The Relationship between Energy Transition, Economic Growth, and Carbon Emission in Nigeria

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ABSTRACT

This study investigates the relationship between energy transition, economic growth, and carbon emission in Nigeria. We employed three variables which are: (i) GDP as a proxy for economic growth (ii) Renewable energy consumption as a proxy for transition (iii) Carbon emission, and utilized the ARDL bound test technique developed by Pesaran, et, al. (2001) with an annual dataset ranging from 1990-2021. However, we found a long-run relationship among the variables, and that carbon emission has a negative and significant relationship in the long-run; but renewable energy consumption has a positive and significant effect on growth, though the short-run effect is negative. Also, renewable energy consumption has a negative effect on carbon emission in both the long-run and short-run. Therefore, the study recommend that the authority should invest heavily on renewables so as to make it accessible and sustainable to low-income earners.

Keywords: Consumption, Carbon emission, transition, and Bound test.

INTRODUCTION

Reservations about carbon dioxide (CO2) emissions, together with the serious environmental problems brought on by climate change and global warming are at the center of policy-making in many nations. The governments of these nations strive to maintain a balance between economic growth and CO2 emissions as their main objective. In other words, these governments seek to sustain rapid economic growth at the lowest possible cost in CO2 emissions (Ren & Wang, 2020). Many economies started the energy transition process to achieve this goal. Because it can change the energy structure in addition to reducing carbon emission intensity, the energy transition is seen as a link between lower carbon emissions and sustainable economic growth (Wang & Wang, 2020).

In addition, the pursuit of stable economic growth and long-term environmental quality is quickly becoming a hot topic among governments, international organizations, and other stakeholders interested in long-term development. This comes as a result of the knowledge that greater usage of energy, particularly from carbon-related sources, in the development of economic expansion is associated with rising levels of carbon emissions that are hazardous to both the environment and human health. Developing countries see carbon-intensive energy limits as damaging to their aspirations to expand their economies, urging that industrial economies enhance funding for programs to prevent global warming caused mostly by their industrial activity (Benjamin & Olusegun, 2020).

As a result, the 1997 Kyoto Protocol made a significant step forward by committing developed economies to drastically decrease their greenhouse gas emissions (Lee & Chang, 2008). Since the world economy's growth is becoming increasingly dependent on carbon-intensive energy, limiting energy consumption or a lack of energy supply has major implications for income. Therefore, this study plan to research the effects of energy transition and economic growth on CO2 emissions in Nigeria in order to understand the relationship between CO2 emissions, economic growth, and energy transition.

Controlling CO2 emissions in oil-producing developing nations, where petroleum and natural gas production and consumption are important drivers of economic growth, may be difficult because it can eventually slow economic growth (Shahbaz et al., 2013). Algeria, Angola, Egypt, Gabon, and Nigeria, for example, increased their average consumption of natural gas from around 107.9 billion cubic feet in 1980 to about 327 billion cubic feet and 759.5 billion cubic feet in 2000 and 2015, respectively (Benjamin & Olusegun, 2020). This implies that the average use of natural gas in these countries in 2015 reflects a surge of around 604% and 133% over 1990 and 2000 levels, respectively. Similarly, consumption of petroleum products in these countries increased from 116.4 thousand barrels per day in 1980 to 213.2 thousand barrels per day in 2000 to approximately 339.2 thousand barrels per day in 2015, representing an increase of approximately 191% and 59% over their 1980 and 2000 values, respectively. This equates to a 15% increase in average GDP per capita across these economies between 1990 and 2015, as well as a 144% spike in average carbon emissions. However, this study is structured into 6 sections in which section two is literature review, section three is methodology, section four is the empirical results while section five and six are conclusion and policy implication, respectively.

LITERATURE REVIEW

Several researchers have cracked on the relationship between energy consumption on renewables and economic growth and their ecological impact in different literature at different points in time. They came up with different opinion after examining its effect. For instance, Cherni & Essaber Jouini, (2017) studied the connection between economic growth, CO2 emission, and renewable energy consumption in Tunisia by employing an ARDL approach and causality effect with a dataset spanning 1990 to 2015. They found long-run stability among the variables, also a bidirectional causality runs from GDP to CO2 and from Renewable energy consumption to economic growth. But no causality between CO2 emission and renewable energy consumption. Also, Benjamin & Olusegun, (2020) investigate non-renewable energy consumption, economic growth and carbon emission in African leading oil-producing countries using a NARDL approach from 1980-2015. The results show asymmetric effects of non-renewable energy consumption on economic growth and carbon emission. Energy consumption slows economic growth but cuts emissions in Nigeria, while in Egypt it promotes economic growth but deteriorates environmental quality, and in Angola, it improves both economic growth and environmental quality. Moreover, Adedoyin et al., (2021) examine the effect of renewable and non-renewable energy on CO2 emissions in 10 biggest electricity generators in Sub-Saharan Africa. The study employed the traditional panel OLS technique and causality test from 1980-2011. They found that a long-run relationship prevails and non-renewable energy consumption fumes CO2 emission while renewable energy consumption retards CO2 emission. Also, there is evidence of bidirectional causality from CO2 emission to non-renewable energy consumption and a uni-directional causality from CO2 emission to renewable energy.

Nevertheless, from 1953-2006, Jalil & Feridun, (2011) examined the impact of energy consumption, economic growth, and financial development on environmental quality in China. They employed the ARDL bound test and found that there is evidence of long-run cointegration and that energy consumption has a decreasing impact on environmental quality. Employing the same approach, Shahbaz et al (2013), (Jayanthakumaran et al., 2012), (Ozturk & Acaravci, 2013), and (Acaravci & Ozturk, 2010) reaffirm the results for South Africa; India, and China; Turkey, and EU, respectively. Besides, Adewale et al., (2019) investigates the dynamic impact of trade policy, economic growth, fertility rate, and renewable and non-renewable energy consumption on the footprint of ecology in Europe from 1997-2014. The study employed the panel ARDL model and the result shows the evidence of a long-run relationship among the variables. Also, the environmental quality deteriorates with an increase in non-renewable energy consumption but renewable energy consumption improves environmental quality. Moreover, Zeren & Akkus, (2020) studied the relationship between renewable energy consumption and economic growth in more than 80 countries in four world regions. They employed panel cointegration of Pedroni tests and causality tests. They found evidence of long-run cointegration amongst the variables and bidirectional causality between renewable energy consumption and economic growth in all the regions. Using a dataset ranging from 1990-2010 with causality model, Cho et al., (2015) investigates the relationship between renewable energy consumption and economic growth in 31 OECD countries and 49 non-OECD countries. The result shows a conservative hypothesis in the two variables in the OECD countries while the less-developed countries showed a feedback hypothesis. However, renewable energy consumption enhances economic growth in non-OECD countries more than in OECD countries. After utilizing Smooth Transition Autoregressive (STAR) model, Alimi et al., (2016) examine the dynamics of nonlinear transition of renewable energy cycle in Tunisia. The result indicates that renewable energy enhances strategic energy transition and enables socio-economic development. In addition, Ã, (2009) examined the relationship between energy consumption and GDP in Tunisia. The study employed Johansen cointegration and causality test from 1971 to 2004. They found the presence of long-run cointegration amongst the variables, and GDP per capita and energy consumption per capita have a long-run bidirectional causality. Meanwhile in the short-run, the causality is unidirectional and it runs from per capita energy consumption to GDP. Further, Safouane et al., (2014) investigates the relationship between output, renewable energy consumption and trade in 11 African countries. The study employed granger causality test from 1980-2008, and the result reveal no prove of causality between renewable energy consumption and output in the short-run and between trade and renewable energy consumption. But in the long-run causality runs from renewable energy consumption to out. However, this study used only three variables that are directly connected to energy transition and economic growth in Nigeria and utilized the ARDL models and decomposed each variable as a dependent variable in order to capture the actual effects of the variables, as such the study fill in the gap.

DATA AND METHODOLOGY

Data

The time series data comprising Gross Domestic Product (GDP) which serves as a proxy for economic growth, Renewable energy consumption (RENEC), and Carbon emission (CO2) were employed as variables for the study. The study used an annual dataset ranging from 1990-2019, and the period was chosen due to the availability of the dataset. The data on GDP was sourced from the World Bank, likewise the data on CO2 emission and RENEC.

Methodology

$$GDP = f(CO2, RENEC) \qquad (1)$$

Where *GDP* stands for Gross Domestic Product, *CO2* stands for carbon emission, and *RENEC* stands for Renewable energy consumption. The relationship between economic growth and carbon emission has become one of the major economic and ecological issues drawing the attention of researchers in recent times. It is difficult to contrast economic growth with ecological issues because development on the global stage holds a conspicuous relationship between economic development and high Greenhouse gas emission (Cherni & Jouini, 2017). However, equation (1) is written, to introduce the econometric format of the linear ARDL specification which follows the standard framework of (Pesaran et al., 2001).

$$\Delta GDP_t = \mu + \alpha_1 GDP_t + \alpha_2 CO2_{t-1} + \alpha_3 RENEC_{t-1} + \sum_{t=1}^{p-1} \gamma_1 \Delta GDP_{t-1} + \sum_{t=1}^{q-1} \gamma_2 \Delta CO2_{t-1} + \sum_{t=1}^{q-1} \gamma_3 \Delta RENEC_{t-1} + \epsilon_1 \qquad (2)$$

$$\Delta CO2_t = \mu + \alpha_1 CO2_t + \alpha_2 GDP_{t-1} + \alpha_3 RENEC_{t-1} + \sum_{t=1}^{p-1} \gamma_1 \Delta CO2_{t-1} + \sum_{t=1}^{q-1} \gamma_2 \Delta GDP_{t-1} + \sum_{t=1}^{q-1} \gamma_3 \Delta RENEC_{t-1} + \epsilon_1 \qquad (3)$$

$$\Delta RENEC_t = \mu + \alpha_1 RENEC_t + \alpha_2 CO2_{t-1} + \alpha_3 GDP_{t-1} + \sum_{t=1}^{p-1} \gamma_1 \Delta RENEC_{t-1} + \sum_{t=1}^{q-1} \gamma_2 \Delta CO2_{t-1} + \sum_{t=1}^{q-1} \gamma_3 \Delta GDP_{t-1} + \epsilon_1 \qquad (4)$$

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where; α_1, α_2,and α_3, represent long-run equations while, γ_1, γ_2, and γ_3, are the short-run equations of ΔGDP, $\Delta CO2$, and $\Delta RENEC$, respectively. While μ represents the constant term, p and q are the optimal lag orders of the first differenced variables selected based on Aikaike Information Criterion (AIC) and Schwartz Information Criterion (SIC). The ARDL technique is based on establishing long-run cointegration among the variables. The cointegration is conducted using either the F_{pss} (Pesaran et al., 2001) that involves testing the null hypothesis of no-cointegration ($\alpha_1 = \alpha_2 = \alpha_3 = 0$) against the alternative hypothesis of cointegration ($\alpha_1 \neq \alpha_2 \neq \alpha_3 \neq 0$), and the F_{pss} test is considered to be non-standard and takes into account the stationarity possessions of the variables. Or the t_{BDM} test of (Banerjee, Dolado & Ricardo, 1998) which is standard and consider the testing of the null hypothesis of no-cointegration (H_0: α_1= 0) against the alternative hypothesis of cointegration (H_1: α_1= 1). Further, the error correction term which is responsible for speed of adjustment after a shock in the model is introduced in equation (5) to account for convergence after any form of divergence in the model.

$$\Delta GDP_t = \delta + \mu\lambda_{t-1} + \sum_{t=1}^{p-1} \gamma_1 \, \Delta GDP_{t-1} + \sum_{t=1}^{q-1} \gamma_2 \, \Delta CO2_{t-1} + \sum_{t=1}^{q-1} \gamma_3 \, \Delta RENEC_{t-1} + \epsilon_1 \qquad (5)$$

Where δ stance as the constant term, μ is the linear parameter of speed of adjustment and λ_{t-1} is the error correction model.

Table 1. Statistical properties of variables

1990-2019	**GDP**	**CO2**	**RENEC**
Mean	195052.3	0.689395	85.06475
Median	99428.73	0.707251	85.11064
Maximum	561602.8	0.916432	8.87E+01
Minimum	15790	0.491393	8.06E+01
Std. Dev.	189819.9	0.12251	2.278999
Skewness	0.649345	0.217528	-2.40E-01
Kurtosis	1.75692	1.78604	1.96E+00
Jarque-Bera	4.039802	2.078715	1.639779
Probability	0.132669	0.353682	0.44048

Source: Author's computation

Table 2 Unit root test Augmented Dickey-Fuller (ADF)

Variables	**Levels**	**First Diff.**	**Order**
GDP	-0.13671	-4.31622^{A}	I(1)
CO2	-1.19759	-5.27001^{A}	I(1)
RENEC	-1.57127	-5.23758^{A}	I(1)

Note: letter (A), (B), & (C) implies that the coefficients are significant at 1%, 5%, & 10% respectively. Also, the unit root test was conducted using the intercept only and the optimal lag was automatically selected by the Swartz information criterion.

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Table 3 Cointegration test Bound tests

Variables	**F-value**	**I(0)**	**I(1)**	**Remark**
GDP	5.357963	2.72	3.83	Cointegrated
CO2	6.274345	4.87	5.85	Cointegrated
RENEC	37.90128	4.87	5.85	Cointegrated

Note: the critical value of the upper bound and lower bound class, I(1) & I(0) is 5% and all three variables are decomposed as an equation. Sourced: author's computation

Table 4 ARDL model Long-run estimate

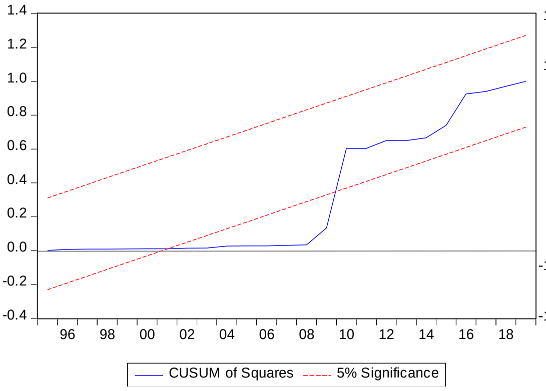
Dependent variables	***GDP***		***CO2***		***RENEC***	
	Coefficients	**t-statistics**	**coefficients**	**t-statistics**	**Coefficients**	**t-statistics**
GDP	-----	-----	9.62E-07 C	0.948889	3.96E-06 c	1.925425
CO2	-21.3548 A	-3.69273	-----	-----	-24.1369 A	-6.30995
RENEC	20.2843 A	4.112387	-0.04959B	-1.73596	-----	-----

Note: the coefficients are significant at 1%, 5%, & 10% which are denoted as (A), (B), & (C), respectively.

EMPIRICAL RESULT

At the onset, the study examined the statistical report of the data in order to ensure its validity which is presented in table 1. The statistical properties of the variables signify that all the estimated coefficients are largely satisfactory. However, the study utilized the ADF test for the presence of unit root because it has the ability to correct for any autocorrelation and heteroscedasticity in the disturbance process of the model by differencing the data. The unit root is detected through the rejection of the null hypothesis (H_0) of no-stationarity. And for the study to proceed with the ARDL estimates the H_0 must be rejected and a second difference I(2) should never be established. From table 2, the H_0 is rejected, and the presence of I(2) is not established though all the variables are integrated into order one I(1) meaning that they are significant after the first difference. Therefore, the study proceeds to the next stage of the cointegration test.

The cointegration test was conducted using the bound testing procedure developed by Pesaran et al., (2001) using the f-statistics provided by (Narayan, 2015) in table 3. The cointegration test established a null hypothesis of no-cointegration against the alternative hypothesis of cointegration, in which if the value of f-statistics is greater than the upper bound I(1), and less than the lower bound I(0), the null hypothesis is rejected otherwise be accepted. From the result acquired, the null hypothesis is rejected and the cointegration is established amongst the variables meaning that all the variables have long-run relationship.



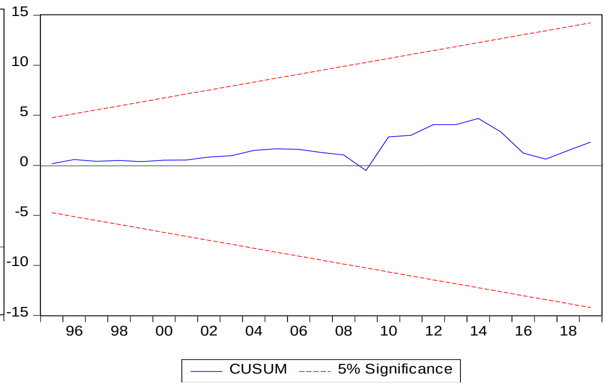


Table 5. ARDL Model Short-run estimate

Dependent variables	$\Delta CO2$		ΔGDP		$\Delta RENEC$	
	Coefficients	**t-statistics**	**coefficients**	**t-statistics**	**coefficients**	**t-statistics**
C	1.555788 [A]	4.54557	-----	-----	91.72892 [A]	11.3345
@TREND	-0.012866 [A]	-4.48073	-----	-----	-0.496856 [A]	-10.9864
D(CO2(-1))	-0.290857 [A]	-2.92428	-----	-----	-----	-----
D(CO2(-2))	-0.454729 [A]	-6.13819	-----	-----	-----	-----
D(CO2(-3))	-0.302847 [A]	-3.27484	-----	-----	-----	-----
D(RENEC)	-0.03251 [A]	-9.25946	-19.88026[A]	-4.02306	-----	-----
D(RENEC(-1))	-----	-----	-----	-----	0.099792	1.170793
D(RENEC(-2))	-----	-----	-----	-----	0.308168 [A]	3.987532
D(RENEC(-3))	-----	-----	-----	-----	0.284543 [A]	3.900685
D(GDP)	1.42E-07	1.28741	-----	-----	-1.54E-06	-0.64648
D(GDP(-1))	-1.86E-07 [C]	-1.89961	-----	-----	-5.13E-06 [B]	-2.15934
ECM(-1)*	-0.291715 [A]	-4.61874	-0.14359 [A]	-4.16650	-0.832077 [A]	-11.3100
R^2	0.909967	-----	0.451736	-----	0.904948	-----
$Adj.R^2$	0.867599	-----	0.43143	-----	0.867983	-----
H	0.9650	-----	0.1741	-----	0.8040	-----
S	0.4602	-----	0.8867	-----	0.7965	-----
CUSUM	Stable	-----	stable	-----	Stable	-----
CUSUMSQ	Stable	-----	unstable	-----	Stable	-----

Note: (A), (B) & (C) implies that the coefficients are significant at 1%, 5%, & 10% respectively. Adj. R^2 is the adjusted r-square, H is heteroscedasticity, and S is a serial correlation. CUSUM and CUSUMSQ are the cumulative sum and cumulative sum of squares which assesses the stability within the 5% critical value.

The ARDL result of both the long-run and short-run estimates are presented in Tables 4 and 5 respectively. Whereby, the study decomposes each variable in the equation as a dependent variable, hence, producing three equations in the model. The first equation shows that CO2 emission has a negative and significant effect on GDP in the long-run, while in the short-run the effect is insignificant. An increase in CO2 emissions drops economic growth by about 21 percent. Meanwhile, the long-term effect of renewable energy consumption on economic growth is positive but in the short-run the effect is negative, and it explains the changes in economic growth by about 20 and 3 units in both the long and short-term, respectively.

In the second equation, it was found that GDP has a positive and significant effect on CO2 in the long-run, while in the short-run the effect is negative, and GDP explains the positive changes in CO2 emission by about 9 units in the long-run and about 1 percent in the short-run. Besides, renewable energy consumption slows down CO2 emission by about 0.4 unit in the long-run, while in the short-run the effect is insignificant. However, in the third equation where Renewable energy consumption serves as the dependent variable, GDP positively and significantly amplifies renewable energy consumption in the long-run, while in the short-run the effect is insignificant. The error correction model is expected to be negative and significant in order to be able to converge in the short-run for any shock or disequilibrium in the long-run (Dhungel, 2014). The result in table 5 proves that the error correction model is negative and significant and will take care of any shock in long-run within a short period of time by about 29, 14, and 83 percent, respectively.

Furthermore, some diagnostics were conducted on the ARDL result to ensure the robustness and reliability, and forecasting power of the result. After using the Breauch-Godfrey serial correlation LM test, the presence of serial correlation was rejected. In addition, the presence of a normal distribution of the residuals failed to be rejected by the Jarque-Bera normality test, and the presence of heteroscedasticity in the data is rejected using the Breauch-pagan-Godfrey heteroscedasticity test. Further, the Brown et, al (1975) approach was utilized to carry out the stability checks in the model. The recursive residuals of cumulative Sum (CUSUM) and cumulative sum of squares (CUSUMSQ) statistical control were employed which are presented in Figures 1 and 2, respectively. Given the result of the CUSUM and CUSUMSQ, and within the 5% critical value, the residuals have stability in the models over time. Therefore, this study reaffirms the findings of (Cherni & Essaber Jouini, 2017), (Benjamin & Olusegun, 2020), and (Shahbaz et al., 2013).

CONCLUSION

This study investigates the effect of energy transition on economic growth in Nigeria from 1990-2019. The study adopted three variables which are Renewable energy consumption, economic growth, and carbon emission, and employed the ARDL model as the technique of analysis also, the study decomposed each variable to become dependent variable. By analyzing the empirical results, some of the conclusions are: (a) all the variable have passed the unit root test and are integrated of order one i.e I(1), and there exist a long-run relationship among the variables. (b) carbon emission has a negative effect on economic growth in the long-run while the effect is insignificant in the short-run. Renewable energy consumption has a positive and significant effect on economic growth in the long-run while in the short-run the effect is insignificant. (c) economic growth has a positive and significant effect on carbon emission in the long-run while in the short-run the effect is negative. Also, renewable energy consumption has negative and significant effect on carbon emission in Nigeria. (d) economic growth has a positive and significant effect on renewable energy consumption in Nigeria.

Moreover, in Nigeria the production technologies are energy intensive that is they consumed more energy. Renewable energy is an essential source of energy that promote growth without stirring carbon emission. It decoupling nature enhance energy efficiency and mitigate the fast approaching climate change by allowing economies to attain their level of economic development needs while closing up the environmental impacts. The biggest hassle of renewable energy is its financial cost. It is way too expensive to build and to maintain the infrastructural grids, especially for developing countries like Nigeria. And is quite arduous to raise a significant amount of investments to build the infrastructures for renewable energy due to limited financial resources. Also, due to the intermittence nature of the sources, the renewable energy storage needs a constant power supply which is an additional cost. Also, lack of adequate grid infrastructure, making it doozy to integrate the renewable energy sources into power grid.

POLICY IMPLICATIONS

In accord to the empirical results we offer the following policy implication: (a) since increase in renewable energy consumption foster economic growth in the long-run, the authority should invest heavily on renewables so as to make it accessible and sustainable to low-income earners because apart from fostering economic growth, it also improves environmental quality and is the seventh item on the sustainable development goals of the UN. (b) however, in the short-run renewable energy has a negative effect on economic growth because it consumes huge amount of money for them to set up and that will have a perverse effect on growth but after sometime it will reach a turning point for the economy and yield growth. Therefore, the authority should formulate a policy that will check out the hardship that the investment in the renewables will bring by subsidizing it for residential sectors. (c) since carbon have negative effects on economic growth, the authority should discourage the consumption of fossil fuels because they produce high carbon emission by imposing a heavy levy on them. As Nigeria produces 2.5mb/day, Nigeria consumes more than 10m liters a day OPEC, (2019) and the prices are deregulated by the government recently, their consumption frustrates the effort to cut carbon emission and threatens the quality of the environment.

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