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Economic growth, energy consumption, and quality environment in Nigeria

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ABSTRACT

The paper examines the impact of energy consumption on economic growth and environmental quality and also verifies the existence of the Environmental Kuznets Curve (EKC) hypothesis in Nigeria. The Autoregressive Distributed Lag (ARDL) approach was used to estimate data covering 1981-2015 period. The result of the first model reveals evidence of inverse and significant impact of energy consumption on economic growth. Capital and trade openness show evidence of positive and significant impact on economic growth but labour reveals a negative and significant impact on economic growth. The result of the second model suggests that energy consumption is significant and positively related to environmental quality. As such, greater consumption of primary energy such as petroleum and natural gas increase carbon emissions which subsequently reduce environmental quality. Trade openness was also found to improve environmental quality. Furthermore, the test for EKC hypothesis did not reveal any evidence of its existence in Nigeria. This could result from the fact that growth level has not been expanded to a certain threshold beyond which additional expansion can reduce carbon emissions and improves environmental sustainability. The study recommends that efficiency in the use of conventional energy will go long way in reducing energy-related carbon emissions and enhance environmental sustainability. While improving human capital development will enhance the impact of labour force on economic growth in Nigeria.

Keywords: *energy consumption; economic growth; environment; Nigeria.*

JEL codes**:** Q43*, Q53*.

1. INTRODUCTION

The consumption of fossil fuel energy as production input to achieve economic growth has become a growing concern for most economies. Most advanced countries have committed to reducing their domestic carbon dioxide (CO2) emissions from fossil fuel energy consumption to a certain level (UNFCCC, 2015). This is due to the contribution of fossil fuel energy to CO2 emissions and environmental degradation (WDI, 2015). Since the industrial revolution, the level of CO2 emissions from human activities is on the increase and the burning of fossil fuel and deforestation have been found to be the primary cause of increased CO2 concentrations in the atmosphere (IPCC, 2017).

Thus, combustion of primary energy such as petroleum, natural gas and coal during production to achieve economic growth and development often translate to CO2 emissions which contribute to greenhouse gasses, increase global warming and reduces environmental quality. According to World Development Indicators in 2014, fossil fuel energy contributes more than 60% of greenhouse gas and environmental pollution with crude oil and coal identified as the highest emitter.

As such, recent studies (Mandelli et al., 2014) have witnessed a new paradigm move by the stakeholders in this area from the use of fossil fuel energy to cleaner sources of energy. Although some advanced countries such as Japan and Germany have started replacing the use of fossil fuel energy with cleaner sources of energy for production to save the environment for the future generation, the technologies and initial sunk costs of

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establishing cleaner energy sources are evidenced to be challenging for a developing country like Nigeria (ECN, 2015; Alam et al., 2016).

Nigeria possesses about 37 billion barrels of crude oil reserve and about 187 Trillion standard cubic feet (Tscf), with crude oil accounting for 42% of total energy; natural gas accounts for 30% of total energy while coal and other fossil fuel sources such as tar sands account for 10% of total energy (ECN, 2013). As the largest developing country in Africa, Nigeria has continued to make efforts to expand its economic growth since 1990's with an average annual growth rate of 6% for over one decade. This growth rate has, however, been achieved through consumption of energy inputs such as petroleum, natural gas and coal which emit CO2, a component of greenhouse gas that leads to global warming.

Studies have also emphasised on the impact of energy consumption on economic growth and the environment (Shahbaz et al., 2014; Mutascu, 2016; Narayan, 2016; Wang et al., 2016; Zoramawa et al., 2020). However, investigating energy consumption, economic growth, environmental quality and EKC hypothesis with trade openness, labour, and capital as control variables in the same framework in Nigeria provides a research gap. This paper fills this gap by examining the impact of energy consumption on economic growth, environmental sustainability and test the existence of EKC hypothesis by integrating the production function and EKC theory in the same framework. The remaining section of the paper is structured as follows. Section 2 deals with the review of related literature, section 3 focusses on the methodology, section 4 emphasizes on the empirical findings while section 5 concludes and provide some policy recommendation.

2. LITERATURE REVIEW

Empirical literature had also investigated the relationship between energy consumption, economic growth and environmental quality. Investigating the link between energy consumption, economic growth and environmental quality in Nigeria is a recent issue. As such, this study will further investigate the relationship between these variables.

Some of the recent studies that examine the link between energy consumption, economic growth and environmental quality include the work of Wang et al. (2016), Zhu et al. (2016), Chen et al. (2016) and Saidi and Hammami (2015). For instance, Wang et al. (2016) investigated environmental quality, economic growth and energy consumption in China. They used a panel data technique to ascertain the dynamic relationship among the variables. Their finding shows evidence of positive bidirectional causality between energy consumption and economic growth, and between energy consumption and indicator of environmental quality which is CO2 emissions. Furthermore, one-directional causality runs from economic growth to environmental quality. Thus, China has a tendency to continue to reduce environmental quality as it largely depends on primary energy consumption for economic growth.

Additionally, Zhu et al. (2016) ascertain the impact of foreign direct investment (FDI), energy consumption, economic growth and on environmental quality in ASEAN-5 countries that include Indonesia, Malaysia, Philippines, Singapore and Thailand. The findings show a negative impact of FDI on environmental quality for all the quantile except the fifth one quantile. Energy consumption also invokes environmental degradation, with the largest impact taking place at higher quantile. However, higher population size tends to improve environmental quality in the high-emitting countries. Their result also supports the validity of the halo effect hypothesis in higher CO2 emitting countries. Thus, the contribution of this study lies in quantile analysis that also incorporated the impact of FDI on energy consumption, economic growth and environmental quality Nexus.

On the other hand, Chen et al. (2016) model the global relationship between energy consumption and environmental quality and economic growth using a panel and vector error-correction technique. The findings suggest that unidirectional causality running from energy consumption to environmental quality exists for both developed and developing countries. Similarly, Saidi and Hammami (2015) used Generalised Method of Moments (GMM) with a dataset from 1990–2012 to ascertain the impact of economic growth and environmental quality on energy consumption in 58 countries. Their result attests evidence of the positive and significant effect of carbon emissions on energy consumption for four global panels. However, economic growth is positively related to energy consumption with statistical power for the four panels only. These empirical literature mostly used panel data analysis and causality test rather than impact analysis.

Literature has also explored the link between energy consumption, economic growth and the environmental quality in Nigeria, using different data set, different control variables, different measurement and obtained different results. This is not surprising as some of the studies are conceptually oriented, others theoretically oriented while some are empirically and policy-oriented.

As such, recent studies on the relationship between energy consumption, economic growth and their effect on environmental quality in Nigeria have been reviewed (see, for instance, Rafindadi, 2016; Babatunde and Babatunde, 2016; Edomah, 2016; Olatomiwa et al., 2015; Abam et al., 2014; Amoo and Fagbenle, 2013; Ajoku, 2012; Bello and Abimbola, 2010).

Rafindadi (2016) tried to explore the effect of economic growth on energy consumption and environmental quality in Nigeria using the ARDL bounds test. The result shows that economic growth is inversely related to energy consumption and environmental quality. On the contrary, financial development increases energy consumption and improves environmental quality. However, trade openness also increases energy consumption and improves environmental quality. Moreover, Babatunde and Oluseyi et al. (2016) evaluate energy consumption and carbon footprint from the hotel sector in Lagos, Nigeria. Linear regression approach was utilised to characterise energy consumption index with a correlation analysis used to ascertain interdependence of CO2 footprint and energy consumption. The finding reveals a significant correlation between energy consumption per unit guest room and the CO2 emissions (an indicator of environmental quality).

Similarly, Edomah (2016) emphasizes the importance of sustainable energy development in Nigeria. He identified the constraints to sustainable energy development in Nigeria to include among others, legal and regulatory constraint, market performance, and cost and pricing constraint. The findings suggest the need for both policymakers and stakeholders to work together so as to achieve sustainable energy development. While Olatomiwa et al. (2015) used a hybrid optimisation method to investigate the economic evaluation of hybrid energy systems for the rural energy consumption of the geopolitical zones in Nigeria. They found that hybrid energy will improve performance in fuel consumption and improves environmental quality.

Abam et al. (2014) on the other hand used a statistical approach to examine energy resource structure and ongoing sustainable development policy in Nigeria. Their conclusion suggests that energy development strategy must adhere to sustainable practice to balance economic growth, social expansion and environmental quality.

Furthermore, Ajoku (2012) assess the modern use of solid biomass energy for sustainable economic growth and development in Nigeria using a survey approach. He found that it possesses high potentials for bioenergy development in Nigeria, but however, required more awareness in order to increase the potentials. Nevertheless, Bello and Abimbola (2010) used a time-series analysis to investigate the impact of economic growth on environmental quality and also test the existence of EKC for Nigeria. The result suggests that economic growth is not the cause of environmental degradation but rather, it is caused by financial development and thus, did not find evidence of EKC in Nigeria.

However, most of this literature is toward the policy aspect and none of them used an extended production theory and the Environmental Kuznets Curve (EKC) hypothesis in the same framework to investigate the impact of energy consumption on economic growth and environmental quality in the presence of three conditional variables in Nigeria. This research employs the autoregressive distributed lag approach to bounds test to contribute to the existing body of knowledge in this area. More, so, investigating the existence of EKC for Nigeria is not common in literature.

3. METHODS

3.1. Theoretical underpinning and model

The theoretical framework for the first model of this paper is the traditional production function that emphasises the transformation of inputs into the output to create goods and services. Besides the use of labour and capital, production includes the use of other input such as energy as an additional input in the process of creating good and services (Shahbaz et al., 2013; Shahbaz et al., 2014; 2014 Omri et al., 2015). Thus, we follow these studies to derive our model in a logarithm form as follows.

$$lnY_t = \alpha_0 + \alpha_1 lnL_t + \alpha_2 lnK_t + \alpha_3 lnE_t + \alpha_4 lnT_t + \varepsilon_t \quad (1)$$

Where $lnY_t, lnL_t, lnK_t,\ lnE_t$ and lnT_t represent economic growth, labour, capital stock, energy consumption and trade openness in their log form respectively. The α_0 is the intercept, $\alpha_1, \alpha_2, \alpha_3, \alpha_4$ are the slopes of the respective variables and ε_t is the error term. It is expected that $\alpha_1, \alpha_2, \alpha_3, \alpha_4 > 0$, however, inefficient utilization of labour, capital, energy consumption and incompetent trade relations can hinder economic growth, in that case, we may expect $\alpha_1, \alpha_2, \alpha_3, \alpha_4 < 0$. From equation (1) we then develop the Autoregressive Distributed Lag (ARDL) approach of Pesaran et al. (2001) as the empirical technique. The ARDL is used due to some of its

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advantages namely: having a good property for small sample size; combining of I(0) and I(1) variables; in-build cointegration analysis and the simultaneous estimation of short and long-run models. The ARDL specification is as follows.

$$\Delta lnY_t = \varphi_0 + \sum_{i=1}^{n} \varphi_{1i}\Delta lnY_{t-i} + \sum_{i=0}^{n} \varphi_{2i}\Delta lnL_{t-i} + \sum_{i=0}^{n} \varphi_{3i}\Delta lnK_{t-i} + \sum_{i=0}^{n} \varphi_{4i}\Delta lnE_{t-i}$$

$$+ \sum_{i=0}^{n} \varphi_{5i}\Delta lnT_{t-i} + \pi_1 lnY_{t-1} + \pi_2 lnL_{t-1} + \pi_3 lnK_{t-1} + \pi_3 lnE_{t-1} + \pi_4 lnT_{t-1} + \mu_t \qquad (2)$$

The error-correction for the long-run model (2) is given as:

$$\Delta lnY_t = \varphi_0 + \sum_{i=1}^{n} \varphi_{1i}\Delta lnY_{t-i} + \sum_{i=0}^{n} \varphi_{2i}\Delta lnL_{t-i} + \sum_{i=0}^{n} \varphi_{3i}\Delta lnK_{t-i} + \sum_{i=0}^{n} \varphi_{4i}\Delta lnE_{t-i}$$

$$+ \sum_{i=0}^{n} \varphi_{5i}\Delta lnT_{t-i} + \eta ect_{t-1} + \mu_t \qquad (3)$$

Furthermore, the theoretical framework of the second model is the Environmental Kuznets Curve (EKC) theory of Grossman and Krueger (1995) which shows that the relationship between economic growth and environmental quality is an inverted U-shape. It provides a theoretical foundation to investigate the impact of energy consumption on economic growth and the EKC hypothesis in the following model.

$$lnCO_{2t} = \rho_0 + \rho_1 lnY_t + \rho_2 lnY_t^2 + \rho_3 lnE_t + \rho_4 lnT_t + \vartheta_t \qquad (4)$$

where $lnCO_{2t}$ is the indicator of environmental quality, lnY_t^2 is the square of economic growth, lnT_t implies trade openness and other variables are as defined earlier. Including trade openness suggests that Nigeria is an open economy. The symbol ρ_0 is the intercept and ϑ_t is the error term. It is expected that ρ_1, ρ_3 and $\rho_4 > 0$ while $\rho_2 < 0$ for EKC hypothesis to exist in Nigeria.

Moreover, the dynamic ARDL model for equation (4) is modelled as follows:

$$\Delta lnCO_{2t} = \beta_0 + \sum_{i=1}^{n} \beta_{1i}\Delta lnY_{t-i} + \sum_{i=0}^{n} \beta_{2i}\Delta lnY_{t-i}^2 + \sum_{i=0}^{n} \beta_{3i}\Delta lnE_{t-i} + \sum_{i=0}^{n} \beta_{4i}\Delta lnT_{t-i}$$

$$+\theta_1 lnCO_{2t-1} + \theta_2 lnY_{t-1} + \theta_3 lnY_{t-1}^2 + \theta_4 lnE_{t-1} + \theta_5 lnT_{t-1} + \vartheta_t \qquad (5)$$

Similarly, the error-correction specification for the model (5) is as follows:

$$\Delta lnCO_{2t} = \beta_0 + \sum_{i=1}^{n} \beta_{1i}\Delta lnY_{t-i} + \sum_{i=0}^{n} \beta_{2i}\Delta lnY_{t-i}^2 + \sum_{i=0}^{n} \beta_{3i}\Delta lnE_{t-i} + \sum_{i=0}^{n} \beta_{4i}\Delta lnT_{t-i}$$

$$+\zeta ect_{t-1} + \vartheta_t \qquad (6)$$

3.2 Variables, measurements and data sources

For the purpose of this research paper, six variables were collected with different measurement from the World Bank's World Development Indicators (WDI) and other database sources from 1981 to 2015. Details of the variables, measurements and data sources are contained in Table 1.

Table 1. Variables, measurements and data sources

S/N	Variables	Measurements	Sources
1	Energy consumption	Energy use (kg of oil equivalent per capita)	WDI, ECN
2	Gross Domestic Product (GDP)	GDP per capita (constant 2005 US$)	WDI
3	CO2 emissions	CO2 emissions (metric tons per capita)	WDI, EIA
4	Labour	Labour force participation rate, total (% of total population ages 15+) (national estimate)	WDI
5	Capital	Gross fixed capital formation (% of GDP)	WDI
6	Trade openness	Trade % of GDP	WDI

4. ANALYSIS AND RESULTS

First, the unit root test was conducted on the variables using the two most famous unit root test of Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP). The results show that the variables do not exceed stationarity at first difference. The use of ADF and PP tests is to ensure that all variables involved are time-invariant (i.e. they all possess zero mean, constant variance and not autocorrelated). Therefore, purely I(0) or purely I(1) or their combination can be used (Pesaran et al. 2001). As presented in Table 2, the result suggests that all variables are stationary at the first differences with significant power of 1% for the majority of the variables.

Table 2. Unit root tests for variables

	ADF				PP			
Variables	Level	*Z*	First difference	*Z*	Level	*Z*	First difference	*Z*
$ln\, Y_t$	-2.1809 (0.4845)	0	-4.7951*** (0.0027)	0	-2.1745 (0.4879)	2	-4.7637*** (0.0029)	2
$ln\, E_t$	-2.8899 (0.1781)	0	-6.1538*** (0.0001)	0	-2.9824 (0.1516)	2	-8.1083*** (0.0000)	9
$ln\, CO_{2t}$	-2.0939 (0.5306)	0	-5.9669*** (0.0001)	0	-2.1603 (0.4954)	3	-6.0114*** (0.0001)	6
$ln\, K_t$	-2.2182 (0.4649)	0	-6.1892*** (0.0001)	1	-2.2322 (0.4576)	1	-5.4244*** (0.0005)	4
$ln\, L_t$	-1.6042 (0.7696)	1	-2.7586** (0.0492)	0	-1.1782 (0.8992)	4	-2.9589** (0.0122)	3
$ln\, T_t$	-0.6755 (0.9649)	7	-4.8085*** (0.0038)	8	-2.0123 (0.5740)	2	-7.9928*** (0.0000)	3

Note: values in (.) are probability values, *** and ** imply significance at 1%, and 5% respectively while *Z* is the lag length for the ADF and PP

Second, the cointegration result that tests the joint null hypothesis of the variables in order to establish the existence of a long-run equilibrium relationship among them was presented in Table 3. The null hypothesis for Eq. (1) is given by *H₀*: $\pi_1 = \pi_2 = \pi_3 = \pi_4 = 0$ while the alternative hypothesis is H_a: $\pi_1 \neq \pi_2 \neq \pi_3 \neq \pi_4 \neq 0$. On the other hand, the null hypothesis for Eq. (4) is given by H_0: $\theta_1 = \theta_2 = \theta_3 = \theta_4 = \theta_5 = 0$ and the alternative hypothesis is specified as H_1: $\theta_1 \neq \theta_2 \neq \theta_3 \neq \theta_4 \neq \theta_5 \neq 0$. The null hypotheses suggest the absence of cointegration while the alternative hypotheses indicate the existence of cointegration among the variables. In order to establish the existence of cointegration, the estimated values of F-statistic through the OLS are compared with the critical values of Narayan (2005). Cointegration exists if the values of the F-statistics are greater than the value of the upper bounds of the Narayan critical bounds values. On the other hand, cointegration does not exist if the estimated F-statistics are smaller than the lower bounds values of the Narayan critical values and the outcome is inconclusive if the F-statistics fall between the upper and the lower bounds values.

Table 3. Cointegration tests

Bound testing for cointegration		
Models	Lags	F-statistics
$Y_t = f(K_t, L_t, E_t, T_t)$	(1,3,1,1,2)	8.8473[0.004]***
$CO_{2t} = f(Y_t, Y_t^2, E_t, T_t)$	(1,0,0,0,0)	4.7789[0.007]***
	Critical values	
Significance level	Lower Bounds	Upper Bounds
1% level	4.590	6.368
5% level	3.276	4.630
10% level	2.696	3.898

Note: optimal lag is 6 and the number of regressors (*k*) =4. Values in parenthesis [.] are p-values, *** indicates significance at 1%

The cointegration results for the Eq. (1 and 4) show that a long-run equilibrium relationship exists between economic growth and environmental quality with their determinants. The F-statistic for Eq. (1) is greater than the upper bound of Narayan (2005) critical values at 1%, 5% and 10%. Furthermore, the F-statistic for Eq. (4) is also greater than the upper bound of Narayan critical values at conventional 5% and 10% level of significance. Thus, the null hypothesis H_0: $\pi_1 = \pi_2 = \pi_3 = \pi_4 = 0$ and H_0: $\theta_1 = \theta_2 = \theta_3 = \theta_4 = \theta_5 = 0$ can be rejected.

Third, the long-run results, short-run result and their diagnostics are presented in Table 4. The impact of energy consumption on economic growth was estimated based on the Akaike Information Criterion (AIC) while the impact of energy consumption on environmental quality was estimated base on the Schwarz Bayesian Criterion

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(SIC). The two selection criteria give us the best results and justify the rationale for using them (see, Sbia et al., 2014).

Model 1 ($Y_t = f(K_t, L_t, E_t, T_t)$) presents the long-run, short-run and diagnostic results of the impact of energy consumption on economic growth while model 2 ($CO_{2t} = f(Y_t, Y_t^2, E_t, T_t)$) presents the long-run, short-run and diagnostic test for the impact of energy consumption on environmental quality and the EKC hypothesis. The long-run results were presented in Panel A, the short-run results were presented in Panel B while the diagnostic results were presented in Panel C.

Table 4. Long-run results, short-run results and diagnostic tests

	Model 1 ($Y_t = f(K_t, L_t, E_t, T_t)$)		Model 2 ($CO_{2t} = f(Y_t, Y_t^2, E_t, T_t)$)	
	Coefficients	t-stat & *p*-values	Coefficients	t-stat & *p*-values
Variables	Long-run results (Panel A)			
$ln\, Y_t$	-	-	15.8807	0.6527[0.519]
$ln\, Y_t^2$	-	-	-1.1928	-0.6458[0.524]
$ln\, E_t$	-4.4907	-2.1874**[0.041]	12.3116	2.7230**[0.011]
$ln\, K_t$	1.0794	3.4061***[0.003]	-	-
$ln\, L_t$	-34.7805	-4.4241***[0.000]	-	-
$ln\, T_t$	0.5687	2.0176*[0.058]	-0.5513	-2.9956***[0.006]
Constant	171.4922	4.8448***[0.000]	-132.4426	-1.9384*[0.063]
	Short-run results (Panel B)			
$\Delta ln\, Y_t$	-	-	7.3284	0.6260[0.537]
$\Delta ln\, Y_t^2$	-	-	-0.5505	-0.6197[0.541]
$\Delta ln\, E_t$	-.20313	-0.3155[0.755]	5.6814	3.0944***[0.005]
$\Delta ln\, K_t$	0.0421	0.6812[0.503]	-	-
$\Delta ln\, L_t$	-2.9884	-0.6359[0.531]	-	-
$\Delta ln\, T_t$	0.0657	1.0496[0.305]	-0.25443	-2.7004**[0.012]
Constant	48.8184	3.6813***[0.001]	-61.1176	-1.7468*[0.092]
ect_{t-1}	-0.2847	-2.6144**[0.016]	-0.4615	-4.0154***[0.000]
	Diagnostic tests (Panel C)			
χ^2*serial*	0.1081	[0.742]	0.4445	[0.505]
χ^2*func*	0.1751	[0.676]	0.8490	[0.357]
χ^2*norm*	0.1624	[.922]	8.2861	[0.016]
χ^2*hetr*	0.1365	[0.712]	0.5320	[0.466]

Note: Values in parenthesis [.] are *p*-values, ***, ** and * suggest significance at 1%, 5% and 10%. χ^2*serial,* χ^2*func*, χ^2*norm*, χ^2*hetr* are tested for serial correlation, functional form, normality and heteroscedasticity respectively

The long-run result of model 1 suggests that an increase in energy consumption can hinder economic growth in Nigeria. This finding may not be surprising because a lot of energy is being used in the production process without conservation in Nigeria. Moreover, primary energy sources such as petroleum, gas and diesel are often used in production in place of cleaner energy sources. Most production sectors that are supposed to use hydropower energy for production are still using fossil fuel energy in Nigeria. This result is consistent with the work of Chindo et al. (2014) which found out that energy consumption has a negative impact on economic growth in Nigeria.

Conversely, capital is positive and significantly related to economic growth in the long-run, implying that capital has a direct relationship with economic growth. The capital which includes the use of machines and equipment in the production is an important requirement of economic growth and development. This result supports the current situation in Nigeria since the replacement of ancient production tools with modern capital increases productivity. The result supports the findings of Streimikiene and Kasperowicz (2016) which reveals a positive impact of capital on economic growth.

Moreover, the long-run result of labour is inversely related to economic growth in the long-run. This outcome is in line with a report by NBS (2015) which shows that the labour productivity of Nigeria is low compared to other developing countries. Thus, the need for increased effort in building human capital resources in Nigeria cannot be overemphasis. Additionally, the long-run coefficient of trade openness is positive and significantly related to economic growth. The result is in agreement with the findings of Shahbaz et al. (2013) who found a positive relationship between trade and economic growth. However, the short-run results in Panel B reveal evidence that energy consumption and labour have an inverse relationship with economic growth but not statistically significant. Whereas, capital and trade openness are positive but also not statistically significant.

Model 2 in Table 4 also presents the result of the impact of energy consumption on environmental quality. The long-run result shows that energy consumption has a positive and significant impact on environmental quality in Nigeria. This implies that higher energy consumption is associated with greater CO2 emissions and environmental degradation. According to a report by the World Bank in the year 2014, primary energy consumption contributes about 60% of global CO2 emissions and greenhouse gases. This result is also consistent with the result of Saidi and Hummami (2015) and Chen et al. (2016) which reveal a negative impact of energy consumption on environmental quality.

Furthermore, the long-run result reveals that trade openness can improve environmental quality in Nigeria. The implication of this is that trade relation between Nigeria and the rest of the world can assist in bringing in new technologies that will help to improve environmental quality in Nigeria. This result is consistent with theories of international trade which shows that comparative specialisation or absolute specialisation in trade can benefit countries. Similarly, the short-run results in Panel B hinted that energy consumption can hinder environmental quality while trade openness can mitigate it. With regards to the EKC hypothesis, the result shows that the coefficient of economic growth and that of its square are both positive and inversely related to the indicator of environmental quality but fail to be significant. As such, the study concludes that EKC does not exist in Nigeria. The essence of testing the EKC hypothesis is to ascertain whether there exists a turning point for Nigeria. The finding is consistent with findings of Bello and Abimbola (2010) that reveals non-existence of EKC in Nigeria.

To further strengthen the reliability of the results, a diagnostic test for serial correlation, function form test for model specification, normality test and heteroscedasticity test were conducted and the results were presented in Panel C of Table 4. The models passed most of the diagnostic test.

5. CONCLUSIONS

The paper examines the impact of energy consumption on economic growth and environmental quality and verifies the existence of the EKC hypothesis in Nigeria. The production function and EKC theory serve as the theoretical framework of the study while the Autoregressive Distributed Lag (ARDL) model constitutes the empirical model. Dataset ranging from 1981-2015 were utilised. The result of model 1 reveals evidence of the negative and significant impact of energy consumption on economic growth. Capital and trade openness reveal evidence of a positive and significant impact on economic growth while labour suggests a negative and significant relationship with economic growth. The result of model 2 shows that energy consumption hinders environmental quality while trade openness improves environmental quality. Furthermore, the empirical finding did not reveal the presence of the EKC hypothesis in Nigeria.

The policy recommendations of the study are as follows. First, efficient use of primary energy to achieve economic growth should be a priority of policymakers through designing a ratio of primary energy to labour and capital for a certain level of output. Achieving this will further require monitoring the production sector of the Nigerian economy. Second, the introduction of environmental tax policy on related primary energy products could be a useful policy measure to increase efficiency in energy utilisation and awareness about environmental quality. For example, 1% of Environmental Added Tax (EAT) can be included in the selling price of an energy-related product like the Value Added Tax (VAT). This will go a long way in creating awareness and reducing environmental degradation. Third, more emphasis on human capital development is required by the government to transform the benefit of the large labour force into comparative production advantage in Nigeria. This will require stringent implementation of the acquisition of basic education, especially, primary and secondary school education in Nigeria. Finally, since trade openness has revealed a positive impact on both economic growth and environmental quality, the government should give more attention to good trade relations with comparative and absolute advantages. This will bring in new technologies, increase specialization, economic growth and subsequently improves environmental quality in Nigeria.

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