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Effect Of Energy Consumption On Environmental Quality In Nigeria

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Abstract
This study explores the impact of energy consumption and economic growth on environmental quality in Nigeria from 1991-2023. The issue of irregular rainfall patterns, droughts, extreme daytime and nighttime temperatures, ecosystem degradation and other climate change issues is evidence of the significant reduction in environmental quality in Nigeria. To examine this concern, the objective of this study included, evaluating the effect of energy consumption and economic growth on environmental quality in Nigeria and testing the validity of the Environmental Kuznets Curve (EKC) hypothesis in Nigeria. Annual time series data sourced from World Development Indicators (WDI) of various years was utilized. This study was anchored on the Environmental Kuznets Curve (EKC) hypothesis and was based on the analytical framework of the Autoregressive Distributed Lag (ARDL) which was used for the analysis. The major findings of this study included that energy consumption, and economic growth had a positive and significant impact on carbon dioxide (CO_2) emissions in the long run and short run. The ARDL results indicated the presence of Environmental Kuznets Curve (EKC) in Nigeria. The study recommends that as the country's demand for energy increases, attention should be given to the environmental impacts of such processes. A viable proportion of alternative energy should be included in the country's energy mix to address both energy needs and the environmental concerns due to carbon dioxide (CO_2) emissions, which cause environmental degradation. This will assist in reducing environmental pollution and, at the same time, sustain long term economic growth. Similarly, the pollution behavior of firms and individuals consuming energy should be regulated by setting an emission standard in the country, and defaulters should be penalized strictly.
Key Words: Energy Consumption, Environment Quality, Environmental Kuznets Curve, Nigeria

1.0 INTRODUCTION

Issues of the global environment constitute a major focus for nations and embody the relationship between energy consumption and economic growth, and the demand for environmental quality. Environmental quality connotes the state or condition of the natural elements (water, land, and air) surrounding mankind. Environmental quality is a normal good, though heterogeneous (Omisakin 2009).

The world has suffered severe environmental problems over the past decades. Undeniably, the impact of ecological distortions and reductions in environmental quality is alarming, causing environmental stakeholders and environmentalists to be highly concerned. These environmental issues have escalated from being a collection of environmental challenges to full blown environmental disasters, including extreme weather conditions, climate change, and rising sea levels. As a result, nations are under pressure to address these environmental crises while maintaining economic growth. Fundamentally, it is believed that human actions such as rapid industrialization, growing population, and expansion of economic activities, urbanization and the widespread consumption of fossil fuels (energy consumption) are the causes of ecosystem destruction in Nigeria. Worthy of note, one of the major contributors to climate change and reductions in environmental quality is carbon dioxide (CO_2) emissions (Osuntuyi & Lean 2023).

Energy functions as an important element of the modern global economy, with its accessibility and affordability serving as critical determinants in shaping economic growth and development trends worldwide (Hasson & Masih 2017). It not only functions as a crucial input in the production, consumption, and distribution processes within an economy (Dantama, Abdulahi & Inuwa, 2012); but also represents a fundamental resource essential for both human survival and the advancement of human civilization (Prince, Inim, Callistus & Udo 2021). When considered in the economic context, energy embodies any resource that enhances the capacity to perform work and its utilization is termed energy consumption (Encarta 2009).

In West African countries, crude oil and natural gases constitute the primary sources of energy. Electricity generation in the sub-region relies heavily on fossil fuels, with oil and gas constituting a significant portion of total generation capacity, most especially in oil-rich nations like Nigeria. In 2018, fossil fuels accounted for more than 77% of Nigeria's electricity generation and almost 70% of West Africa's CO2 emissions (Davis, Sokoloski, Nallagatla & Tenaglia, 2021). Given the threats of climate change compounded by environmental degradation and the need for its mitigation, it is important to evaluate the effect of energy consumption on environmental quality in Nigeria for appropriate environmental policies.

Irregular rainfall patterns, droughts, extreme daytime and nighttime temperatures, ecosystem degradation and other climate change issues are evidence of the significant reduction in environmental quality in West African countries. It is estimated that 56 percent of the coastlines in Benin, Côte d'Ivoire, Senegal, and Togo are eroded, making coastal degradation and erosion a significant problem in West African states (Nigeria, inclusive). The steady rise in temperatures compounded by irregular rainfall patterns observed in Nigeria adversely affects human health by increasing the transmission of vector-borne diseases in the country (UNFCCC 2015).

The Nigerian government has implemented policies geared towards curbing environmental degradation. In this regard, Nigeria is a signatory to the United Nations Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol, and the Paris Accord. The government took a stand to improve the energy supply and utilization of renewable energy sources across the country by establishing the National Renewable Energy and Energy Efficiency Policy (NREEEP). The policy document outlined robust programs that include large-scale deployment of renewable energy technologies and the use of energy efficient technologies in the agriculture, commercial, transport, industry and residential/household sectors of Nigeria (Gungah, Emodi & Dioha, 2019).

Despite these policies, and the abundance of renewable energy resources in Nigeria, the nation's energy consumption remains dominated by fossil fuels, exposing it to environmental degradation and consequently poor health conditions. Similarly, Nigeria is plagued by inadequate health infrastructure and insufficient energy efficiency, moving them away from achieving sustainable development (Chaabouni & Saidi, 2017).

This study therefore, seeks to contribute to existing literature by exploring the impact of energy consumption and economic growth on environmental quality by including some variables that have been neglected by most researchers. These variables include quality of governance, energy prices and labour force. This study also tests the validity of the Environmental Kuznets Curve (EKC) hypothesis for Nigeria. Empirical evidence on the existence of the EKC hypotheses in Nigeria is inconclusive Aiyetan & Olomola, (2017); Alege & Ogundipe, (2013); Akpan & Chuku, (2011). While some studies have confirmed its existence Aiyetan & Olomola (2017); others provide evidence against it Alege & Ogundipe, (2013). The different estimation techniques employed by different researchers as well as the variables employed in the study can explain the differences in the results. This paper is arranged as follows; in the next section, a review of selected theoretical and empirical literature on the relationship between energy consumption and environmental quality is presented. This is followed by the baseline econometric model to be estimated. After this, data and methodological issues are discussed. Empirical results are reported in the subsequent section before the concluding remarks and policy recommendations. The aim of this study is to investigate the effect of energy consumption on environmental quality in Nigeria between 1991 and 2023

2. REVIEW OF RELATED EMPIRICAL STUDIES

Ogboru and Angu (2015) investigated the relationship between environmental degradation and economic progress. The study adopted a theoretical approach and found that a large number of cases of illnesses such as cancer, tuberculosis, viral infections etc are as a result of polluted environment. 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. This empirical literature mostly used panel data analysis and causality test rather than impact analysis.

Chiou-Wei, Zhu, Chen and Hsueh (2016) investigate the nexus of energy consumption and economic growth using the EGARCH-M model including more variables. The additional variables reveal a negative and significant impact on energy consumption and economic growth. Bi directional Causality exists between economic growth and energy demand for the Philippines, unidirectional runs from economic growth to energy demand for Singapore, and a neutrality hypothesis holds for the rest of the countries. Chen, Chen, Hsu and Chen (2016) modeled 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. 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. Chen et al. (2016) modeled 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..

Akanbi, Adebayo and Olomola (2014) Energy Consumption, ICTs Development and Environmental Quality using the panel of 6 countries in West Africa using data from U.S. Energy Information Administration (EIA) and World Development Indicators and Generalized Method of Moments (GMM). It was found that carbon dioxide emissions increased energy consumption. The results obviously would facilitate the policy planners to formulate related policies in line with carbon free economy thereby enhancing sustainable development in selected countries. Falade and Adeyemi (2020) the Effect of Sectorial Contributions to GDP on Environmental Degradation: A Verification of the Environmental Kuznets Curve Hypothesis in Nigeria. The study adopted the Autoregressive Distributed Lag (ARDL) model using time series data for the period 1981-2018. The results show a long-run relationship between economic growth (disaggregated into key sectors) and environmental degradation measured by carbon dioxide emissions. These results imply that the key sectors of the economy have varied effects on environmental degradation, hence the hypothesis is inconclusive. Nigeria is therefore advised to pursue economic growth via industrial and services sectors with an emphasis on environmental sustainability, which could be achieved through the use of renewable and cleaner technology in nation-building.

Józ´wik, Dog˘an and Gürsoy (2023) analyses the Impact of Renewable Energy Consumption on Environmental Quality in Central European countries, using data from 1995 to 2019. An analysis of the panel data reveals a statistically significant positive relationship between economic growth and carbon emissions, and a negative relationship among digitalization, renewable energy consumption, and carbon emissions. However, the role of financial development as a mediator between renewable energy consumption and environmental quality manifests varied impacts across different countries.

3.0 METHODOLOGY

The theoretical framework of this study is anchored on the Kuznet Hypothesis (EKH) which assumes that energy consumption and economic growth has a significant impact on greenhouse gas emission and by implication on the environmental quality. Based on the theoretical framework and an adaptation of Akanbi et al (2014) and Sulaiman (2014) the model for this study is specified as follows:

$CO2 = f\ (EC, EG, EG^2\ \ EP, QGOV, LF)$ 3.1

Mathematically, the model is specified as:

$CO2 = EC + EG + EG^2 + EP + QGOV + LF$ 3.2

In econometric terms, it is specified as:

$CO2 = \beta_O + \beta_1 EC_t + \beta_2\ EG + \beta_3\ EG^2 + \beta_4\ EP_t + \beta_5 QGOV_t + \beta_6 LF_t + \mu_t$ 3.3

Where CO_2 is carbon emission, EC is energy consumption, EG is economic growth, EG^2 is the squared root of economic growth, EP is energy price, QGOV represents quality of governance, and LF is labour force.

From the above, β_O and $_O$ are the intercepts, while $\beta_1 - \beta_6$ are the coefficients.*u* is the stochastic error terms and the *t* denotes time measured in years.

Data used in this paper are annual figures covering the period 1991-2023 and were gathered from the World Bank Indicators (WDI). To test the cointegration relationship between variables, the Autoregressive Distributed Lag (ARDL) bounds test according to Pesaran, Shin, & Smith (2001) is adopted because estimates using the ARDL method are more efficient with small sample sizes. ARDL is considered one of the most successful, flexible, and easiest approach to use models for multivariate time series analysis. Previous studies on the Environmental Kuznets Curve (EKC) hypothesis often estimate a quadratic or cubic function of GDP in the model. However, this can cause serious collinearity or multicollinearity problems that affect the regression results. Therefore, Narayan & Narayan (2010) propose an alternative approach to test the inverted U-shaped relationship between income and environmental pollution by comparing short-term and long-term income elasticities of Carbon Dioxide (CO_2) emissions. If the long-run income elasticity is lower than the short-run one, it is understood that the increase in income leads to less CO_2 emissions, or the Environmental Kuznets Curve (EKC) hypothesis is proved, and vice versa. As discussed above, based on recent empirical literature, the unrestricted error correction model (UECM) in the ARDL is considered to model the relationship between environmental quality and economic growth as follows: To illustrate the ARDL modelling approach adopted for the study will be restated as follows:

In the ARDL equations and model above, the terms with the summation signs (∑) represent the Error Correction Model (ECM) dynamics. The coefficients η_i are the long run multipliers corresponding to long run relationship. $\beta_{0\text{ and}}$ μt represent the constant and the white noise or disturbance term respectively while β_j, δ_j, ϕ_k, $ϟ_{P,}$ and α_r represents the short run effects. Δ is the first difference operator, L stands for logarithm of the data while k is the lag length for the Error Correction Model. The reason for taking variables log is to smooth out the data series and make sure that it is not negatively or positively skewed. Therefore, equations 3.4 was estimated to obtain the relationship between the dependent variables environmental quality Proxied by CO2 emissions from gaseous fuel consumption (% of total) and the independent variables including Energy Consumption (EC) proxied by Total final energy consumption (TFEC) (TJ), economic growth (EG) proxied by GDP growth rate, Energy Prices (EP) Proxied by crude oil prices measured in billions of dollars, Quality Of Governance (QGOV) Proxied by government effective index measured as estimates: (-2.5 [weak] to 2.5 [strong]) and labour force (LF) measured by labour force participation rate % of total population ages 15+.

4.0: RESULTS AND DISCUSSION

4.1 Descriptive statistics

Descriptive statistics is a summary statistic that quantitatively describes or summarizes the features of a dataset. The descriptive statistics was done using the raw data of the variable and not the transformed data, the result is presented in table 1.

Table 1 Descriptive statistics

	CO2	EC	EG	EG^2	EP	QGOV	LF
Mean	22.28275	4151803	4.051198	125.2130	51.00010	-1.029239	59.39137
Median	23.15717	3983952	4.195924	43.44299	50.75000	-1.002810	60.24900
Maximum	33.48066	6104064	15.32916	832.6683	105.0100	-0.901510	60.69700
Minimum	11.11135	2572466	-2.035120	-125.4001	13.06000	-1.204820	55.27000
Std. Dev.	7.625190	1100807	3.723016	208.3744	30.70946	0.061506	1.514975
Skewness	-0.136738	0.212611	0.494357	1.676758	0.450153	-0.689633	-1.295021
Kurtosis	1.535977	1.775940	3.905990	5.393199	1.912090	2.550011	3.565539

Jarque-Bera	3.049962	2.308813	2.47262	23.33851	2.741887	2.89192	9.66704
Probability	0.217625	0.315245	0.290433	0.000009	0.253867	0.235252	0.0007972
Sum	735.3308	1.37E+08	133.6895	4132.030	1683.003	-33.96488	1959.915
Sum sq. Dev	1860.593	3.88E+13	443.5472	1389437	30178.27	0.21583	73.4476
Obsevations	33	33	33	33	33	33	33

Note: CO2: carbon emission, EC: energy consumption, EG: Economic growth, EG^2: square root of economic growth, EP: energy prices, QGOV: Quality of governance, LF: labour force, significance level: 5%
Source: Researcher's compilation, (2024) Using EVIEW 12.0

On Table 1, the descriptive statistics of the OLS model variables for Carbon Dioxide (CO_2) emissions, energy consumption, economic growth, energy prices, and quality of governance, and labor force. The mean or average values of the variables ranged from -1.02 to 4151803, representing the average values for the Carbon Dioxide (CO_2) emission and the independent variables. The range for each variable was calculated as the difference between the maximum and minimum values. For instance, the range for CO_2 emission was 22.3. The skewness statistics indicated that carbon emission Carbon Dioxide (CO2), quality of governance (QGOV) and labour force (LF) were negatively skewed while energy consumption (EC), economic growth (EG), squared root of economic growth (EG^2) and energy prices (EP), were positively skewed. Based on the skewness results, it can be concluded that there were no outliers in the distribution. The kurtosis statistics revealed that the data values ranged from 1.535977 to 5.3905990, indicating that the variables/data were more peaked than the normal curve (leptokurtic). Furthermore, the Jarque-Bera statistic values of 2.308813 to 23.33851 we rejected the null hypothesis of normal distribution for the variables at the 5% (0.05) critical values.

4.2 Unit Root Test

The unit root test is conducted to check if there is stationarity in the variables. Establishing stationarity is of paramount importance because without it, data processing may yield biased results. This, in turn, leads to unreliable interpretations and conclusions. This study evaluated stationarity through Augmented Dickey-Fuller (ADF) tests and Philips-Peron (PP) tests.

Table 2 Summary of ADF and PP Unit root test

Variables	**ADF Statistics**	**5% Critical Value**	**Philip-Perron Statistics**	**5% critical value**	**Order of Integration**
CO2	-7.332396	-2.963972	-11.50372	-2.960411	First difference
EC	-5.691074	-2.960411	-6.721338	-2.960411	First difference
EG	-2.973778	-2.957110	-2.958522	-2.957110	Level
EG^2	-20.15424	-2.960411	-6.497687	-2.957119	First difference
EP	-5.390858	-2.963971	-5.217004	-2.960411	First difference
QGOV	-3.950013	-2.957110	-3.954483	-2.957110	Level
LF	-4.223370	-2.963972	-3.171881	-2.960411	First difference

Source: Authors compilation (2024) using E-view 12

As indicated on Table 2, all the variables contained in the model are stationary but at different order. All the variables used in the model were stationary at first difference except quality of governance which was stationary at level. Given these results of different orders of integration/stationarity, there was a need to conduct a co-integration test to ascertain whether or not there exist long-run relationships amongst the variables.

4.3 Co-integration Test

A cointegration test is carried out to identify if some set of non-stationary time series variables possess a long-run equilibrium relationship or not. This study used the ARDL F-Bound test since the unit root test shows that the variables are stationary at both level and first order.

Table 3: ARDL Bounds Test Result

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
			Asymptotic: n=1000	
F-statistic	9.230712	10%	1.99	2.94
k	6	5%	2.27	3.28
		2.5%	2.55	3.61
		1%	2.88	3.99
Actual Sample Size	31		Finite Sample: n=35	
		10%	2.254	3.388
		5%	2.685	3.96
		1%	3.713	5.326
			Finite Sample: n=30	
		10%	2.334	3.515
		5%	2.794	4.148
		1%	3.976	5.691

Source: Authors compilation (2024) using E-view 12

To determine whether there is either a long-run or short-run relationship between a set of variables, the bond test criteria stipulated by Peseran et al (2001) has to be met. The criteria stipulates that, for co-integration or a long-run relationship, the F-statistic of the bounds test must be greater than the upper bounds (the I(1) bound) at all significance levels (1%, 2.5%, 5%, 10%). On the other hand, if the F-statistic lies below the lower bounds (the I(0) bound) at all level of significance, then there is a no-cointegration condition or short-run relationship among the variables. If the F-statistic falls between the I(0) and I(1) bounds at all significance levels, then the result is inconclusive.

On table 3, the F-statistic (9.230712) lies above the I(1) bound at all significance levels. Hence, there exist both long-run and short-run relationships between energy consumption and environmental quality in Nigeria.

4.4 Evaluation of Long run and Short run Results

Since we have established that a long-run relationship exists in model, the ARDL model was used to determine the short run and long run coefficients of the regression models.

Table 4: ARDL RESULTS

Dependent Variable: CO_2 Emission				
Variable	**Coefficient**	**Standard Error**	**T-statistic**	**Probability**
LONG RUN ESTIMATES				
EC(-1)	1.314264	0.216601	6.067682	0.0000
EG(-)	0.014951	0.004165	3.589494	0.0030
D(EG2)	-0.000148	6.70E-05	-2.204830	0.0447
EP(-1)	0.111088	0.071641	1.550630	0.1433
QGOV**	-1.90469	0.102094	-1.865624	0.0832
LF(-1)	-1.467154	1.055760	-1.389667	0.1863
SHORT RUN ESTIMATES				
EC(-2)	2.470638	0.0865101	2.855896	0.0127
EG(-1)	0.005456	0.002556	2.134502	0.0510
EG2	-0.003375	6.70E-05	-2.204830	0.0447
EP(-2)	-0.135006	0.064101	-2.106159	0.0537

QGOV	-0.190469	0.102094	-1.865624	0.0832
D(EP)	-0.000581	0.000354	-1.640423	0.1174
QGOV	0.049786	0.066020	0.754114	0.4600
LF	-2.55783	1.716795	-1.313950	0.2100
LF(-1)	4.081496	2.750151	1.484099	0.1599
C	-4.752446	2.507532	-1.895268	0.0789
R^2 = 0.986933 D.W statistic = 2.601076 Prob(F-stat) = 0.000000 Adjusted R^2 = 0.971999 F-statistic = 66.08658				

Source: Authors compilation (2024) using E-view 12

Table 4 presents the parsimonious ARDL regression result showing the long-run and short run relationship in the model. The model had an R-squared of 0.986933, indicating that the model was adequately fit. It was implied that approximately 98% of the variations or dynamics in CO_2 emissions were accounted for by energy consumption and other regressors proxied by energy consumption, economic growth, energy price, quality of governance and labour force. The result showed an F-statistic value of 66.08658 with a probability value of 0.000000, indicating that the explanatory variables (energy consumption, economic growth, energy prices, quality of governance and labor force) jointly had a highly significant impact on Carbon Dioxide (CO_2) emission by implication, energy consumption significantly Carbon Dioxide (CO_2) emission. The result also presented a Durbin-Watson statistic of 2.601076. As a rule of thumb, this value was relatively higher than the critical value of 2, indicating that the model possessed negative autocorrelation.

From the long-run analysis of the model, energy consumption exert positive and significant effect on CO_2 emissions, a 1 percent increase in energy consumption results to a 131% increase in carbon emission in the long run. This conforms to a-priori expectation as Nigeria energy consumption mix is dominated by nonrenewable energy which has a huge hydrocarbon component and emits a great deal of CO_2 into the atmosphere. Results corroborate findings by Khalid, Shahid, Niazi, Murtaza, Bibi & Dumat (2017); Aiyetan & Olomola (2017). However, the economic growth (EG) coefficient of 0.014951 implies that a 1% increases in economic growth increases CO_2 emission by 1.49% in the long run. This also conforms to a-priori expectation and theoretical postulations as posited by the EKC hypothesis, while corroborating findings by Aiyetan & Olomola (2017); Egbetokun, Oluwatope, Adeyeye & Sanni (2019). Energy prices was found to have a positive but insignificant relationship with Carbon Dioxide (CO_2) emission in the long run, this implies that in the long run, energy prices alone cannot significantly increase CO_2 emission in Nigeria. Quality of governance and labour force had a negative but insignificant impact on CO_2 emission on the long run in Nigeria for the period under review.

For the short run analysis, energy consumption in the second lagged period had a positive and significant impact Carbon Dioxide (CO_2) emission for the period under review, this conforms to a-priori expectation and theoretical postulation. The result is in line with the findings of (Aiyetan & Olomola (2017). A percentage increase in energy consumption in this period increases CO_2 emissions by 247%. Similarly, with a coefficient of 0.005456, economic growth had a positive and significant impact on CO_2 emission. A 1% increase in economic growth leads to a 0.54% increase in carbon emission in the short run. This result conforms to a-priori expectation and theoretical postulations as posited by the Environmental Kuznets Curve (EKC) hypothesis, while corroborating findings by Aiyetan & Olomola (2017). Energy prices in the second lagged period was found to have a negative and significant impact on CO_2 emission in Nigeria. With a coefficient of -0.000581, a 1% increase in energy price leads to a 0.05% increase in CO_2 emission in the short run for the period under review. While quality of governance and labour force in the second lagged period had a positive but insignificant relationship on CO_2 emission in the short run in Nigeria for the period under review.

The error correction term reported in the short run analysis is statistically significant, negative and less than one. This means that the speed of adjustment from short-run to long –run equilibrium given any shock in the model is about 47 percent.

4.5 ARDL Post-Diagnostic Test

a. Test for Autocorrelation; (Breusch Godfrey)

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The Autocorrelation test is used to check if the error terms of different observations are correlated with each other which is against the assumptions of OLS. Autocorrelation is manifested by OLS estimators which are not BLUE (Best linear unbiased estimates). In our study, the Breusch Godfrey test is used to detect the presence of autocorrelation for the two models. The result is presented in Table 5.

Table 5: Summary of Breusch-Godfrey Serial Correlation LM Test.

The Model			
F-statistic	8.228969	Prob. F(2,12)	0.0056
Obs*R-squared	17.92808	Prob. Chi-Square(2)	0.0001

Source: Researchers' Computation from E-View 12

The hypothesis for this auto correlation test is
H_0 = There is no serial correlation.
H_1 = There is a serial correlation.

Therefore, the decision rule is if the P value is less than the chosen level of significance (0.05 or 5%), then we reject the null hypothesis that there is no serial correlation and accept the alternate hypothesis that there is a serial correlation. Based on this, the probability value of the F-statistics for the model as seen in Table 4.5 are greater than 0.05. Hence, the null hypothesis of no serial correlation is accepted for the model.

b. Test for Heteroscedasticity (Breusch- Pagan Godfrey)

The Heteroscedasticity test is conducted to ascertain if the variance of the error term is constant for all observations. This forms one of the assumptions of the Ordinary Least Square (OLS) which if the assumption does not hold; we face the problem of heteroscedasticity. Therefore, to confirm that the variance of the error term is constant, the Breusch- Pagan Godfrey heteroscedasticity test was adopted. This result is presented in Table 6.

Table 6: Summary of Heteroskedasticity Test: Breusch-Pagan-Godfrey.

Breusch-Pagan-Godfrey Heteroskedasticity Test			
F-statistic	0.850030	Prob. F(10,19)	0.6258
Obs*R-squared	15.27563	Prob. Chi-Square(10)	0.5046
Scaled explained SS	2.354096	Prob. Chi-Square(10)	1.0000

Source: Researchers' Computation (2024) using E-views 12

Hypothesis

$H_0 = \beta_1 = \beta_2 = \beta_3 = 0$ (absence of heteroskedasticity)
$H_1 = \beta_1 \neq \beta_2 \neq \beta_3 \neq 0$ (presence of heteroskedasticity)

Decision Rule: Accept the null hypothesis (H_0), that there is no heteroscedasticity in the residuals if P-value is greater than 0.05. Therefore, this study accepts the null hypothesis of absence of heteroscedasticity given that the P-values of the model are all greater than 0.05.

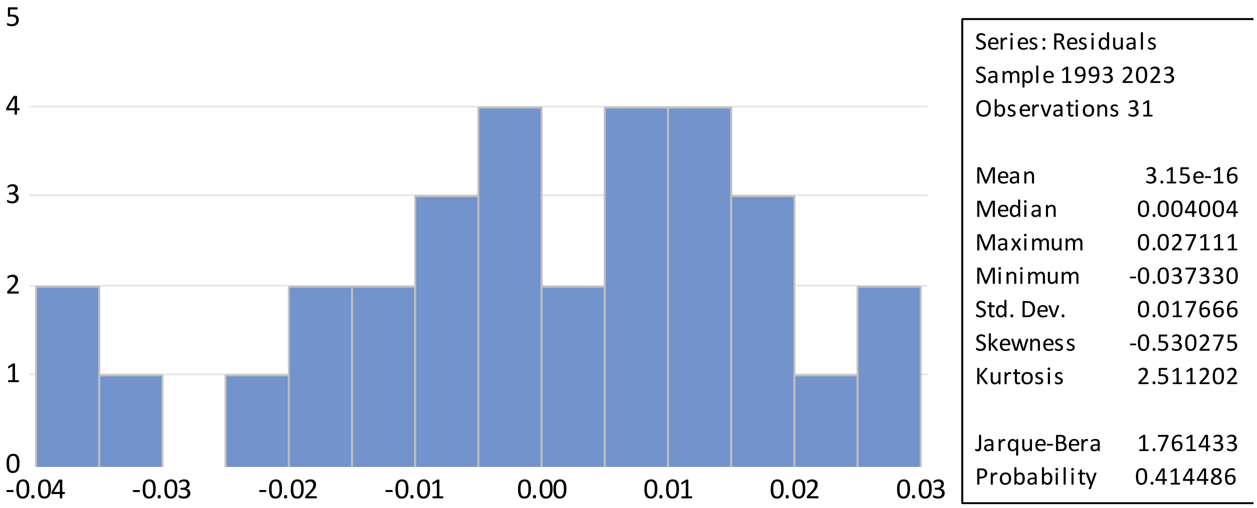
c. Normality Test

The Normality test is used to ascertain the normal distribution for the model.

Hypothesis

H_0 = residuals are normally distributed
H_1 = residuals are not normally distributed

Fig 1 Normality Test Result



Source: Author's compilation (2024) using E-view 12.

Decision Rule: Since the probability value of the Jarque-Bera is 1.761433 for equation 1 and the probability value of the Jarque-Bera is 0.414486 for the model, we accept the null hypothesis that the residuals are normally distributed and reject the alternate hypothesis that the residuals are not normally distributed. Hence, the model are normally distributed as supported by the descriptive statistics result.

d. Model specification test

The Ramsey Regression Equation Specification Error Test (RESET) will be used to check if our model is correctly specified. The Ramsey RESET test helps check if the non-linear combinations of the fitted values help explain the dependent variable. If that is the case, then the model is mis-specified. This result is shown in Table 7 and.

Hypothesis

H_0 = Model is correctly specified.

H_1 = Model is not correctly specified.

Table 7: Summary of Ramsey RESET Test

The Model			
	Value	**Df**	**Probability**
t-statistic	0.221938	13	0.8278
F-statistic	0.049256	(1, 13)	0.8278

Source: Researchers' Computation (2024) from E-Views 12

The decision rule for this test is that if the P value is greater than or equal to the 5% level of significance. Hence, the probability value for t-statistic and f-statistics are greater than 0.05. Therefore, we accept H_0 that the model correctly specified and reject H_1 that the two model are not correctly specified.

4.6 Testing the Validity of EKC in Nigeria

Testing the validity of the Environmental Kuznets Hypothesis for Nigeria Given the condition of the EKC to be: If $\beta1 > 0$, $\beta2 <0$, an inverted U relationship that validates the Environmental Kuznets Curve (EKC) exists. From the ARDL results for the CO2 model, the short run and long run results validates the existence of the EKC for Nigeria. Results indicate $\beta1 > 0$ (i.e. 1.4951) and $\beta2 < 0$ (i.e. -0.0148) in the long run and $\beta1 > 0$ (i.e. 0.5456) and $\beta2 < 0$ (i.e. -0.3375) in the short run which validates proof of the EKC. This corroborates findings by Aiyetan and Olomola, 2017. The turning point of income level at which environmental degradation starts to decline is calculated in the long run and given as:

Y* =

From the ARDL results, $\beta1$= 1.4951 and $\beta2$ = -0.0148

Therefore, Y* = -1.4951/ 2(-0.0148) = 0.7531

The variable Y is measured in logarithm form, therefore, exp(Y*) will yield the monetary value representing the peak of the EKC. exp (0.7531) = 2.1235 The study therefore observed that the income level at which environmental degradation starts to decline for Nigeria otherwise known as the turning point is $2.1235.

5.0 CONCLUSION AND POLICY RECOMMENDATIONS

This study empirically investigated the impact of energy consumption on environmental quality in Nigeria from 1991 to 2023. The objectives of this study are to examine the impact of energy consumption and economic growth on environmental quality in Nigeria and to analyze the validity of Environmental Kuznets Curve (EKC) in Nigeria. Given these objectives, the study hold empirical, theoretical and policy-oriented significance for the body of literature. This study developed a model within the theoretical framework of the EKC and the energy ladder hypothesis. The variable of interest was energy consumption. On the other hand, gross domestic product, proxied by per-capita income, energy prices, quality of governance and labor force were the independent variables in the model, while CO2 emissions was the dependent variable. The study employed the autoregressive distributed lag (ARDL) estimation technique for short and long term estimations and conducted various statistical tests to ensure model robustness.

The major findings of this study include that energy consumption, and economic growth have a positive and significant impact on CO2 emission in Nigeria both in the short run and long run for the period under review, energy prices were found to have a negative and significant impact on CO2 emissions in the short run but it had a positive and insignificant impact on CO2 emissions in the long run. While quality of governance and labour force had a negative but insignificant impact on CO2 emissions in the short run and long run for the period under review in Nigeria. The square root of economic growth (E^2) had a negative and significant impact on CO2 emissions in Nigeria. The ARDL results using the alternative method proposed by Narayan and Narayan (2011) indicated the existence of EKC in Nigeria. In summary, the model of this study proved to be reliable for policy formulation and forecasting as it passed various econometric tests, including heteroscedasticity, autocorrelation, normality and Ramsey RESET

The study recommends that as the country's demand for energy increases, attention should be given to environmental impacts of such processes. A viable proportion of alternative energy should be included in the country's energy mix to address both the energy needs and environmental concerns due to CO2 emissions which cause environmental degradation. This will assist in reducing environmental pollution and at the same time sustain long term economic growth.

In addition, the government should undertake massive investments in energy infrastructure to enhance accessibility, coupled with corruption-free subsidies for renewable energy, among others. The subsidy should be introduced only on renewable energy infrastructures in order to enable easy patronage, particularly at the early stage of economic growth.

REFERENCES

- Aiyetan, I., Olomola, P. (2017). Environmental degradation, energy consumption, population growth and economic growth: Does Environmental Kuznets curve matter for Nigeria? *Economic and Policy Review,* 16 (2): 24-36.
- Akanbi, B. E., Adebayo, A. A., Olomola, P. A. (2014). Analysis of Economic Liberalization and Telecommunication Sector Performance in Nigeria. *Journal of Knowledge Management, Economics and Information Technology,* 4(6).
- Akpan, U. F., Chuku, (2011). A. Economic Growth and Environmental Degradation in Nigeria: *Beyond the Environmental Kuznets Curve.* Retrieved from https://ideas.repec.org/p/pra/mprapa/31241.html.
- Alege, P., Ogundipe, A. (2013). Environmental quality and economic growth in Nigeria: A fractional cointegration analysis. *International Journal of Development and Sustainability,* 2(2). Retrieved from www.isdsnet.com/ijds.
- Chaabouni, S., Saidi, K. (2017). The Dynamic Links Between Carbon Dioxide (CO_2) Emissions, Health Spending and GDP Growth: A Case Study for 51 Countries. *Environmental Research, 158(1)*: 137-144. https://doi.org/10.1016/j.envres.2017.05.041
- Chen, P. Y., Chen, S. T, Hsu, C. S., Chen, C. C. (2016). Modeling the global relationships among economic growth, energy consumption and CO2 emissions. *Renewable and Sustainable Energy Reviews, 65,* 420–431.
- Chiou-Wei, S. Z., Zhu, Z., Chen, S. H., Hsueh, S. P. (2016). Controlling for relevant variables: Energy consumption and economic growth nexus revisited in an EGARCH-M (Exponential GARCH-in-Mean) model. *Energy, 109,* 391–399.
- Dantama, Y. U., Abdulahi, Y. Z., Inuwa, N. (2012). Energy consumption - Economic growth nexus in Nigeria: An empirical assessment based on ARDL bound test approach. *European Scientific Journal*, 8(12): 141-158. https://doi.org/10.19044/esj.2012.v8n12p%p
- Davis, M. M., Sokoloski, J., Nallagatla, S., Tenaglia, B. (2021). Exploring Nucleic Acid Structure-Function Relationships in Remote Biochemistry Instruction. Federation of American Societies for Experimental Biology, *The FASEB Journal, 35(51):* https://doi.org/10.1096/fasebj.2021.35.S1.05476

- Egbetokun, A., Oluwatope, O., Adeyeye, D., Sanni, M. (2019). The role of industry and economic context in open innovation: Evidence from Nigeria (chapter 5): 67-87 in: Rexhepi, G.: Hisrich R, Ramadani V, ed., Open Innovation and Entrepreneurship: Impetus of Growth and Competitive Advantages, *Springer Chan*, 2019.
- Encarta, O. A. (2009). The dialectics of energy and energy consumption in the developing economy. *Proceeding of 2009 annual conference of the Nigeria Economic Society,* 181-204
- Falade, O., E., Adeyemi, W. O. (2020). The effect of sectorial contributions to GDP on environmental degradation: a verification of the environmental Kuznets curve hypothesis in Nigeria. *Journal of Economics and Behavioral Studies,* 14(4). DOI: https://doi.org/10.22610/jebs.v14i4(J).3354
- Gungah, A., Emodi, N. V., Dioha, M. O. (2019). Improving Nigeria's renewable energy policy design: A case study approach. *Energy Policy, 130*: 89-100. http://doi.org/10.1016/j.enpol.2019.03.059
- Hasson, A., & Masih, M. (2017). Energy consumption, trade openness, economic growth, carbon dioxide emissions and electricity consumption: evidence from South Africa based on ARDL.*MPRA Paper 79424, University Library of Munich, Germany*.
- Józ´wik, B., Dog˘an, M., Gürsoy, S. (2023). The Impact of Renewable Energy Consumption on Environmental Quality in Central European Countries: The Mediating Role of Digitalization and Financial Development. *Energies,* 16, 7041. https://doi.org/10.3390/en16207041
- Khalid, S., Shahid, M., Niazi, N. K., Murtaza, B., Bibi, I., Dumat, C. (2017). Comparism of technologies for remediation of heavy metal contaminated soils. *J. geochem. Explor.,* 182: 247-268
- Narayan, P. K., Narayan, S. (2010). Carbon dioxide emissions and economic growth: Panel data evidence from developing countries. *Energy Policy, 38*(1): 661–666.
- Ogboru, I., Angu, R. (2015). Environmental degradation and sustainable economic development in Nigeria: A theoretical approach. *Research Journal of Economics,* 3(5): 25
- Omisakin, A. O. (2009). Economic Growth & Environmental Quality in Nigeria: Does Environmental Kuznets Curve hypothesis hold? *Environmental Research Journal,*; *3*(1): 14-18.
- Osuntuyi, B. V., Lean, H. H. (2023) Environmental degradation, economic growth, and energy consumption: The Role of Education. *Wiley Online Library. Sustainable Development,* 31(2): 1166-1177
- Pesaran, M. H., Shin, Y., Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics,* 16(3): 289–326.
- Prince, A. I., Inim, I. O., Callistus, E. O., Udo, E. S. (2021). Energy consumption effect on economic growth in Nigeria: Multivariate framework. *International Journal of Economics, Management and Accounting*, 519-542.
- Rafindadi, A. A. (2016). Does the need for economic growth influence energy consumption and CO2 emissions in Nigeria? Evidence from the innovation accounting test. *Renewable and Sustainable Energy Reviews, 62*: 1209–1225.
- Saidi, K., Hammami, S. (2015). The impact of CO_2 emissions and economic growth on energy consumption in 58 countries. *Energy Reports,* 1: 62-70. https://doi.org/10.1016/j.egyr.2015.01.003
- Sulaiman, S. (2014). The Causality between Energy Consumption, Co2 Emissions and Economic Growth in Nigeria: An Application of Toda and Yamamoto Procedure. *Adv. in Nat. Appl. Sci., 8*(8): 75-81, 2014
- UNFCCC. (2015). United Nations Framework Convention on Climate Change: available at www.unfccc.int/