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DOES URBANIZATION INTENSIFY CARBON EMISSIONS IN NIGERIA?

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Abstract:

This study examines the urbanization and CO_2 emissions nexus in Nigeria using the Autoregressive Distributed Lag (ARDL) method to analyze the annual time series data spanning from 1974 to 2015. Findings suggest that urbanization, GDP, energy use, and carbon emissions are strongly and positively correlated, while trade and carbon emissions exhibit a weak and negative correlation. The ARDL result shows a negatively significant short-term and long-term connection between urbanization and carbon emission in the Nigerian economy. In the short-term, GDP, trade and energy use positively affect carbon emission while in the long-term, trade and GDP negatively affect carbon emissions with energy use having a positive impact on carbon emissions. The study, therefore, concludes that urbanization does not cause carbon emission to rise in Nigeria, but energy use does. From the findings, it was recommended that there is a need for the use of energy-saving and environmentally friendly technology to reduce the amount of carbon emission in the economy.

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INTRODUCTION

In the pursuit of sustainable energy development as one of the foremost goals of every nation, several factors must be taken into consideration. Chief among these are improved energy efficiency and sustainability (Liu *et al*., 2017). However, it has been argued that some of the main factors contributing to increased environmental degradation are economic activities and unrestricted energy use (Abdallh & Abugamos *et al* 2017). Human activities undeniably contribute to an increase in greenhouse gases and depletion of the ozone layers. Furthermore, daily human activities in most cases inversely relate to the ecosystem and sometimes lead to environmental damages and, if not urgently addressed, may claim human lives and harm the significant factors of production (Ali *et al*., 2016a). Moreover, economies with poor environmental awareness and increased urbanization may trigger higher levels of environmental degradation.

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Although several researchers agree that urbanization increases output, economic profits, affluence and inspiration to reshape politics, arts, science, and other human interests in an economy (see, Stewart and Lee, 1986; Glaeser, 2011; and Ali *et al*., 2016, among others), Bloom *et al*. (2008) add that urbanization also triggers the quick spreading of infections, increased crime, poverty, and may also lead to the degradation of environmental quality. United Nations (2014) projects that rural-urban migration comes 2050 may increase to 70 percent from the 50 percent noted in 2014, and much of this is most likely to occur in Africa. Findings from this projection formed the major discussion at the 2016 Habbit III Conference which took place in Ecuador (Quito), with growing concerns on how to devise the means to avert the negative impact of urban growth on the environmental quality of the continent.

The relationship between urbanization and environmental quality has been a major source of controversy among notable scholars and policymakers. Remarkably, the recent literature is marked with various empirical claims about the connection between urbanization and environmental quality across different economies (see, for example, Zhu *et al*, 2012; Sadorsky, 2013; Wang *et al*., 2015; Ali *et al*., 2016; and Bilgili *et al*., 2017, among others). However, this paper investigates a sensible number of them and notices divergence in their findings. Factors, for example, the idea of nations examined, the models evaluated, the fundamental arrangement of statistical properties, estimation strategies utilized, and data coverage might be answerable for the varied discoveries.

This study revisited the literature on urbanization-environmental quality nexus on the following point of view: First, this paper investigates the connection between urbanization and environmental quality in Nigeria, and from the observations in the literature, a few investigations on the urbanization-environmental quality nexus has been carried out in Nigeria (see e.g., Martínez-Zarzoso, 2008; Enete and Ayadiulo, 2012; and Adusah-Poku, 2016), with inconclusive findings.

A study about Nigeria is important due to its massive population and rapid rate of development, all of which could negatively affect the country's environment. Secondly, this paper adopts the STIRPAT model (*i.e*. Stochastic Impact Regression on Population, Affluence and Technology), which has gained much attention in environmental policy analysis in most researches. The main idea behind the model is that the standard of living in urban centers and the demographics are factors considered in determining environmental quality. This is unlike the Environmental Kuznet Curve (EKC) hypothesis, which only considers an increase in per capita income as the main determinant of environmental quality and may lead to erroneous conclusions. Thirdly, the Autoregressive Distributive Lag (ARDL) model founded by Pesaran *et al* (2001), which is capable of considering time series of different orders of integration was adopted, while also allowing for structural breaks using the Bai – Perron unit root test which endogenously discovers as far as five (5) likely breaks. The issue of structural breaks is vital due to the evidence of volatility and significant changes in the time series data employed, and neglecting structural breaks in the data employed when they actually exist may lead to erroneous estimates. The study also adopts the Granger causality test to validate the causality nexus among urbanization and carbon emissions. In structural analysis, the positive hypothesis regarding the causal arrangement of the investigated data is required, while the subsequent causality effect of sudden surprises or advancement to stated variables on the variables used in the model are summarized.

Other parts of this paper are separated into four sections. The second part includes the literature review and the third part discusses the methodology used for the study. The fourth part presents the analytical framework of the study, while the last part concludes and proffers policies.

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LITERATURE REVIEW

The Environmental Kuznet Curve proposition has spurred the interest of many scholars over the years. According to Kuznet (1956), as the economic activities of a country increases, it attracts more investment opportunities, and bring in cheaper labor from the rural areas to urban centers to participate in industrialization, ignoring the initial mainstay (agriculture) for a better-paying job. Kuznet (1956) argues that in the process of migrating, the average wage inequality will reduce after 50 percent of population has migrated, but will get to a certain stage whereby the effect will have an inverted U-shaped curve. Going by Kuznet proposition, the theory implies that as the number of rural-urban migration increase because of improved economic activities, the environmental quality of the economy starts to degenerate gradually. However, this has been found to be subjective as the data used by Kuznet (1956) were more of middle-income countries in Latin America, thus generating a debate as to its evidence in other country groups, particularly low-income countries.

Meanwhile, Dietz and Rosa (1994, 1997) argue against this assertion from the opinion that this model limits the determinant of environmental degradation to economic growth alone. They introduce the STIRPAT model which has gained much attention in environmental policy analysis in most researches. The main idea behind the model is that standard of living in the urban city and demographics are factors to be considered in determining environmental quality.

Empirically, Poumanyvong and Kaneko (2010) analyzed the urbanization effect on CO_2 emissions and energy consumption using a STIRPAT model and a balanced panel data analysis for a sample of 99 nations spanning from 1975 to 2005. The study verified that the impact of urbanization on CO_2 emissions and energy consumption depends on the levels of the economies development. It further subscribed that, urbanization reduces energy consumption in low-income class, and causes energy consumption for middle and high-income classes to rise. Besides, the study noted that urbanization in all the income groups positively impacted carbon emissions, but more was reflected in the middle and high-income classes. Zhu, You and Zeng (2012) revisited the Environmental Kuznet Curve (EKC) by analyzing the data spanning from 1992 to 2008 for 20 emerging countries using semi-parametric panel data model with fixed effects. They noted little evidence for the inverted U-shape and could not confirm the Kuznet hypothesis in their analysis as they found a nonlinear connection among urbanization and carbon emissions. Evidence from 16 emerging countries, Sadorsky (2014) leaned on the STIRPAT model and applied panel regression technique to assess the link between urbanization and carbon emissions between 1979 and 2009. The findings showed that the effect of urbanization on CO_2 emissions in those countries is positive, but not statistically significant.

For the period 1983 to 2005, De Leon Barido & Marshall (2014) examined how the national level of CO_2 emissions reacted to urbanization and environmental policies in 80 countries by using panel data analysis. Findings from their study suggest that, for the random and fixed effects, carbon emission increases by 0.95% for every 1% increase in urbanization, and for every economy with a strong environmental policy, urbanization has demonstrated more benefits to environmental quality. Their result showed specifically that the elasticity effect for higher-income and lower-income countries are -1.1 and 0.21 for an economy with a strong environmental policy, while it is 0.65 and 1.3 for economies with a weaker environmental policy, respectively. Incorporating the quadratic form of urbanization into the STIRPAT model, Wang *et al.* (2015) also adopted semi-parametric panel data regression analysis to explore the carbon emissions impact of urbanization in OECD countries. They confirmed from their findings that the Environmental Kuznets Curve hypothesis holds in the OECD countries.

For 22 urbanized emerging economies, Rafiq *et al*. (2016) clarified the link between urbanization, trade openness, CO_2 emissions and energy intensity by employing heterogeneous panel data analysis for a dataset spanning the period 1980 to 2010. The analysis showed that urbanization increases energy intensity and CO_2 emissions, while trade openness reduces both energy intensity and CO_2 emissions.

For the developing countries, Sadorsky (2013) adopts panel heterogeneous regression analysis to evaluate the energy intensity effect of industrialization, urbanization and income in 76 developing economies. The result reveals that energy intensity reduces by -0.45% to -0.35 when income increase by 1%. The elasticities of industrialization stretch between 0.07 to 0.12 in the long-term. The study further argued that the urbanization impact on energy intensity is mixed as its coefficient is slightly greater than unity when it is statistically significant. In China, Sheng and Guo (2016) applied dynamic fixed effect technique, pooled mean group, and mean group to assess the urbanization impact on CO_2 emissions in both short-term and long-term using the data between 1995 and 2011. The findings suggested that urbanization would have a long-lasting impact on CO_2 emissions in the economy of China. Ali *et al*. (2016a) used the ARDL model to examine the impact of urbanization on carbon emission in the economy of Singapore between 1970 and 2015. Their findings revealed that urbanization had a strong adverse impact on CO_2 emissions, while economic growth appeared to impact positively on carbon emission in the economy. They argued that urbanization should not be considered an obstacle to environmental quality when considering policies.

Similar to the findings of Ali *et al*. (2016b), Pata (2017) examines the relationship between urbanization, industrialization, and carbon emission in Turkey between 1974 and 2013 using the ARDL model. The study concludes that in Turkey, urbanization and industrialization decrease the level of environmental quality captured by an increase in carbon emissions per head. In a study carried out on urbanization-carbon emission nexus in 20 MENA using semi-parametric panel fixed effects regression together with panel data between the period of 1980 and 2014, Abdallh and Abugamos (2017) discover little proof for EKC hypothesis, because the environmental quality of the region is found to be significantly supported by urbanization. They further conclude that economic growth and energy consumption are the major causes of CO_2 emissions in the region.

Liu, Yu and Gong (2017) investigates the effect of urbanization and ageing on energy intensity using two-way fixed effect model. Their findings reveal ageing negatively impacts energy intensity, energy intensity and GDP per capita are positively affected by urbanization, while energy prices and productivity negatively affect energy intensity. Bilgili *et al.* (2017) adopt the panel data analysis to examine urbanization-energy intensity nexus in 10 Asian countries between 1990 and 2014. They observe that urbanization has a significantly negative effect on energy intensity in both short-term and long-term. Using the threshold vector error correction method, Liu and Xie (2013) confirmed that the causality connection between energy intensity and urbanization in China is nonlinear. Similarly, Zi *et al.* (2015) examine the link between urbanization and carbon emissions in China using a threshold model. Arguments from their findings suggest the pattern of thresholds varies geographically, and emissions increase when the threshold of 0.43 is surpassed as residential income increases. Moreover, an increase in urbanization and industry percentage in overall GDP causes carbon emissions to rise and fall respectively.

From a comparative study of the urbanization influence on CO_2 emissions for the economy of China and Japan, Ouyang and Lin (2016) find a similar result for the economies as CO_2 emissions show increasing growth during urbanization process in the economies, but a significant difference exists considering energy intensity, energy structure, and carbon dioxide emissions per capita among the two countries, which serves as a determining factor for carbon dioxide emissions growth. He *et al.* (2016) analyze the provincial panel data from 1995 to 2013 for china using the STIRPAT model. They divided the 29 provinces into 3 regions. Findings from the study reveal that the EKC hypothesis hold for the major regions of China. For region 2 and 3, urbanization negatively affects carbon dioxide emissions, while for region 1, only population influences emissions, and not urbanization. Zhang *et al.* (2017) incorporate a panel data consisting of 141 nations spanning between 1961-2011 into a STIRPAT model. Their results for urbanization and CO_2 emissions nexus confirm EKC hypothesis and the turning point is around 73.8%. Yang *et al.* (2017) employ data from 266 prefecture-level cities between 2000-2010 to analyze the urbanization effect on energy used and economic growth in China using the Pooled Ordinary Least Squares (POLS) method. Results from their findings show urbanization positively and significantly affect energy used and economic growth within the period. Wang *et al.* (2015) study nexus among urbanization, energy consumption, and CO_2 emissions in the ASEAN countries between 1980 and 2009 using panel fully modified ordinary least squares method. It was observed that CO_2 emissions rise by 0.20% whenever urban population increases by 1%, a unidirectional causal nexus running from urbanization to CO_2 emissions and energy consumption.

Martínez-Zarzoso (2008) employs heterogeneous panel data regression analysis to examine the relationship between CO_2 emissions and urbanization in selected developing countries. These countries are grouped into three (3); the low group, low-middle-income group and the upper-middle-income group. Findings from the study show that the impact of urbanization is higher than unity, 0.72, and negative for low-income group, low-middle-income group, and upper-middle-income group respectively. Adusah-Poku (2016) investigates the nexus between urbanization, population, and carbon emission in 45 sub-Saharan African countries using pooled mean group (PMG) to analyze the dynamic heterogeneous panels of the data spanning from 1990 to 2010. The study validates a short-term and long-term positive impact of both urbanization and population on carbon emissions and tends to grow faster in economies such as Nigeria and Ethiopia with larger populations, compared to the countries with smaller populations, such as Cape Verde and Equatorial Guinea. Ali *et al.*, (2016b) for the economy of Nigeria adopts the ARDL method and STIRPAT model to explore the effect of energy use, economic growth, urbanization, and trade on CO_2 emissions in Nigeria. Findings from the study suggest energy consumption, economic growth, and urbanization positively impact CO_2 emissions in Nigeria in both short-term and long-term.

In conclusion, it is evident from the review of literature that, while there have been several studies investigating carbon emissions and its relationship across different factors, little or no country-specific study exists on urbanization-carbon emissions nexus in Nigeria. Most of these studies have been subjective and qualitative in nature. The point of departure to this study lies in the adoption of the STIRPAT framework while also making use of the ARDL model, which accounts for the impact of the structural break in analyzing the nexus between urbanization and carbon emissions in Nigeria.

Data and Methodology

The study adopts the STIRPAT model in line with the work of Poumanyvong and Kaneko (2010), Ali *et al.*, (2016b), Ali *et al.*, (2016a), and Zhang *et al.*, (2017) to analyse the link between urbanization and CO_2 emissions in Nigeria. The IPAT model accounts for urbanization as a factor that contributes to increased carbon emissions in the economy. Dietz and Rosa (1994) introduce the Stochastic type of the IPAT equation.

The equation encompasses quantitative variables of population size (P), affluence per capita (A), and industrial weight in economic interaction measured as a polluting technology (T). It is a year based model, specified as;

$$I_i = aP_i^{\beta_o} A_i^{\beta_1} T_i^{\beta_2} \varepsilon_i \tag{1}$$

Where: I_i ,P_i, Ai , and T_i indicate environmental impact (I) population (P), affluence (A), and technology (T) in an economy. i, α, β are the parameters to be estimated; and ε_i is the random error term. According to the pioneers, Dietz and Rosa (1994, 1997), STIRPAT is mainly applied to study the factors that affect the environment. The main argument behind the model is that CO_2 emission is produced by demographics, but varies on the highly efficient standard of living in the urban city. Ali *et al.*, (2016a) submitted that the economic activities in the urban cities may have two different effects: those connected to higher consumption and incomes that promote industrialisation, and attracts the use of fossil fuels.

Following the views of the authors, the model for this study is formulated by adapting the model of Ali *et al.,* (2016b) in the economy of Nigeria, which implies that urbanization, energy use, GDP, and trade are the main factors influencing carbon emissions in the country. The model is, therefore written as:

$$CO_2 = \left(GDP, EU, U, T\right) \tag{2}$$

Energy consumption per capita (oil equivalent), Urbanization rate, and Trade (calculated as the ratio of import plus export to GDP at current LCU). respectively Equation (2) is further transformed into a logarithm function as:

$$InCO_2 = \beta_0 + \beta_1 InGDP_t + \beta_2 InEU_2 + \beta_3 U_t + \beta_4 T_2 + \varepsilon_t \tag{3}$$

For this study, the ARDL model, which is permitted for variables stationary at I(0), I(1), or a combination of I(0) & I(1) is used. It is also used because of its ability to estimate both the short-run and long-run magnitudes, as well as the error correction value.

In order to estimate equation (3), the associated conditional standard autoregressive distributed lag ARDL (p, j_1, j_2, j_3, j_4) long run model for CO_{2i} can be expressed as:

$$InCO_{2t} = c_0 + \sum_{q=1}^{p} \beta_1 InCO_{2_{t-1}} + \sum_{q=0}^{j_1} \beta_2 InGDP_{t-i} + \sum_{q=0}^{j_2} \beta_3 InEU_{t-i} + \sum_{q=0}^{j_3} \beta_4 InU_{t-i} + \sum_{q=0}^{j_4} \beta_5 T_{t-i} + \varepsilon_t \tag{4}$$

However, accounting for structural breaks, the breaks are captured using $\sum_{r=1}^{s} B_r Dummy_{rt}$ in equation 5 where $Dummy_{rt}$ is a dummy variable accounting for every breaks termed as $Dummy_{rt} = 1$ for $t > T_B$ or else $Dummy_{rt} = 0.t$ represents the time period; T_B are the dates of the structural break, where r =1, 2, 3,……., k and Br is the break dummy coefficient.

$$InCO_{2t} = c_0 + \sum_{q=1}^{p} \beta_1 InCO_{2_{t-1}} + \sum_{q=0}^{j_1} \beta_2 InGDP_{t-i} + \sum_{q=0}^{j_2} \beta_3 InEU_{t-i} + \sum_{q=0}^{j_3} \beta_4 InU_{t-i} + \sum_{q=0}^{j_4} \beta_5 T_{t-i} + \sum_{q=0}^{s} \beta_r Dummy_{rt} + \varepsilon_t \tag{5}$$

The short-term dynamic parameters of the impact of urbanization on carbon emission is obtainable by estimating the equation as;

$$\Delta InCO_{2t} = \vartheta_0 + \sum_{q=1}^{p} p_1 \Delta InCO_{2_{t-j}} + \sum_{q=0}^{j_1} p_2 \Delta InGDP_{t-j} + \sum_{q=0}^{j_2} p_3 EU_{t-j} + \sum_{q=0}^{j_3} p_4 U_{t-j} + \sum_{q=0}^{j_4} 5_5 \Delta T_{t-j} + \vartheta ecm + \varepsilon_t \quad (6)$$

From equations 4 to 6, $\beta_1 - \beta_5$ serves as the variables long-term multiplier. While $p_1 - p_5$ are the variables short-term multipliers, $c_0 and \vartheta_0$ are the long-term and short-term intercept of the models. $j_1 - j_4$ are the length of optimal lags for each of the variables. ecm_{t-1} is the error correction term defined as;

$$ECM_{t-1} = \Delta InCO_{2t} - \vartheta_0 - \sum_{q=1}^{j_1} p_2 \Delta GDP_{t-j} - \sum_{q=1}^{j_2} p_3 EU_{t-j} - \sum_{q=1}^{j_3} p_4 U_{t-j} - \sum_{q=1}^{j_4} p_5 \Delta T_{t-j} \quad (7)$$

The causal link between the dependent and independent variables is tested using the granger causality test. The model is expressed as;

$$\Delta Z_t = \mu_t + \sum_{t=1}^{p-1} \Gamma_i \Delta Z_{t-1} + \Pi Z_{t-p} + \varepsilon_t \quad (8)$$

Z_t is a 5x1 vector matrix of the endogenous variables (CO_2, GDP, EU, U and T). $\Gamma_i \Delta Z_{t-1} + \Pi Z_{t-p}$ is a vector, with a lag operator and $\in_t$, a vector of idiosyncratic errors.

Discussion of Results

Descriptive Statistics

The descriptive statistics result represented in Table 1 shows that the variables' value for mean lies within their lowest and highest values. On average, within the period under study, the variables- CO_2, Urbanization, GDP per capita, Energy use and Trade grow an average of 11.13%, 34.96%, 10.02%, 6.58% and 0.51% respectively. The result of the skewness reveals that carbon emissions, per capita GDP, and trade are negatively skewed, while Urbanization and energy use reveal a positive skewness. Following the kurtosis result, the study concludes that the variables are leptokurtic in nature, as they have values less than three. The Jarque-bera statistics result showed that the entire variables are normally distributed with a probability distribution value greater than 10%.

Table 1: Descriptive Statistics

	$InCO_2$	UR	InGDP	InEU	T
Mean	11.1296	34.9636	10.0177	6.5763	0.5120
Maximum	11.5588	47.7760	13.1718	6.6825	0.8181
Minimum	10.4123	23.3890	6.5405	6.5095	0.2112
Std. Dev.	0.3657	7.1085	2.2210	0.0486	0.1685
Skewness	-0.5181	0.1835	-0.1797	0.4250	-0.2433
Kurtosis	1.8397	1.9466	1.7330	1.9878	2.0274
Jarque-Bera	3.4282	1.7629	2.4574	2.4750	1.6754
Probability	0.1801	0.4142	0.2927	0.2901	0.4327
Observations	34	34	34	34	34

Source: Author's Computation (2018)

Correlation Test

The correlation result showed that the correlation relationship between the entire variables and carbon emissions is strongly positive and statistically significant, except for trade, which was negative and insignificant. This means that strong nexus exists among energy use-carbon emission, GDP-carbon emission, urbanization-carbon emission, and are significant at 1%, while the weak negative relationship between trade and CO_2 emission is insignificant and weak. This validates the absence of the multicollinearity problem among the variables. The result is presented in Table 2 below:

Table 2 *Correlation Matrix Test Results*

	$\ln CO_2$	UR	lnGDP	lnEU	T
$\ln CO_2$	1				

UR	0.6044	1			
	(0.0002)	-----			
lnGDP	0.5536	0.9823	1		
	(0.0007)	(0.0000)	-----		
lnEU	0.7237	0.8749	0.8532	1	
	(0.0000)	(0.0000)	(0.0000)	-----	
T	-0.1903	0.1264	0.2443	0.0919	1
	(0.2811)	(0.4761)	(0.1638)	(0.6053)	-----

( ) in parenthesis denotes the probability values of the variables

Source: Author's Computation (2018)

Unit Root Test

As a prerequisite for analyzing time series data with large T, it is common practice in the literature to test the series for non-stationarity. Hence, the study subjects all the series used in the model to unit root testing. The study adopts the Ng-Perron test for stationarity. The null-hypothesis of the nonstationary test states there is absent of unit root among the series.

The unit root test is a compulsory test to show if the data used for the study are free from unit root problems. From the results in Table 3, the variables are stationary at I(0) and I(1). This suggests the presence of unit root problem in the data used as all the variables are not mean, reverting at levels as some only converge to long-term equilibrium after first differencing. To check if there is a long-term relationship among the variables, the ARDL bounds test is employed. Another innovation of this study is the adoption of the Bai-Perron (2003) structural break test, which is capable of determining five (5) possible breaks endogenously. Testing for structural breaks allows us to deal with multiple structural changes in the model, failure of which could lead to spurious conclusions. Capturing the structural breaks link between Urbanization-Carbon emission nexus is, however, the first in the context of Nigeria.

Table 3: *Ng Perron Unit Root Test Results [Trend and Intercept]*

	MZa	MZt	MSB	MPT
		Levels		
InCO_2	-6.340	-1.776	0.280	14.371
U	-33.766***	-4.040***	0.120***	3.080***
InGDP	-6.579	-1.672	0.254	13.884
InEU	-18.095***	-2.978***	0.165***	5.213***
T	-7.118	-1.674	0.235	13.072
		First Difference		
InCO_2	-15.960*	-2.824*	0.177*	5.716*
U	-4.835	-1.555	0.322	18.847
InGDP	-15.750*	-2.781*	0.177*	5.935*
InEU	-15.859*	-2.773*	0.175*	5.995*
T	-15.025***	-2.733***	0.182***	1.659***

Note: *, **, *** implies the level of significance at 10%, 5% and 1% respectively.
Source: Author's Computation (2018)

The optimal lag test was also carried out in the study to know the correct number of lags to use for the study. Schwarz Information Criteria (SIC) was used to decide on the optimal lag length. The finding shows an optimal lag selection of 2, which was used in the study. Table 4 below shows the result:

Table 4: *Optimal Lag test result*

Lag	LogL	LR	FPE	AIC	SIC	HQ
0	-21.6378	NA	3.84E-06	1.7186	1.9499	1.79396
1	176.02	318.803	5.72E-11	-9.4207	-8.0329	-8.9683
2	219.8772	56.5898***	1.94E-11	-10.6372	-8.0931***	-9.8079
3	254.5179	33.5233	1.54e-11***	-11.2592***	-7.5586	-10.0529***

Source: Author's Computation (2018)

The result of the bounds test reveals the existence of a cointegrating link among the variables in the long-term. This is validated by F-statistic value found to exceed the maximum and the minimum bound class of the variables at a 5% significance level. The result is showed in table 5 below:

Table 5: *ARDL Bounds Test Result*

DEP/VARIABLES	F-Stat	Bounds (5%)		Outcome
		I(0)	I(1)	
InCO_{2t}=f(UR_t, InGDP_t, InEU_t, T_t)	4.75	3.47	4.57	Co-integration

Source: Author's Computation (2018)

In addition, the study examines the significance of structural breaks in the urbanization-emissions nexus. To determine the breaks, the Bai-Perron (2003) test was adopted; therefore incorporated into the model as fixed regressors in the ARDL model. The Bai-Perror break test result is reported in Table 6 below, and only one break is recorded for Nigeria. The break date identified to correspond with the sequence of OPEC cuts during that period which may have affected energy use.

Table 6: *Bai-Perron (2003) Structural Break Dates*

Country	*Break Period*	*Break Range*
Nigeria	2000	1982 - 1999 2000 - 2015

Compiled by the author

ARDL Estimation

From the results of the unit root test, it was revealed that all the variables examined were not integrated of order 2, and therefore, we go on to estimate the ARDL model. As a benchmark, we first ran the ARDL model analysis without considering structural breaks. This was done to establish the existence of a long-term nexus among the variables. To carry out this, we used F-test proposed by Pesaran *et al*. (2001) to test the null hypothesis of no cointegration against the alternative hypothesis of co-integration. The maximum of 2 lags suggested by SIC is used as an optimal number of lags on each first-differenced variable. The results of the bounds test suggest that a long-term co-integrating nexus exists among the variables. This is validated by F-statistic value found to exceed both the upper and lower bound class of the variables at a 5% significance level (see Table 5).

The long-term and short-term ARDL estimation result for both scenarios (with and without breaks) are presented in Table 7. In the short-term, findings from the result support the presence of a significantly negative connection between urbanization and carbon emissions in Nigeria. Significantly, a unit development in urbanization results in approximately 50% reduction in carbon emissions. Similarly, the result reveals an adverse significant connection between trade and CO_2 emissions both with and without breaks. In the same vein, evidence supports the presence of a negatively significant connection between GDP and carbon emissions. Specifically, a percentage increase in GDP leads to approximately 33% reduction in carbon emissions in the short-term. However, taking structural breaks into account, the relationship is positive but insignificant.

On the other hand, energy used exhibits a positively significant connection with carbon emissions in Nigeria. In particular, a percentage increase in energy use will cause carbon emissions to rise by 6.16% in the short-term, and a similar result was observed while accounting for breaks. This implies that irrespective of the consideration of breaks, the energy use affects carbon emissions negatively.

From the short-term results, it can be deduced from the result that increases in carbon emissions in Nigeria can actually be attributed to increased energy consumption, not urbanization. Overall, the result reveals that the independent variables have the ability to correct about 76% of deviations of emissions from the expected equilibrium in the long-term back to equilibrium. This satisfies the a priori expectation of the error correction result which is negatively significant at a 1% significance level. The result can be seen in Table 7.

The long-term results from the model estimation provide evidence on behalf of a significantly negative connection between carbon emissions and urbanization, GDP, and trade in Nigeria. In particular, a unit change in urbanization and trade and a percentage change in GDP causes emission to fall by 65%, 1.78% and 1.09% respectively. Similar to observations in the short-term, there is strong evidence of a positively significant connection between energy use and carbon emissions with and without breaks.

From the ARDL findings, the results are found to be in consonance and against the submission of some existing studies. The long-term and short-term results of the urbanization-carbon emission nexus is against the submission of Sadorsky (2014) for 16 emerging countries, de Leon and Marshall (2014) for 80 countries, Ouyang and Lin (2016) for Japan and China, and Wang *et al.*, (2016) for ASEAN countries, but confirms the findings of Ali et al. (2016a) for Singapore and Pata (2017) for Turkey, in that a negatively significant nexus exists between urbanization and CO_2 emissions in Nigeria. The results deviate from the submission of these studies because they are panel analyses and not country-specific. Against the study of Ali *et al.*, (2016b) for Nigeria, the study argued that the reaction or changes in consumer behaviour towards energy consumption due to the implementation of several environmental policies (such as the Paris Climate Change Agreement) and the introduction of new energy-efficient technologies (solar systems, among others) into the economy may have caused the deviation of the study findings from Ali *et al.* (2016b) in the long-term. The findings of our study conformed with that of Ali *et al.* (2016b) which only exist in the short-term, but are not valid in the long-term. Moreover, the result agrees with Bilgili *et al.* (2017) and Abdallh and Abugamos (2017) that urbanization is a significant determinant factor of reduction in carbon emissions in Nigeria. The findings also corroborate the findings of Abdallh and Abugamos (2017), which state that energy use is the major source of carbon emissions in a developing country like Nigeria.

Finally, findings from the study suggest breaks are significant in urbanization-carbon emissions nexus in Nigeria in both the long-term and the short-term. Moreover, the results of the diagnostic checks suggest the absence of serial correlation and heteroscedasticity (see Table 7):

Table 7: *ARDL Estimation Result*

Variables	ARDL Without Breaks	ARDL With Breaks
	Long Run Results	
Constant	*-23.9420* *(-2.5149)***	*-48.0845* *(-4.0273)****
Trend	*0.7048* *(6.9686)****	*0.5117* *(3.2651)****
UR	*-0.6547* *(-6.5520)****	*-0.5528* *(-4.2557)****
lnGDP	*-1.0932* *(-5.3958)****	*-0.6462* *(-2.2420)***
lnEU	*8.8199* *(5.7639)****	*11.7661* *(5.9487)****
T	*-1.7795* *(-4.8019)****	*-2.1752* *(-5.3343)****
B	--	*0.3465* *(1.9572)**

	Short Run Results	
Constant	*-18.2453* *(-2.6459)***	*-53.9210* *(-3.8023)****
ΔTrend	*0.5371* *(5.5315)****	*0.5738* *(3.0594)***
ΔlnCO$_{2t-1}$	--	*0.3303* *(2.1840)**
ΔUR	*-0.4989* *(-5.9901)****	*-0.6199* *(-3.9151)***
ΔlnGDP	*-0.3341* *(-2.2275)***	*0.0048* *(0.0325)*
ΔlnGDP$_{t-1}$	*0.2355* *(1.4856)*	*0.3839* *(1.6861)*
ΔlnEU	*6.7213* *(5.5443)****	*6.1678* *(4.4224)****
ΔlnEU$_{t-1}$	--	*-0.2128* *(-0.1164)*
ΔlnEU$_{t-2}$	--	*-0.3435* *(-0.1901)*
ΔlnEU$_{t-3}$	--	*-3.3827* *(-2.3898)***
ΔT	*-0.6509* *(-2.8461)****	*-1.0811* *(-3.9002)****
ΔT$_{t-1}$	*0.5597* *(2.2781)***	*0.3862* *(1.6740)*
ΔT$_{t-2}$	--	*0.4786* *(1.8959)**
ΔT$_{t-3}$	--	*0.7660* *(2.6880)***
B	--	*0.3885* *(1.8897)**
ECM$_{t-1}$	*-0.7621* *(-6.3034)****	*-1.1214* *(-8.1050)****
F-stat.	26.4063***	30.7841***
Bound F-stat.	4.7482**	14.1064***
Adj. R²	0.8913	0.9487
J.B stat	0.7981 [0.6710]	0.3384 [0.8443]
LM (1)	0.5795 [0.5698]	1.2491 [0.3321]
ARCH (1)	0.7556 [0.3919]	0.0161 [0.9001]
Ramsey test	7.5344 [0.0125]	2.1748 [0.1711]
Lag Selection (SIC)	(1,0,2,0,2)	(2,0,2,4,4)

*B represents dummy for the identified break date as identified in the Bai Perron test presented in Table 6. Standard errors are presented in brackets and probability values are presented in parentheses. The critical values for the Lower and Upper Bounds respectively are 3.03 and 4.06 for the symmetric models at 10% significance level. ***, **, and * indicate statistical significance at 1%, 5% and 10% respectively.*

Granger Causality Test

Further testing on the causality nexus among the variables that was carried out. From the result, it was discovered that a uni-directional causality nexus between CO_2 to urbanization and CO_2 to trade at a 5% significance level. This implies that emissions drive urbanization and that urbanization does not explain emissions in Nigeria. Likewise, there is no causality nexus between GDP and CO_2, EU and CO_2. The implication of this is that emission is the reason behind the act of urbanization in Nigeria. See the result below in Table 8:

***Table 8**: Granger Causality Result*

Null Hypothesis:	Obs	F-Statistic	Prob.
UR does not Granger Cause LOGCO	32	1.1785	0.3231
LOGCO does not Granger Cause UR		9.9270	0.0006
LOGGDP does not Granger Cause LOGCO	32	1.5367	0.2333
LOGCO does not Granger Cause LOGGDP		1.3275	0.2819
LOGEU does not Granger Cause LOGCO	32	1.6443	0.2119
LOGCO does not Granger Cause LOGEU		0.0413	0.9596
T does not Granger Cause LOGCO	32	0.4359	0.6511
LOGCO does not Granger Cause T		3.8337	0.0342
LOGGDP does not Granger Cause UR	32	0.4437	0.6462
UR does not Granger Cause LOGGDP		1.0920	0.3499
LOGEU does not Granger Cause UR	32	0.0478	0.9534
UR does not Granger Cause LOGEU		6.7583	0.0042
T does not Granger Cause UR	32	1.0835	0.3527
UR does not Granger Cause T		1.4061	0.2625
LOGEU does not Granger Cause LOGGDP	32	2.8221	0.0771
LOGGDP does not Granger Cause LOGEU		3.6717	0.0389
T does not Granger Cause LOGGDP	32	0.8766	0.4277
LOGGDP does not Granger Cause T		2.5914	0.0934
T does not Granger Cause LOGEU	32	0.9376	0.4039
LOGEU does not Granger Cause T		3.2484	0.0544

Source: Author's computation (2018).

CONCLUDING REMARKS

This paper investigates the link between urbanization and carbon dioxide emission in Nigeria using annual data from 1984 to 2015. The ARDL technique is used to analyse the data. Results from the study provide evidence of a positively significant correlation between CO_2 emission and urbanization in Nigeria. The ARDL bounds test confirmed a cointegration nexus among the variables in the long-term. From the ARDL estimation result; urbanization, GDP, and trade negatively affect carbon emissions in the short-term and long-term in Nigeria. Energy consumption shows a positively significant nexus with carbon emissions in the short-term and long-term, taking into account breaks. This, by implication, means that, as urbanization, GDP, and trade incline towards reducing the amount of carbon emission into the atmosphere in the long run, energy use causes the environmental quality to diminish. This could be as a result of the migrants' exposure to more efficient energy products, such as the renewable energy products, which aid against the use of inefficient energy products, such as oil equivalent energy use, which contributes more to carbon emission. From the causality test result, findings suggest carbon emissions drive urbanization in Nigeria. The study concludes from the findings that urbanization is not a significant factor in contributing to an increase in carbon emissions, but rather energy use. However, we recommend policies to reduce the amount of carbon emission through energy conservation, and that efficiencies should be adopted. This is achievable through the adoption of efficient renewable energy technologies.

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year	Carbon Emission (kt)	GDP per Capita (current LCU)	Energy Use per capita (oil equivalent)	Urban Population (ratio of total)	Trade (% of GDP)
1971	32280.6	181.0867	579.0964	18.151	0.244636
1972	41426.1	188.1045	585.4539	18.549	0.227636
1973	49577.84	203.8182	597.1382	18.952	0.312678
1974	62291.33	317.8672	600.4265	19.363	0.39747
1975	47395.98	362.0658	608.4557	19.78	0.411703
1976	55247.02	438.6487	622.2918	20.205	0.421381
1977	50567.93	499.6593	636.2368	20.636	0.473953
1978	48294.39	520.2937	645.8924	21.074	0.433148
1979	70289.06	601.0817	653.1639	21.518	0.438784
1980	68154.86	684.3113	665.1001	21.97	0.485713
1981	65958.33	685.3477	676.3869	22.671	0.482933
1982	65602.63	692.6157	691.7809	23.389	0.377485
1983	59929.78	729.4444	693.5561	24.122	0.270372
1984	69625.33	789.3021	677.7652	24.872	0.236089
1985	69893.02	879.5493	682.8194	25.635	0.259001
1986	73505.02	872.868	671.499	26.414	0.237168
1987	59343.06	1270.271	676.8561	27.209	0.416467
1988	70747.43	1635.607	678.8559	28.019	0.35312
1989	42441.86	2460.585	684.4483	28.842	0.603918
1990	38162.47	2955.288	697.1921	29.68	0.530302
1991	40014.3	3367.268	712.2482	30.176	0.648766
1992	64289.84	5542.176	721.9704	30.677	0.61031
1993	58268.63	6960.196	715.4378	31.182	0.581098
1994	44865.75	8974.894	680.7101	31.691	0.423089
1995	33267.02	18595.84	682.2696	32.205	0.597678
1996	38936.21	25277.37	693.7783	32.725	0.57691
1997	40175.65	25603.91	699.6507	33.247	0.7686
1998	40164.65	24198.89	687.1179	33.773	0.661732
1999	44774.07	27757.66	694.1713	34.304	0.558464
2000	79170.53	38555.41	703.2447	34.84	0.713805
2001	83339.91	39131.13	720.0472	35.669	0.818128
2002	98114.25	55400.52	724.6113	36.508	0.633836
2003	93130.8	66245.96	746.6122	37.356	0.752189
2004	97039.82	86219.74	748.3413	38.212	0.484481
2005	104689.2	106055.7	757.9587	39.074	0.507484
2006	98891.66	131191.7	744.5452	39.943	0.646093
2007	95055.97	143022.4	750.7831	40.819	0.644629
2008	96148.74	164055	752.8598	41.702	0.64973
2009	76735.64	163443.7	721.4534	42.588	0.618029
2010	92016.03	349791.6	755.9892	43.48	0.426514
2011	96093.74	391174.5	778.4994	44.362	0.527941
2012	99636.06	433955.8	798.3031	45.234	0.443801
2013	95650.03	471456.1	779.8515	46.094	0.310489
2014	99741.91	510805.4	763.3914	46.942	0.308852
2015	101750.1	525316.4	746.9312	47.776	0.211244

Source: World Development Indicators (2016)

DA LI URBANIZACIJA POJAČAVA EMISIJU UGLJENIKA U NIGERIJI?

Rezime:
Ova studija ispituje odnos urbanizacije i emisije CO_2 u Nigeriji primenom metode autoregresivne distribucije kašnjenja (ARDL) za analizu podataka o godišnjim vremenskim serijama u rasponu od 1974. do 2015. Rezultati studije sugerišu da urbanizacija, BDP, upotreba energije i emisija ugljen dioksida snažno i pozitivno. koreliraju, dok trgovina i emisije ugljen dioksida pokazuju slabu i negativnu korelaciju. Rezultat ARDL pokazuje negativno značajnu kratkoročnu i dugoročnu vezu između urbanizacije i emisije ugljen dioksida u ekonomiji Nigerije. Kratkoročno, BDP, trgovina i upotreba energije pozitivno utiču na emisiju ugljen dioksida, dok dugoročno trgovina i BDP negativno utiču na emisiju ugljen dioksida upotrebom energije koja ima pozitivan uticaj na emisiju ugljen dioksida. Stoga, studija zaključuje da urbanizacija ne uzrokuje porast emisije ugljen dioksida u Nigeriji, ali upotreba energije uzrokuje. Na osnovu rezultata preporučena je neophodnost upotrebe štedljive energije i ekološki prihvatljive tehnologije za smanjenje količine emisije ugljenika u ekonomiji.

Ključne reči:
ARDL,
emisije CO_2,
STIRPAT model,
urbanizacija**.**