy, which will guide future energy related sub-sectoral policy developments, in order to avoid policy conflicts which may otherwise arise.

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