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Article

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The Relationship between Urbanization, CO_2 Emissions, Economic Growth and Energy Consumption in Nigeria

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ABSTRACT

The first objective is to examine the trend analysis of the relationship between energy consumption and carbon dioxide on one hand and the trend analysis of the relationship between economic growth and CO_2 emission on the other hand for the period of 1970-2017. The second objective is to determine the long-run relationship and direction of causality among the variables. To achieve this objective, the study used Granger causality test and the results shows a bi-directional causality between urban population and Energy consumption. The third objective is to examine the impact of urbanization, energy consumption, economic growth on carbon dioxide emission in Nigeria. To achieve this, the study employed autoregressive distributed lag (ARDL) test approach. The results show that in the short run, energy consumption and the previous lag of economic growth have a positive and significant impact on carbon dioxide emission in Nigeria. Only urban population has a negative but significant impact on CO_2 emission in Nigeria. In the long run however, urbanization is still statistically significant but negative while energy consumption and economic growth still has a positive and significant impact on CO_2 emission. The major reason is that the bulk of the country's energy consumption is from non-renewable means. Thus, the study recommend appropriate measures and mitigation policies needs to be put in place to reduce the damage on the environment and to prevent further destruction.

Keywords: Urbanization, CO_2 Emission, Economic Growth, Energy Consumption, ARDL
JEL Classifications: Q43, Q53, O47

1. INTRODUCTION

Nigeria's population is about 187 million people (NPC, 2017), making it the most populated country in Africa. For a developing country such as Nigeria, the presence of more than 60% of its population among the working population is a good example in terms of production, the availability of labor among others, but, on the other hand, this may not be the case for the quality of the environment. The urban growth rate has been increasing exponentially by 5% annually since the country's independence in 1960. According to World Development Indicators (WDI, 2019), Nigeria's population is expected to reach 245 million by 2035. Despite its huge population, Nigeria is blessed with abundant natural resources such as crude oil, gold, coal, bitumen etc. Nigeria also derives its energy resources through hydro, wind, solar, petroleum and natural gas with hydro, petroleum. In Nigeria, natural gas is the dominant form of energy overtime.

Energy is the cornerstone of wealth creation that gives life to all sectors. It is the main source of income for the country and creates job prospects for the people. Energy adds value to the state of Nigeria through extraction, transformation and distribution to all sphere of live. It serves as an input to the manufacturing process of goods and services and helps in stimulating the economy (Gbadebo and Okonko, 2009; Aladejare, 2014; Abosedra et al., 2015; Gambo et al., 2018).

After the independence in 1960 and the discovery of oil in the late 1960s to 1970s, this discovery had led to the abandonment of the agricultural sector. As a consequence, rural-urban migration has been increased in Nigeria. After 1970, oil price shock came to an increase in the rate of urbanization, population, industrialization and environmental crisis resulted in a paradigm shift. That called for the diversification of energy consumption to a thorough search of an alternative or to revert to energy intensity.

Interestingly, electricity and petroleum products are the main output generated from the country's energy resources. As a matter of fact, electricity constitutes a total of just 2% of the total energy use/consumed in a country with such huge population. To make matters worse electricity is just 9% of the household's total energy consumption with the rest been dependent on petrol, kerosene and diesel to generate electricity on private scale.

The unstable and epileptic nature of the country's electricity supply has put pressure on the demand for fossil fuel such as petrol, diesel and kerosene up to an unsustainable manner due to the fact that all social and economic activities are centered on availability of energy. The daily consumption of petrol alone stood at 30 million liters per day. Unfortunately, Nigeria is now over dependent on the import of petroleum products despite exportation of 2 million barrels of crude oil daily and as the 6th exporter of crude oil in the world.

In terms of economic growth, Nigeria's GDP in 2018 is \$400 billion. It is the highest in Africa followed by South Africa with \$320 billion. Despite the country's enormous wealth in oil and gas, more than half of the population still lavish in poverty especially in the urban areas. Urbanization is a serious problem in Nigeria due to energy and infrastructure poverty in rural areas. Growth in economic activity and the availability of industrial enterprises in urban centers (for example, Lagos and Port Harcourt) contributed to the migration from rural areas to cities. The growth rate of cities in Lagos is 5.8% (Aliyah and Amadu 2017). The resulting increase will require an increase in energy demand, and this will make emissions inevitable because the country's energy sources are not renewable. Increased CO_2 emissions directly affect people and indirectly affect their livelihoods (Heil and Selden 2001). A country must also be open to trade for many years. As of September 2018, the country's trade surplus amounted to 805.2 billion Naira, compared with 467.7 billion in 2017, as the Central Bank of Nigeria reported. Therefore, as asserted by Ayinde et al. (2019) it is safe to conclude that Nigeria's increase in urban population coupled with rapid industrialization has led to economic growth and ultimately on energy consumption at the detriment of environmental standards by continuously releasing carbon dioxide into the environment. Benna and Garba (2016) and Elimelech and Phillip (2011) also argued that continuous increase in fossil and liquid fuel usage will have an adverse effect on the environment such as pollution and other environmental degradation. There is a lack of literature in this area of research, especially for Nigeria, which should be a potential candidate for such a study. Only one study by Ali et al. (2016) was discovered in the literature for the case of Nigeria. Ali et al. (2016) depended on the Stochastic Impact of Regression on Population, Impact and Technology (STIRPAT) model to study the relationship between carbon emissions, urbanization, and economic growth. They rely on the ARDL model, neglecting the possibility of a structural break in this structure, knowing that environmental actions and policies in Nigeria have never been linear. The study also did not take into account the causal relationship and did not allow the introduction of a quadratic term for urbanization variable in the model. The main objective of this study is to examine relationship between urbanization, energy consumption, economic growth and carbon dioxide in Nigeria. The specific objectives are to examine the trend of urbanization, energy consumption, economic growth and carbon dioxide emission in Nigeria from 1970 to 2017, to determine the long-run relationship and the direction of causality between urbanization, energy consumption, economic growth and carbon dioxide emission in Nigeria; and to examine the impact of urbanization, energy consumption, economic growth on carbon dioxide emission in Nigeria.

2. ENVIRONMENTAL KUZNETS CURVE (EKC)

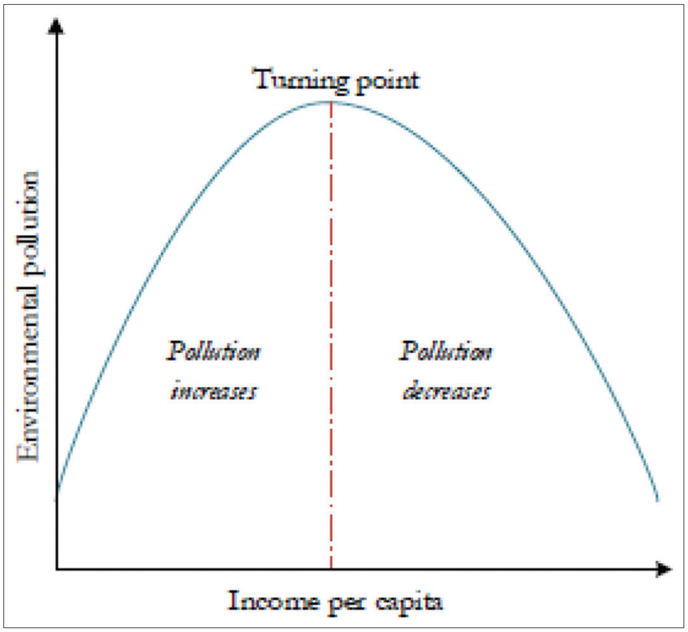
Environmental Kuznets Curve was named after Kuznets (1955) who developed the inverted U-shaped theory of the relationship between environmental pollution and income per capita. According to Kuznets, at the beginning of economic transformation, income per capita is attributed to low quality of environment. But after the peak period of economic growth, pollution begin to decrease and income going upward. The EKC was made popular by Grossman and Krueger (1991) paper on the North American Free Trade Agreement (NAFTA). There are several factors that can be used to explain the inverted U-shape of economic growth and environmental degradation. For instance, Mariam Oganesyan (2017) explained that in the last stage of economic transformation, many countries will adopt cleaner and renewable form of energy which is not only efficient but effective and reduces carbon dioxide emissions. Secondly, these countries will import rather than produce high energy-intensive goods. Lastly, awareness of the danger of climate change will push countries to be more environmentally conscious. Figure 1 shows the EKC curve.

Stern (2004), categorically stated that developing countries tend to be more better off or contribute less to the environmental pollution than developed countries because they are more sustainable and environmentally responsive as a result of their low income per capita. He compared the gap between incomes of developing and developed countries. As a matter of fact, he explained that many empirical studies on EKC are weak statistically or suffers from mis-diagnostics or the methodologies they used are questionable. Some of these studies will be reviewed next.

3. EMPIRICAL LITERATURE

Ali et al. (2016) investigated the level of CO_2 emission in Nigeria using urbanization rate, energy use and economic progress as dependent variables from 1971 to 2011. Their study used ARDL approach to test the coefficients from their study. They reported that CO_2 emissions in Nigeria is not affected by urbanization growth, but it is affected by energy consumption and economic growth. Akpan and Akpan (2012) employed the VECM to

Figure 1: Environmental Kuznets curve



Source: Mariam Oganesyan (2017)

investigate how energy, carbon dioxide emission and economic growth can affect each other. Using data from 1980 to 2008, they concluded that energy consumption and economic growth increase CO_2 emission in Nigeria but energy consumption have a greater impact on the CO_2 emission rate than economic growth in Nigeria.

Onakoya (2013) assesses the causal link between energy consumption and economic growth in Nigeria from 1975 to 2010. The results of his study uncovered that petrol, electricity and the total energy utilization have huge and positive connection with economic development in Nigeria. Lin et al. (2015) also examined the impact of industrialization on CO_2 emission in Nigeria. The results of their study show that GDP has a reverse and huge connection with CO_2 emission in Nigeria. Ejuvbekpokpo, (2014) showed that GDP have a cynical brunt on carbon emission in Nigeria. The results showed that economic growth negatively affects CO_2 in Nigeria. Gambo et al. (2018) investigated the linkage between energy usage, CO_2 emission and economic growth utilizing ARDL technique to cointegration. The empirical findings show that high energy consumption have a huge and positive impact on GDP. The outcome shows that an expansion in energy consumption in Nigeria is significantly correlated with the GDP as a sign of economic growth while FDI and fossil fuel are contrarily linked with GDP. Ayinde et al. (2019) examined the connection of energy utilization and economic growth on one hand and industrialization and urban development on the other hand. After collecting data from 1980 to 2016, they used VEC model and Granger causality test. The result shows that GDP has positive and significant impact on energy consumption in the long run. Whereas in the short run, no causal relationship is found between energy consumption, GDP, industrialization and urbanization.

Adegboye and Babalola (2017) investigated the causal connection between energy used and economic growth in Nigeria from 1981 to 2013. An ARDL and error correction model Granger Causality test was used and findings shows that there is a unidirectional connection between energy use and economic growth and that adjustments in energy utilization brings about changes in economic growth with a significant positive connection exists between the two factors which are vigorous to the two estimation strategy utilized.

Dantama et al. (2012) examine the effect of energy utilization on economic growth in Nigeria from 1980 to 2010. They used the ARDL technique to co-integration and concluded that there is a long-run connection between economic development and energy utilization. Both petroleum utilization and electricity utilization are statistically significant on economic development however coal usage is not significant. Chindo et al. (2014) also found a long run relationship between CO_2 emission, energy consumption and economic growth in Nigeria but energy consumption does not affect economic growth in the short run. Their study used ARDL to arrive at this conclusion.

4. THEORETICAL FRAMEWORK

Here, a theory that constitutes mathematical expressions and derivations, as regards the subject matter of this study, is examined. The theoretical framework to be used in the study is the Stochastic Impacts by Regression on Population, Affluence and Technology (STIRPAT). This research will employ the use of Impact, Population, Affluence and Technology (IPAT) Model. This model was propounded by Ehrlich and Holdren in 1971 to relationship that exist between human activities and his environment. He gives the implicit form as thus:

$$I = f(P, A, T)$$

Where, I = emission level;
P = population;
A = affluence;
T = technology

This theory has been used by many articles to test for the empirical relationship on how rapid population growth and economic growth can affect environmental degradations.

Over the years this model has been criticized on many grounds. First, Xu et al. (2016) argued that this theory conflict with the Environmental Kuznet Curve (EKC) theory by assuming that environmental emissions will change proportionally or monotonically. In EKC however, it is assumed that the relationship between economic growth and environmental degradation is not monotonic or proportional. Secondly, Xu et al. (2017) assert that IPAT is just an accounting equation to determine the relationship between human activities and environment. Liu and Xiao (2018); Nathaniel (2019) also concluded that the parameter's elasticities are the same i.e. P, A and T offers the same outcome on environmental impact. The linkage between energy consumption, urbanization, economic growth and CO_2 emission has gained momentum over the last three decades (Ehrlich and Holdren (1971), Dietz and Rosa (1997), Zhang et al. (2016), Nathaniel (2019)). In examining this on Nigeria's data, the study uses STIRPAT model. This approach has got a wide application in econometric analysis (for example, Wang et al. (2015), Liddle (2015) and Nathaniel (2019)). In order to address these problems, Dietz and Rosa (1997) developed a model called Stochastic Impacts by regressing on Population, Affluence and Technology on environmental impact (STIRPAT). This model builds on the existing IPAT and its takes into consideration the potential determinants of environmental impact. The model is written implicitly as thus:

$$E = f(EC, P, A, T)$$

This model is non-linear therefore it can be further transformed as thus:

$$E_t = \phi 0 EC_t^{\alpha} P_t^{\beta} A_t^{c} T_t^{d} e_t \quad (1)$$

Where, E_t = CO_2 emission, EC_t = Energy consumption, P_t = Population size, A_t = Affluence and T_t = Technology. ∅,α,β,c and d are the various elasticities and e_t is the error term. Unlike the EKC, the STIRPAT model incorporates technology, affluence and population as potential determinants on environmental degradation. To empirically estimate the model, we take the logarithm of each of the variables. As such, Eq. (2) becomes:

$$lnE_t = \delta + \alpha * ln(EC_t) + \beta * ln(P_t) + c * (lnA_t) + d * ln(T_t) + \gamma \quad (2)$$

ln represents natural logarithm, δ and γ represents the natural logarithm of ∅ and e_t. ∅ shows that when there is no change in other variables, the emission is zero and e_t captures the impact of other variables that are not included in the model.

The current study included trade flow to augment the model since openness to trade encourage technological transfer from developed countries to their trading partners. The impact of technology on the economy is hydra-headed. It can reduce pollution, promote economic activities, and also encourage dumping. Therefore, its impact can either be positive or negative. By performing logarithm transformation on the variables, converting all variables into per capita terms by dividing through by population in line with the studies of (Shahbaz and Lean 2012; Lean and Smyth 2010), into the model, we have equation 3,

$$lnE_t = \vartheta_0 + \beta_1 lnEC_t + \beta_2 lnU_t + \beta_3 lnY_t + \beta_4 lnT_t + \varepsilon_t \quad (3)$$

lnE_t, $ln_{EC}t$, lnU_t, lnY_t, and lnT_t are the natural logarithm of per capita CO_2 emissions, energy consumption, urbanization, economic growth or GDP per capita and trade openness respectively.

5. DATA AND METHODOLOGY

This study used annual data for the period from 1970 to 2017, obtained from World Bank development indicator 2018. The availability of the relevant required data relating to the study variables informed the choice of the study period. Also, this source of data is considered reliable and dependable. Table 1 shows the description of the variables.

The study adopted the use of the Augmented Dickey-Fuller (ADF) and Phillip-Perron (PP) to test for stationarity and the presence of unit root. Autoregressive-Distributed Lag (ARDL) bounds test to co-integration has been used to determine if there is any long run relationship between the variables. ARDL has been used to analyze data collected for the period 1970-2017. Finally, Granger causality test has been used to determine the direction of causality between the variables. The aim was to provide a robust data analysis and hypotheses testing.

5.1. Autoregressive-Distributed Lag (ARDL)

The Engle-Granger or Johansen tests require pre-testing for unit root. Therefore, it is liable to pre-testing bias. (Harris, 1995) highlighted that the unit root tests lack sufficient power with poor size property particularly in small samples. Although the test necessitates that all variables should be integrated of similar order. Occasionally, the result might be inconsistent. The Johansen test requires large samples, minimum of 100 observations because of the lag specification of Vector Auto-Regression (VAR), Pesaran et al. (2001) proposed ARDL technique to avoid the complication inherent in the current process. The ARDL cointegration test is suitable whether all the variables are integrated of I(0) or I(1) or some are I(0) and I(1). Consequently, pre-testing for unit root is not required. It is applicable regardless of whether the sample size is small or large. ARDL is utilized for testing the future relationship and estimating long-run parameters.

ARDL bounds test approach was introduced by Pesaran and Shin (1999) and later it was developed by Pesaran et al. (2001). This approach is based on the estimation of an Unrestricted Error Correction Model (UECM). Which enjoys several advantages over the conventional type of cointegration techniques. First, it can be applied to a small sample size study (Pesaran et al., 2001) and therefore conducting bounds testing will be appropriate for the present study. Second, it estimates the short- and long-run components of the model simultaneously, removing problems associated with omitted variables and autocorrelation. Third, the standard Wald or F-statistics used in the bounds test has a nonstandard distribution under the null hypothesis of no-cointegration relationship between the examined variables, irrespective whether the underlying variables are I(0), I(1) or fractionally integrated. Fourth, this technique generally provides unbiased estimates of the long-run model and valid t-statistic even when some of the regressors are endogenous (Harris and Sollis 2003). Inder (1993) and Pesaran and Pesaran (1997) have shown that the inclusion of the dynamics may correct the endogenity bias. Fifth, the short as well as long-run parameters of the model could be estimated simultaneously. Sixth, once the orders of the lags in the ARDL model have been appropriately selected, we can estimate the cointegration relationship using a simple Ordinary Least Square (OLS) method. In view of the above advantages, ARDL-UECM used in the present study has the following form as expressed in Equation (1):

$$\Delta lnE_t = \vartheta_t + \sum\nolimits_{i=1}^{p} \gamma_1 \Delta lnE_{t-1} + \sum\nolimits_{i=1}^{q} \gamma_2 \Delta lnEC_{t-1} + \sum\nolimits_{i=1}^{r} \gamma_3 \Delta lnU_{t-1} + \sum\nolimits_{i=1}^{s} \gamma_4 \Delta lnY_{t-1} + \sum\nolimits_{i=1}^{v} \gamma_5 \Delta lnT_{t-1} \beta_1 lnE_{t-1} + \beta_2 lnEC_t + \beta_3 lnU_t + \beta_4 lnY_t + \beta_5 lnT_t + \varepsilon_t$$

Where Δ the difference operator, γ_t are the long-run multipliers and ε_t is the white noise error term. The bounds test is based on

Table 1: Description of variables

Variable	Source	Unit of measurement	Definition
E (CO_2 emission per capita)	World Bank Indicator (2018)	Metric tons per capita	This is the total amount of carbon dioxide emitted by household and firms from burning of fossil fuel.
EC (Energy consumption per capita)	World Bank Indicator (2018)	Kg of oil equivalent per capita	Fossil fuel consumption such as petroleum products, coal, natural gas etc.
U (Urban population per capita)	World Bank Indicator (2018)	Percentage of total population	Total number of people living in the urban areas.
Y (GDP per capita)	World Bank Indicator (2018)	Gross domestic product per capita is a proportion of a nation's financial yield that records for its number of individuals. It separates the nation's total national output by its all out populace.	Gross domestic product per capita is a proportion of a nation's financial yield that records for its number of individuals. It separates the nation's total national output by its all out populace.
T (Trade openness)	World Bank Indicator (2018)	Index	This is the ratio of trade to GDP. It is calculated by Import + Export GDP

the joint F-statistics (Wald statistics) for cointegration procedure. Pesaran et al. (2001) explained that there five steps to ARDL Bound test method:-

- Identify a tentative model,
- Estimate the equation using Ordinary Least Square (OLS) method,
- Diagnostic checking,
- Use Wald test (F-test) to determine the null and alternative hypotheses as below:

H_0: $\beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = 0$ (No long run relationship)

H_1: $\beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq \beta_5 \neq 0$ (There is long run relationship).

- To observe the computed F-Test against the critical value, if the critical value is higher than the F–test this means that there is cointegration, but if it is between the lower and upper bound critical value this means that it is inconclusive and when it is below lower critical value it means no cointegration exist.

If there is cointegration among the variables, the next step incorporates in estimating the long-run coefficients of the ARDL model as follows:

$$lnE_t = \vartheta_0 + \sum_{i=1}^{p}\beta_1 lnE_{t-1} + \sum_{i=1}^{q}\beta_2 lnEC_{t-1} + \sum_{i=1}^{r}\beta_3 U_{t-1} + \sum_{i=1}^{s}\beta_4 T_{t-1} + \sum_{i=1}^{v}\beta_5 Y_{t-1} + \varepsilon$$

Where all variables are defined as in Eq. (1). The last step is to estimate the short-run dynamic coefficients by running the error correction model presented in Eq. (3):

$$\Delta\Delta lnE_t = \vartheta_0 + \sum\nolimits_{i=1}^{p}\gamma_1\Delta lnE_{t-1} + \sum\nolimits_{i=1}^{q}\gamma_2\Delta lnEC_{t-1} + \sum\nolimits_{i=1}^{r}\gamma_3\Delta lnU_{t-1} + \sum\nolimits_{i=1}^{s}\gamma_4\Delta lnT_{t-1} + \sum\nolimits_{i=1}^{v}\gamma_4\Delta lnY_{t-1} + \theta ECM_{t-1} + \varepsilon_t$$

where, γ_1, γ_2, γ_3 and γ_4 are the short-run dynamic coefficients of the model's convergence to equilibrium and θ is the speed of adjustment parameter and ECM is the error correction term that is derived from the estimated equilibrium relationship of Equation (1). The ECT indicates the extent of disequilibrium that can be adjusted at each period and it should be statistically significant coefficient with a negative sign.

5.2. Unit Root Test Result

In this time series, properties of all variables used in estimation were examined in order to obtain reliable results. Thus, this study was carried out through Augmented Dickey Fuller (ADF) test and Phillip-Perron (PP) test. This development arises from the prevalence of substantial co-movements among most economic time series data, which has been argued in the literature as undermining the policy implications that could be inferred from such modelling constructs, Engel and Granger (1987). The ADF and PP tests were used to determine the order of integration. That is, the number of times a variable must be differenced before it becomes stationary. In this analysis, the model with constant is considered. The null hypothesis in both the ADF and PP test is that there is the presence of unit root. Tables 2 and 3 report the results of ADF and PP tests, respectively.

The Table 2 results i.e. ADF test shows that log of CO_2 emission, log of energy consumption, log of urban population, log of economic growth and log of trade openness are all stationary at first difference. All variables are significant at 1%.

Similarly, the above results from Phillip-Perron Test (PP) shows that log of CO_2 emission, log of urban population, log of economic growth and log of trade openness are all stationary at first difference except, log of energy consumption which is stationary at level. All variables are significant at 1% apart from log of energy consumption which is significant at 10%.

5.3. ARDL-Bound Test Approach to Cointegration

The co integration test is a statistical property of time series variable. Two or more-time series are co integrated if share a common stochastic drift (Gujarati, 2004). The test assumes that the co-integrating vector is constant during the period of study. The test adopted for this research is ARDL-Bound test approach to co-integration since the unit root results show mixed order of stationarity of I(0) and I(1). It is also used to confirm the long run relationship between the dependent and independent variables. But before determining whether the variables are cointegrated, it is important to determine the optimal lag length first. The test result is presented in Table 4.

The ARDL bounds tests was employed to determine the existence of a long run relationship among the variables. From the result in Table 5, there is evidence of long run relationship between (i.e. cointegration) between urbanization, energy consumption, carbon dioxide emission, trade openness and economic growth. The results show that their F-statistics are all above the upper bound of critical value at 5% level of significant.

The result further shows that there are five unique cointegrating relationships between the variables. This means that there is a long run relationship between the urban population, energy use, CO_2 emission, trade openness and economic growth. For instance, when CO_2 emission is the dependent variable, the calculation is written as $FInE(InE|InU|InEC|InY|InT) = 20.77136$ which is higher than the upper bound critical level of 1, 5, and 10% therefore we reject the null hypotheses of no cointegration here.

5.4. ARDL - ECM Results

Since it has been established that cointegration exist between the variables, it is important to analyze both the long-run and short-run dynamics using the autoregressive distributed lag (ARDL) error correction method approach. In order to get the short-run and the long run coefficients, an error correction model (ECM) is estimated, the result is given below in Table 6.

In Table 6, the adjustment term is larger (−0.5462) suggesting that the rate of adjustment to long-run equilibrium is faster and that the CO_2 emission adjusts to its realization with a lag correcting 54 percent of the discrepancy between the long-term and short-term CO_2 emission within the period. Also, the regression results from this model shows that in the short run, the previous lag of CO_2 emission, energy consumption, economic growth and urban population are all statically significant at 1% and 5% level respectively. The coefficient of energy consumption is 3.6636 which is positive and significant at 1% level of significance. The result implies that a unit increase in the metric tons of oil consumed will lead to 366% increase in the CO_2 emission. Coincidentally, this is in line with the findings of Solomon Nathaniel (2019), Ali et al. (2016), Raggad (2018) and Abdallh and Abugamos (2017). The major reason is that the bulk of the country's energy consumption is from non-renewable means. Another interesting factor is the fact that Nigeria is among the major producers of non-renewable energy sources in the world. So, as a major player in the market, it is not surprising that the country's carbon dioxide emission level is at an alarming rate.

Surprisingly, the coefficient of the urban population is not significant but the co-efficient of the urbanization is −0.6905 which is negative but significant at 5% level of significance. This indicates that a unit increase in the urban population will lead to 69% reduction in CO_2 emission.

The story is the same for economic growth as the result shows that the coefficient of economic growth in the current year is not significant but the coefficient of the previous year (0.9534) which is positive and significant at 1% level of significance. This implies that a dollar unit increase in economic growth will result to a 95% increase in CO_2 emission.

In the long run, the coefficient of energy consumed is 3.8706 which is positive and significant at 1% level of significance. This means that in the long run a unit increase in the kg of oil consumed will lead to a 387% increase in CO_2 emission ceteris paribus. For economic growth however, the coefficient is 1.753 which is also positively and significant at 1% level of significance. This indicates that a dollar unit increase in the economic growth will

Table 2: Augmented-Dickey fuller (ADF) test

SERIES	Augmented Dickey fuller (ADF)				Order of integration
	Level	Prob.	1st difference	Prob.	
*In*E	−0.423596	0.8964	−6.743944	0.0000*	I(1)
*In*EC	−2.404420	0.1460	−7.535729	0.0000*	I(1)
*In*U	−1.361004	0.5930	−7.045706	0.0000*	I(1)
*In*Y	−0.372305	0.9054	−5.809277	0.0000*	I(1)
*In*T	−2.297856	0.1769	−7.369718	0.0000*	I(1)

*, **, ***Indicates 1%, 5% and 10% significant

Table 3: Phillip-Perron test (PP)

SERIES	Phillip-Perron test (PP)				Order of integration
	Level	Prob.	1st difference	Prob.	
*In*E	−0.423596	0.8964	−6.743944	0.0000*	I(1)
*In*EC	−2.738232	0.0753***	−7.535729	0.0000*	I(0)
*In*U	−1.110684	0.9163	−3.738806	0.0293*	I(1)
*In*Y	−0.746180	0.8247	−5.894061	0.0000*	I(1)
*In*T	−2.521111	0.1170	−7.344334	0.0000*	I(1)

*, **, ***Indicates 1%, 5% and 10% significant

Table 4: Selection order criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	−109.7003	NA	0.000126	5.213650	5.416399	5.288839
1	236.7724	598.4529	5.75e-11*	−9.398745	−8.182253*	−8.947611*
2	261.9717	37.79901*	5.96e-11	−9.407806	−7.177569	−8.580727
3	287.2432	32.16367	6.64e-11	−9.420145	−6.176164	−8.217120
4	316.1090	30.17794	7.13e-11	−9.595866*	−5.338140	−8.016896

From the table above, the optimal lag length is one (P*=1) lead to a 175% increase in CO_2 emission as a result of continued industrialization. Finally, the coefficient for urban population is −1.2640 which is negative and significant at 5% level of significance. The implication is that a unit increase in the number of people living in the urban cities will decrease the CO_2 emission in the long run. For this model, the adjusted R^2 indicates that 92% of the dependent variable can be explained by the explanatory variables.

5.5. Direction of Causality Test

In order to determine the direction of causality between the variables, Engle-Granger pairwise test was conducted to provide answers to the third objective of this study. Granger causality is a situation whereby one-time series variable consistently and predictably changes before another variable. However, even if a variable Granger causes (precedes) another, it does not mean that the first variable "causes" the other to change. Granger causality has many tests, but they all involve distributed lag models in one form or another, however Granger suggested that to see if X Granger-caused Y, we should run:

$$Y_t = \beta_0 + \beta_1 Y_{t-1} + \ldots + \beta_p Y_{t-p} + \alpha_1 X_{t-1} + \ldots + \alpha_p X_{t-p} + \varepsilon_t \quad (1)$$

and test the null hypothesis that the coefficients of the lagged X_s (the α_s) jointly equal zero. If we can reject this null hypothesis using the F-test, then we have evidence that X Granger-causes Y.

Applications of this test involve running two Granger tests, one in each direction. That is, run Equation 2 and also run to test for Granger causality in both directions by testing the null hypothesis that the coefficients of the lagged Y_s (the α_s) jointly equal zero

$$X_t = \beta_0 + \beta_1 X_{t-1} + \ldots + \beta_p X_{t-p} + \alpha_1 Y_{t-1} + \ldots + \alpha_p Y_{t-p} + \varepsilon_t \quad (2)$$

If the F-test is significant for equation 1 but not for equation 2, then we can conclude that X Granger-causes Y. Table 7 presents the Pairwise Granger Causality Tests.

In Table 7, from the pairwise test above, the most unique result is the bi-directional relationship between Nigeria's urban population

Table 5: Bounds test

Dependent variable	F-Statistics	Cointegration	Result
*In*E	*F*E = 20.77136	Yes	Estimate ARDL-ECM (error correction model)
*In*EC	*F*EC = 30.47802	Yes	Estimate ARDL-ECM (error correction model)
*In*U	*F*U = 15.11946	Yes	Estimate ARDL-ECM (error correction model)
*In*Y	*F*Y = 4.627757	Yes	Estimate ARDL-ECM (error correction model)
*In*T	*F*T = 7.123374	Yes	Estimate ARDL-ECM (error correction model)

Table 6: Error correction results

ARDL (1, 1, 0, 1, 1) Model dependent variable is *ln*E				
Variables	**Coefficients**	**Standard error**	**t-statistic**	**P-value**
Short-run coefficients				
C	−4.583906	0.517847	−8.851861	0.0000
*D(In*E(−1)	−0.546292	0.069438	−7.867363	0.0000*
*D(In*EC)	3.663687	0.150423	24.35588	0.0000*
*D(In*EC(−1)	2.114483	0.233820	9.043205	0.0000*
*D(In*U)	−15.00923	13.84098	−1.084405	0.2850
*D(In*U(−1)	−0.690548	0.338969	−2.037197	0.0486**
*D(In*Y)	1.596784	1.035918	1.541420	0.1315
*D(In*Y(−1)	0.953476	0.370571	2.572990	0.0141*
*D(In*T)	0.024438	0.232298	0.105200	0.9168
Adjustment				
CointEq(−1)*	−0.546292	0.050989	−10.71397	0.0000*
Long-run coefficients				
*In*EC	3.870606	0.267322	14.47921	0.0000*
*In*T	0.044734	0.424953	0.105267	0.9167
*In*U	−1.264062	0.545997	−2.315144	0.0261**
*In*Y	1.745359	0.637715	2.736893	0.0094*
EC = *InE* − (3.8706**InEC* + 0.0447**InT* − 1.2641**InU* + 1.7454**InY*)				
R-squared		0.934917		
Adjusted R-squared		0.928719		
F-statistic		150.8326		
Prob. (F-statistic)		0.000000		
Durbin-Watson Stat.		1.283069		
Number of Obs.		47		

*, **, ***Represents 1%, 5%, 10% respectively

Table 7: Pairwise Granger causality tests

Null hypothesis:	F-statistic	Prob.	Decision
InEC does not Granger Cause InE	0.09529	0.7590	Unilateral causality from CO_2 emission to
InE does not Granger Cause InEC	6.21524	0.0165*	Energy consumption
InT does not Granger Cause InE	0.00842	0.9273	No unilateral or bilateral causality
InE does not Granger Cause InT	0.08612	0.7705	
InU does not Granger Cause InE	3.04158	0.0881***	Unilateral causality from urban population to
InE does not Granger Cause InU	1.28821	0.2625	CO_2 emission
InY does not Granger Cause InE	4.03078	0.0508**	Unilateral causality from economic growth to
InE does not Granger Cause InY	0.65800	0.4216	CO_2 emission
InT does not Granger Cause InEC	0.00056	0.9812	No unilateral or bilateral causality
InEC does not Granger Cause InT	0.85288	0.3608	
InU does not Granger Cause InEC	7.29694	0.0098*	Bilateral causality between urban population
InEC does not Granger Cause InU	2.96486	0.0921***	and Energy consumption
InY does not Granger Cause InEC	6.93548	0.0116*	Unilateral causality from economic growth to
InEC does not Granger Cause InY	0.19349	0.6622	energy consumption
InU does not Granger Cause InT	0.03609	0.8502	Unilateral causality from trade openness to
InT does not Granger Cause InU	16.6331	0.0002*	urban population
InY does not Granger Cause InT	0.68610	0.4120	Unilateral causality from trade openness to
InT does not Granger Cause InY	4.65922	0.0364*	economic growth
InY does not Granger Cause InU	0.11254	0.7389	No unilateral or bilateral causality
InU does not Granger Cause InY	1.71060	0.1977	

*, **, ***Represents 1%, 5%, 10% respectively

Table 8: Diagnostics test results

Test	F-statistics	P-value	Conclusion
Breusch-Godfrey (Serial correlation)	1.836807	0.1328	No high-order autocorrelation
Bruesch-Pagan (heteroscedasticity)	0.431840	0.9202	No heteroscedasticity
ARCH-LM	0.180962	0.9469	No conditional heteroscedasticity

growth and energy consumption rate. Recent research suggests that the main contributors to increases in energy use are electricity and industrial production (Franco et al., 2017). Since urbanization would increase electricity demand, a logical consequence of urbanization is the overall increase in energy consumption. This is evidence as more people troop into the urban cities every day, more energy resources will be needed to meet the demand of new entrant into the cities. Furthermore, the alarming growth rate of the total population also calls for concern policy makers.

The results also show a unilateral causal relationship between urban population and CO_2 emission. This result is in consistent with Wang et al. (2016). A policy recommendation to this kind of result is for the government to consider the possibility of reduction rural-urban migration by decongesting the cities in order reduce carbon dioxide emission level. Another important policy recommendation is to provide social amenities in the rural settlements to create jobs and better living for people to curb urban congestions across the country. This result is consistent with recent economic agglomeration theory which identifies the benefits for economic development of the urbanization and spatial proximity. The main reason is that bigger cities allow stronger differentiation and greater spillover effects between and within industry according to (Quigley, 2008).

Furthermore, the granger-causality test also detects a unilateral causality from economic growth to CO_2 emission. This means as Nigeria's GDP is increasing over the years, it is having an adverse effect on the environment. This is evidence from the Table 7 which

Figure 2: CUSUM

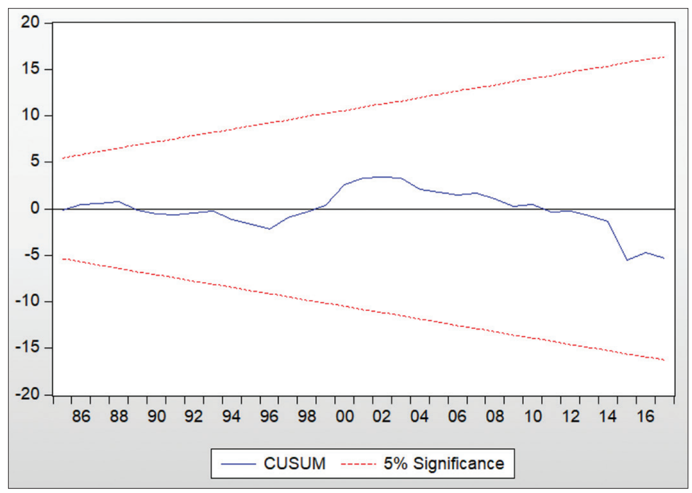
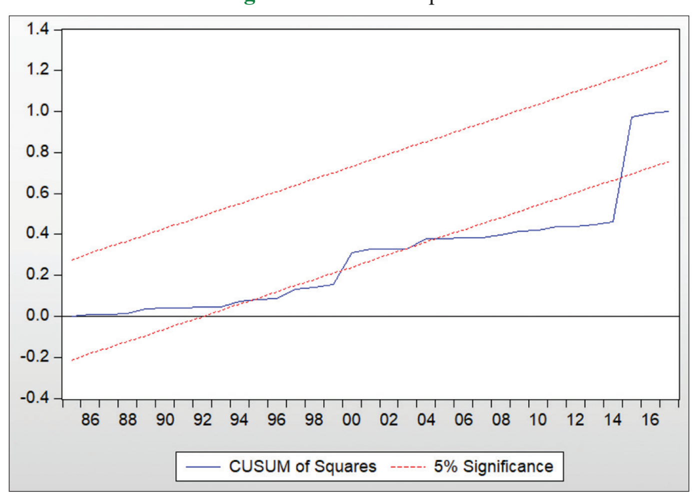
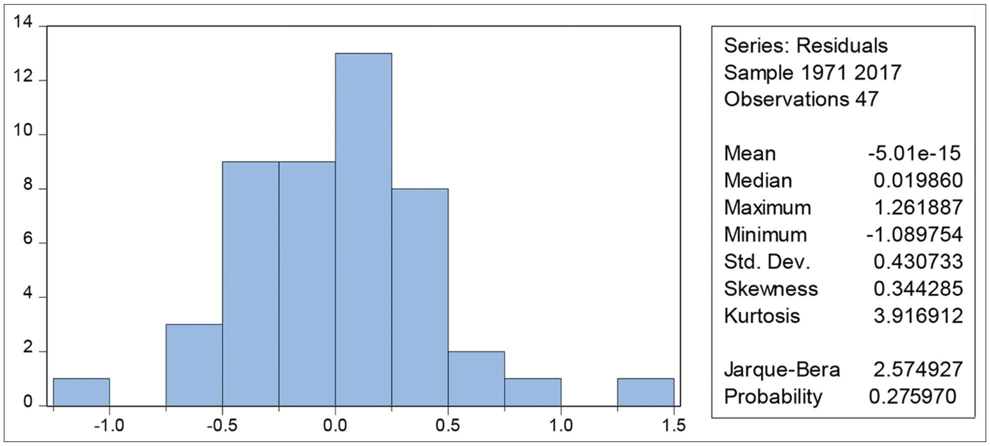


Figure 3: CUSUM square



also shows that there is also unilateral causality from economic growth to energy consumption. The implication for this kind of result is huge and enormous, it basically shows that the country

Figure 4: Jacque-Bera normality test



has been growing at the expense of the environment. However, this does not come as a shock as the country keeps pumping more crude oil into the world market at the risk of environmental degradation and climate change. Finally, there is unilateral causality from trade openness to urban population and also from trade openness to economic growth. This means that as the country's import and export is affecting the urbanization growth rate and economic activities overtime.

5.6. Diagnostic Tests

In order to ensure that the model used in this study is devoid of econometrics problems, diagnostic tests were carried out to check for goodness of fit, serial correlation, heteroscedasticity, conditional heteroscedasticity and normality. The results are stated below in Table 8.

From the Table 8, it was confirmed that the error terms of the short run models have no serial correlation, no heteroscedasticity or conditional heteroscedasticity. Furthermore, the stability of the long run parameters was tested using the cumulative sum of recursive residuals (CUSUM). The results are presented in Figures 2 and 3.

From the Figure 2, the results fail to reject the null hypothesis at 5% level of significance because the plots of the tests fall within the critical limits. Therefore, it can be realized that the selected ARDL models are stable in the long run. The results from the CUSUM square (Figure 3) shows slight deviation from 1995 to 1999 and from 2004 to 2014 but return back to into the 5% boundary.

The null hypothesis for Jacque-Bera normality test is that sample data are normally distributed while the alternative hypothesis is that the sample data are not normally distributed. Therefore, from the result in Figure 4, we reject the null hypothesis that the data used are normally distributed.

6. CONCLUSION AND POLICY IMPLICATIONS

The nexus between urbanization, economic growth, CO_2 emission and energy consumption have received some measure of attention in extant studies. However, there is dearth of knowledge how such mechanism operates with respect to the channel of influence. Prodded with the above, this study extends the frontiers of knowledge in this area by examining the relationship between these variables and how its shape the relationship between man and the environment in Nigeria. These objectives were achieved by analyzing the trend of energy consumption and carbon dioxide on one hand and between urban population and GDP per capita on the other hand. The study also employed autoregressive distributed lag (ARDL)-Bounds testing technique in analyzing time series data spanning a period of 47 years (1970–2017). The empirical analysis showed that rapid urbanization, increase in energy consumption and persistent economic growth will have negative effect on Nigeria's carbon dioxide emission level over time.

Therefore, there is need to, as a matter of urgency shift focus away from over-reliance on petroleum products and explore other greener ways of generating power such as investing in hydro power plants instead of using gas plants. Another unique way of generating power is by investing in solar energy, as luck will have it Nigeria is located along the sub-Sahara Desert which the country can tap into the abundant sunlight to generate power.

In conclusion, this research has proven that with the fast rate of urbanization in Nigeria, rapid economic growth and increasing demand for energy for industrialization the negative side effect is been reflect in the CO_2 emission of the country. Increasing CO_2 emission means Nigeria is also contributing to climate change even if it is by small margin. Finally, in order to avoid natural disasters in the future government must ensure that gradual diversification programs are implemented from an oil-based economy to a sustainable development-driven country.

As obvious as it is that energy is the magic wand that can change the story overtime. Based on the findings, this research recommends these measures:

1. In order to tackle population explosion, there is need for urgent intervention by the Federal government in ensuring the use of contraception and to encourage family planning. This will help in reducing high rate of poverty especially in those areas where they have high birth rates.

2. Increasing population growth puts pressure on the environment, so therefore policies must be put in place to address the issue of deforestation and oil pollutions.
3. Government should develop a lasting solution to the state of infrastructural deterioration such as health care, good road networks, quality education and reducing poverty.

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