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# THE CAUSALITY BETWEEN URBANIZATION, INDUSTRIALIZATION AND CO<sub>2</sub> EMISSIONS IN NIGERIA: EVIDENCE FROM TODA AND YAMAMOTO APPROACH



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## ABSTRACT

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O18, L16, Q53, C92.

The main objective of this paper is to inspect the causal relationship between urbanization, industrialization and CO<sub>2</sub> emissions in Nigeria using the technique of Modified Toda and Yamamoto causality for the period spanning 1982 -2018. The long run causality result indicates that there is bidirectional causality running from economic growth to CO<sub>2</sub> emissions and from industrialization to economic growth. This suggests that higher economic growth is linked with CO<sub>2</sub> emissions and the growth of industries is related with higher economic growth. Again, unidirectional causality also exists running from urbanization to economic growth, urbanization to CO<sub>2</sub> emissions, urbanization to industrialization. Based on these findings, it is therefore recommended that Nigerian government should strategies comprehensive environmental policy in the coming years that would make the environmental rules and regulations more severe to dodge any inconveniences that is associated with urbanization and industrialization in the near future for the purpose of maintaining the quality of the environment.

**Contribution/ Originality:** This study contributes to the existing literature via a novel attempt in providing a quantitative analysis of the causal relationship between urbanization, industrialization and CO<sub>2</sub> emissions in the case of Nigeria using Modified T-Y causality procedure.

## 1. INTRODUCTION

With universal race in all areas of life receiving an exponential step, nations are yearning to discover means to strive with an upper hand. For several nations, growth and development are equal with industrialization, and that is the basic since the growth of industries is associated with economic cease and unavoidable urbanization. In the discussion of industrialization, one aspect that need proper consideration is making sure that growth rate in that section is supportable and that the remaining impact on the total economy is positive. In several occasion that the industry growth rate is faster, safeguarding its inclusion in the other sectors became difficult. For examples, seeing the net influence of industrialization and urbanization may negatively impact on the larger population (Mahmooda et al., 2020).

Exploration and utilization of natural resources signifies the growth of industrialization. Whereas improving the industrial operations and concentrating on production so that the nation can become self-reliant, the environmental quality become the last thing to be remembered in that growth plan filed. As such nation's environment and the carbon emission became the significant areas of the economy to be affected by industrialization. Industrialization increased necessitate the diminishing of natural resources and the total welfare of the larger population. Equally urban and rural environments fall victims and there is exerts a lot of pressure in terms of decreasing the natural resources (Dubey & Narayanan, 2010).

There is an existing argument that as nations started attaining advancement stage, people started seeing the chance of moving to the urban cities and this serve as the major cause of weakening the environmental quality. Newman (2006) is of the view that in the investigation of the influence of urbanization on the environment, some result have recognized environmental negativity due to their use of population influence and ecological footprint methods rather than a sustainability valuation method and in some situation instead of generating heat island, but urbanization may end of with cooling consequence. Dodman (2009) discovered that base on the investigation of greenhouse gas emissions records of numerous towns, shows that in many situations, the emissions per capita of these towns are less than the total country's emissions. Ejaro and Abubakar (2013) viewed that if rapid urbanization is left unrestricted, from the understandings of numerous emerging nations, frequently causes growth in poverty, crime insecurity and therefore, unmaintainable development. In another development, Iroye (2015) observed that due to prospect in construction industry encouraged by increase in population and urbanization has led to illegal and unwarranted mining practiced in the river bed of stream channel of River Asa in Ilorin and this activities has compact the quality of the water and has also exhausted the level of groundwater in the wells neighboring the river banks.

There are numerous instances were nation's industrialization has deteriorated the water, air and soil texture and this became strong reason that environmental degradation is driving by industrialization (Mahmood, Alkhateeb, & Furqan, 2020). In Nigeria, the country has been pursuing industrialization since the earlier of 1960s and this was carried out with help of sequential formulation of industrial development policies (Audi, Mohammed, & Ola, 2014; Famade, 2007). Even though, the stage of industrialization in Nigeria is low, but it has not only influenced the level of economic and social development but similarly, produces problem on the environment in general. Similarly, industrialization brings about better health care facilities in terms of drugs manufactured and other medical equipment (Audi et al., 2014). But on the environmental part, the problem of greenhouse gas from constant flaring of gas in multi-national oil companies from the oil sector and the federal government have put in place numerous policies to curb the issue, but all efforts have failed (UNIDO, 2004). Again, Audi et al. (2014) shows that absence of suitable industrialization guidelines and their appropriate execution could be associated with environmental insecurity, social and economic underdevelopment which could afterward interrupt on industrialization and sustainable development.

In the case of Nigeria, road transportation appears to have emitted a great amount of greenhouse gases that effect the environment in a negative manner as a result of consuming energy. For instance, Chindo (2014) revealed that higher economic growth and energy consumption are associated with CO<sub>2</sub> emissions in a bidirectional causal relationship for the periods spanning 1970 to 2010. In another development, Maji (2015) indicate that trade openness and economic growth have joint significant inverse relationship with the quality of the environment as such these variables proof to be more important in improving the quality of the environment with population having significant positive effect on environmental degradation for the 1981-2011 periods. Maijama'a, Musa, Saleh, and Garba (2020) in their study discovered that foreign direct investment, wood fuel consumption, economic growth and agricultural land area impact positively on deforestation and deforestation is degrading the environmental quality for the period of 1990 to 2012 in Nigeria.

Therefore, it is on the basis of this introduction that this paper intent to discover the existing connection between urbanization, industrialization and CO<sub>2</sub> emissions in Nigeria using [Johansen and Juselius \(1990\)](#) test for cointegration and [Toda and Yamamoto \(1995\)](#) procedure for the period under investigation.

Following this section, section 2 contains the empirical literature review on the association between urbanization, industrialization and CO<sub>2</sub> emissions. Third section offered the methodology of the paper. Fourth section provides the data and empirical discussion of the findings and lastly the fifth section include the conclusion and policy recommendation.

## 2. LITERATURE REVIEW

The first strand of the literature review provides useful insight on the relationship between industrialization and the environmental pollution or carbon dioxide emissions from the evidence around the world and the case study and these evidences consists of [Audi et al. \(2014\)](#) who studied the connection between industrialization and sustainable development in Nigeria by utilizing primary data with help of unstructured interviews administered to directors of ministries in kaduna state and some secondary data source and their able to come to a conclusion that deficiency of appropriate government strategy, satisfactory funding, poor infrastructural services and absence of funding are among the issues accountable for the back-ward nature of industrialization in Nigeria. [Haraguchi, Martorano, and Sanfilippo \(2019\)](#) inspects the driving factors behind industrialization for developing countries using time series data for the 1970 to 2014 periods and show how factors that includes technological, political and organizational changes brings about increase or decrease in industrialization. The outcome indicates that factors such as nation's early economic situation before industrialization stage takes place, demography, nation's political and strategic profile, and the nation's geographical and strategy creation activities are responsible for industrialization formation. [Li et al. \(2019\)](#) maintained that industrialization have a significant influence on the quality of air of a certain nation. They employed data from 2003-2017 periods for over 31 Chinese regions to archived the aimed of assessing the influence of industrialization on the Chinese environment. The outcome revealed that during the study period, the industrialization activities have influenced the quality of air in the country and this suggests that industrialization and quality of the environment are contrary to each other. And that the environmental quality get worse at the beginning as industrialization progresses and after some certain level of progress, the level of emissions will decrease. [Du and Xie \(2019\)](#) offered useful discussion on the procedures of deindustrialization into consideration. But the study did not pay attention to the existence of environmental kuznet hypothesis. However, the discussion is in conformity with the fact that when a nation is making improvement towards decreasing the level of its carbon dioxide emissions in order to realize a cleaner environment, the procedure became simpler and smoother for the nations that are deindustrializing when associated with the ones that are still on the industrialization track. This implies that level of nation's industrialization does not contribute an important part in achieving cleaner environment. In Pakistan, [Ullah, Ozturk, Usman, Majeed, and Akhtar \(2020\)](#) examined the asymmetric influence of industrialization on the level of country's carbon dioxide emissions for the periods of 1980-2018. Their examination result revealed that industrialization, urbanization, deindustrialization and income level have significant positive influence on the level of carbon dioxide emissions with the support of asymmetry through different degree of the influence of industrialization and deindustrialization. [Mahmood et al. \(2020\)](#) studied the influence of urbanization, industrialization on carbon dioxide emissions covering 1968-2014 periods in Saudi Arabia. By means of linear and nonlinear ARDL models, the results revealed that urbanization and industrialization have obstruct the environment with urbanization having flexible consequence while industrialization having rigid consequence on carbon dioxide emissions. The asymmetry is reported between industrialization and carbon dioxide emissions and the growing industrialization has greater environmental consequence than declining industrialization.

The second strands of the literature review emphasis more on the relationship between urbanization and the environmental pollution which provides a snap shoot with evidences from the case study and around world. Using China as a case study, [Li and Ma \(2014\)](#) suggest that the turning point towards improved environment in the inverted U shape is about 60 percent rate of urbanization and that the inverted U-shaped association between urbanization/ economic growth and the quality of the environment is worldwide. [Ohwo and Abotutu \(2015\)](#) in their study revealed the evidences of environmental influence of urbanization in Nigeria. The associations between urbanization progression and the environment are indicated that the main mechanisms of the environment that include air, water and land are unfavorably distressed by the everyday anthropogenic actions of urban dwelling and in the course of exploiting the natural resource. The objective of certifying environmental sustainability is seriously endangered by urbanization and has generated numerous serious environmental problems and they have negative influences on man and other living organisms in the environment. Therefore, if the pressures modeled by urbanization in the country are not effectively accomplished, the size of the environment to uninterruptedly conform life may be endangered with terrible penalties on human life expectancy. [Kasman and Duman \(2015\)](#) who examined the causal relationship among urbanization, economic growth, energy consumption, CO<sub>2</sub> emissions and trade openness for the sample periods of 1992 to 2010 and using European union member nations as a case study. By utilizing panel unit root tests, panel cointegration and panel causality tests to analysis the panel data, the outcome showed that the sign of Environmental Kuznets Curve hypothesis is maintained and this provide confirmation for the existence of an inverted U-shaped association between environmental pollution and economic growth for the designated nations. Also, by utilizing data for the periods spanning 1980-2009 periods in Malaysia together with the help of ARDL approach, [Begum, Sohag, Abdullah, and Jaafar \(2015\)](#) scrutinized the influence of population growth, economic growth and energy consumption on CO<sub>2</sub> emissions. The outcome of the scrutinization revealed that CO<sub>2</sub> emissions increase economic growth and that the increase in CO<sub>2</sub> emissions was abnormal from 1980 to 2009 and the increased in economic growth was the same. The findings also indicate that economic growth and energy consumption have long run joints positive impacts on CO<sub>2</sub> emissions. [Khobai and Le Roux \(2017\)](#) investigate the association between urbanization, energy consumption, CO<sub>2</sub> emissions, trade openness and economic growth from 1971-2013 periods for South Africa as a case study. The data were examined using Johansen Juselius test for cointegration and Granger causality base on vector error correction model. After the discovery of the long run equilibrium relationship between the series, the existence of long run bidirectional causality running from energy use to economic growth was reported. In another development, [Behera and Dash \(2017\)](#) inspected the possible interrelationship among urbanization, foreign direct investment, energy consumption and CO<sub>2</sub> emissions using sample of 17 nations from the South and Southeast Asian (SSEA) areas for over 1980-2012 periods. The outcome from the Pedroni cointegration test indicate that CO<sub>2</sub> emissions is significantly influence by energy consumption using fossil fuel and primary energy consumption. Moreover, Using ARDL approach and granger causality test to analyze the data for over 1971-2013 period, [Ahmad et al. \(2018\)](#) studied the influence of total population, energy consumption and economic growth on CO<sub>2</sub> emissions in China. Their outcome revealed a connection between economic growth and CO<sub>2</sub> emissions. The granger causality test indicates an existence of unidirectional causality running from economic growth to CO<sub>2</sub> emissions and that use the of energy and economic growth have got excessive budding to boost carbon emissions in the long run period. In another examination, [Isik, Dogru, and Turk \(2018\)](#) investigates the interrelationship between energy consumption, urbanization, environmental pollution and economic growth using technique of heterogeneous panel analysis such as dynamic ordinary (DOLS) least squares, fully modified least squares (FMOLS) and granger causality test to analyzed the data. The outcomes indicate that there is an equilibrium long run association between CO<sub>2</sub> emissions, GDP, structure of energy consumption and urbanization. In all the provincial panels, energy consumption and economic growth have influence on CO<sub>2</sub> emissions but urbanization influence on CO<sub>2</sub> emissions is only within the provinces of national and medium-developed. [Ikporukpo \(2018\)](#) studied the relationship between urbanization and

environment using two cities in Nigeria, based on solid waste, sewage, water, air and noise pollutions, shows that, even though the influence has deteriorated over the years, it lingers to be significant. An additional thorough investigation of the condition in the two towns of Abuja and Yenagoa displays evidently the role that actual environmental management played in an improvement of the influence implying that the development-stage-dependent facilitator school of thought is the most important in the Nigerian experience.

The third aspect of the literature review dwelled on the connection between economic growth and the environmental pollution and the ones reviewed include, [Olusanya \(2012\)](#) inspects the long run correlation between energy consumption and the economic growth in Nigeria over 1985 to 2010 period. The study analyzed the data using ordinary least square method and the outcomes indicate that electricity and petroleum have significant positive impact on economic growth whereas coal and gas revealed a significant negative influence on economic growth. Nevertheless, the study concludes that economic growth in Nigeria is strongly determined by rise in energy consumption in Nigeria for the period under study. [Alper and Oguz \(2016\)](#) discovered the causal relationship between consumption of renewable energy and economic growth for some European Union nations over 1990-2009 periods. Using the ARDL method, their outcomes exposed an indication of significant positive effect of consuming renewable energy on economic growth. Though, this effect is statistically insignificant for all the member nations. The positive significant effect was only recorded for Bulgaria, Estonia, Poland, and Slovenia. Moreover, no causality relationship was recorded for Cyprus, Estonia, Hungary, Poland and Slovenia. By analyzing time series data for the periods of 1971 to 2014 to obtained the short run and long run connection between the variables in Saudi Arabia, [Mahmood, Alrasheed, and Furqan \(2018\)](#) examined the emitters of pollution and the outcome of the examination revealed that there is an existing sign of environmental kuznet curve and this indicate that as the country's economy started realizing higher levels of income, country's pollution also begins to rise. But gradually the higher levels of economic growth will assist in reducing the level of CO<sub>2</sub> emissions and help the economy at the end. [Valadkhani, Smyth, and Nguyen \(2019\)](#) evaluated the influence of energy consumption on the nation's levels of pollution by employing data for 1965-2016 periods for over 60 nations bearing in mind the discussion that sources of energy can have different influence on the level of CO<sub>2</sub> emissions and they examined each for its sole influence which consists of coal, gas, oil, other renewable energy and hydroelectric respectively and the degree of CO<sub>2</sub> emissions they produced. The real level of country's income influence the CO<sub>2</sub> emissions produced from consuming energy base on their source. [Kouton and Amonle \(2019\)](#) Studied the influence of renewable energy consumption on economic growth for the period spanning 1991-2015 in Côte d'Ivoire. The empirical outcome from ARDL model revealed that the influence of renewable energy consumption on economic growth is statistically insignificant while the short run influence appears to be conflicting and that non-renewable energy/renewable energy change is not that effective and is under the process in the country. [Akadiri, Akadiri, and Gungor \(2019\)](#) investigates the influence of energy consumption on Saudi economy and its environmental equality together with the part play by international trade. The investigation was done with the help of data for the periods of 1968 to 2016. The result indicates that these series had a positive impact which suggest that growing trading activities and the level of income could bring about higher consumption of energy and to be precise gas consumption. This means that with an increase in gas consumption, nation's CO<sub>2</sub> emissions impact on the environmental and the impact is degrading in the long run. [Mahmood et al. \(2020\)](#) studied the environmental influence of energy consumption and economic growth using time series data from 1968-2014 in Saudi Arabia. After carrying out the analysis on the data, the result revealed that there is an existence of cointegration relationship among the variables and that energy consumption and economic growth have positive impact on CO<sub>2</sub> emissions in the short run and long run periods. This indicate that growing economic growth of the country is associated with emitting pollution.

It is on the basis of these reviewed literatures that this paper would contribute to the existing literatures on the relationship between urbanization, industrialization and emission of CO<sub>2</sub> in the case of Nigeria using the technique of T-Y procedure.

### 3. METHODOLOGY

#### 3.1. Toda and Yamamoto Non-Granger Causality Test

For us to carry out the estimation of this model, we have engaged granger non-causality test by means of Toda and Yamamoto (1995) procedure. The Toda and Yamamoto approach for testing causality is suitable and valid in no matter the level of integration of the variables and cointegrated or not cointegrated. Meaning whether the variables are purely I (0), I (1), I (2) or combination of the three order of integration. The important feature of Toda and Yamamoto causality is that pre-testing for cointegrating properties of the system is not needed and this make the avoidance of potential bias that is connected with both unit root and cointegration tests since it is applicable regardless of whether the variables are integrated of order I(0), I(1) and (2) with the existence of cointegration or without cointegration of random order (Chindo, 2014; Menyah & Wolde-Rufael, 2010; Rambaldi & Doran, 1996). The procedure of Toda and Yamamoto is design based on the augmented VAR modelling approach together with Wald test statistic and the Wald statistic is associated with asymptotic chi-square ( $\chi^2$ ) distribution which is irrespective of integration order of the variables and their cointegrating properties. This make it suitable for VAR model on levels of the series and most importantly provision of long-run causality among the variables which is not captured in other approach that use first differencing. As mentioned earlier, Toda and Yamamoto method engaged modified Wald test for parameter limitations of VAR (i.e. j is the lag length of the system). In this procedure, the lag order (j) is artificially augmented by the maximum order of integration given as “d<sub>max</sub>” and it will become (j+d<sub>max</sub>)<sup>th</sup> by the Toda and Yamamoto procedure. In our own situation, to test for non-granger causality using Toda and Yamamoto, we utilized VAR with 5 lags (j=3 and d<sub>max</sub>=2). Therefore, the following system of Equation given in matrix form below in Equation 1 were calculated:

$$\begin{bmatrix} \ln CO_{2t} \\ \ln EC_t \\ \ln ID_t \\ \ln UB_t \end{bmatrix} = \phi_0 + \phi_1 \begin{bmatrix} \ln CO_{2t-1} \\ \ln EC_{t-1} \\ \ln ID_{t-1} \\ \ln UB_{t-1} \end{bmatrix} + \phi_2 \begin{bmatrix} \ln CO_{2t-2} \\ \ln EC_{t-2} \\ \ln ID_{t-2} \\ \ln UB_{t-2} \end{bmatrix} + \phi_3 \begin{bmatrix} \ln CO_{2t-3} \\ \ln EC_{t-3} \\ \ln ID_{t-3} \\ \ln UB_{t-3} \end{bmatrix} + \phi_4 \begin{bmatrix} \ln CO_{2t-4} \\ \ln EC_{t-4} \\ \ln ID_{t-4} \\ \ln UB_{t-4} \end{bmatrix} + \phi_5 \begin{bmatrix} \ln CO_{2t-5} \\ \ln EC_{t-5} \\ \ln ID_{t-5} \\ \ln UB_{t-5} \end{bmatrix} + \begin{bmatrix} \mathcal{G}_{\ln CO_{2t}} \\ \mathcal{G}_{\ln EC_t} \\ \mathcal{G}_{\ln ID_t} \\ \mathcal{G}_{\ln UB_t} \end{bmatrix} \quad (1)$$

where ln is natural log sign, CO<sub>2t</sub> is the natural log of CO<sub>2</sub> emissions, lnEC<sub>t</sub> is the natural log of economic growth, lnID<sub>t</sub> is the natural log of industrialization, lnUB<sub>t</sub> is the natural log of urbanization,  $\phi_1, \dots, \phi_5$  are the 5 x 5 matrices of quantities with  $\phi_0$  identity matrix of 4x1 and  $\mathcal{G}_s$  are the stochastic error terms which are assumed to have zero mean with constant variance. To test the hypothesis that CO<sub>2</sub> emissions (lnCO<sub>t</sub>) does not granger cause

industrialization ( $\ln ID_t$ ), we employed the following hypothesis:  $H_0 = \phi_{ik}^1 = \phi_{ik}^2 = \phi_{ik}^3 = \phi_{ik}^4 = \phi_{ik}^5 = 0$ . Where

$\phi_{ik}^j$  are the coefficients of  $\text{CO}_2$  emissions ( $\ln \text{CO}_2$ ) in Equation 1

Also, to test for the reverse non causality from industrialization ( $\ln ID_t$ ) to  $\text{CO}_2$  emissions ( $\ln \text{CO}_2$ ), we utilized the following null hypothesis:  $H_0 = \phi_{ik}^1 = \phi_{ik}^2 = \phi_{ik}^3 = \phi_{ik}^4 = \phi_{ik}^5 = 0$ . Where  $\phi_{ik}^j$  are the coefficients of industrialization variables in Equation 1. Again, the same procedures are applied for testing causality between other series in the Equation 1.

#### 4. DATA AND EMPIRICAL RESULTS DISCUSSION

The data on  $\text{CO}_2$  emissions was extracted from the Publications Office of the European Union and data on economic growth (GDP constant 2010 US\$), industrialization (industrial value added) and urbanization (urban population) were sourced from World Development Indicators (WDI) all for the periods of 1982-2018. All the variables were transformed into natural logarithmic form for the avoidance of regression problems and for easy interpretations of the coefficients in terms of elasticity (Musa, Majjama'a, Shaibu, & Muhammad, 2019). The Bar representation and trend of the series are depicted in Figure 1.

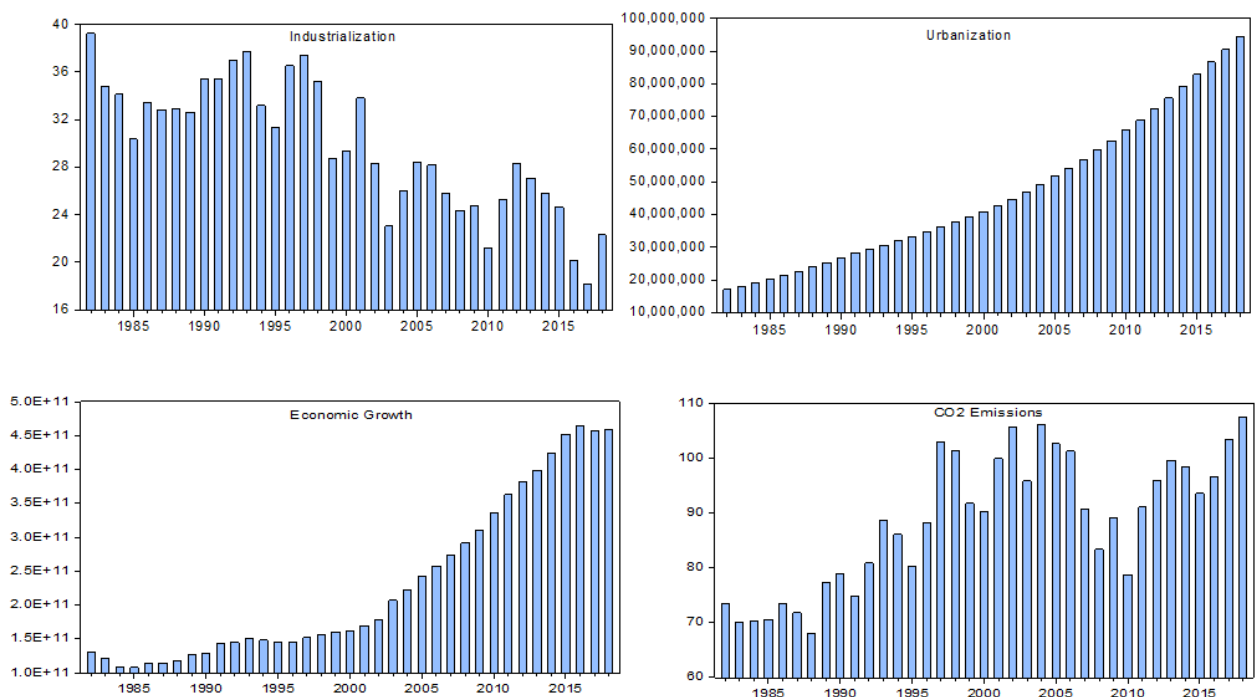


Figure-1. Bar representation and the trend of the series.

##### 4.1. Descriptive Statistics

The descriptive statistics is reported in Table 1 with the mean, median, maximum values, minimum values, standard deviation, skewness, kurtosis and Jarque-Bera respectively. The standard deviation coefficients of all the variables comparatively are far below their respective mean and median values and this implies the variability of these variables. The skewness coefficients indicate that  $\text{CO}_2$  emissions, industrialization and urbanization are negatively skewed while economic growth is positively skewed.  $\text{CO}_2$  emissions, economic growth and urbanization are mesokurtic as indicated by the kurtosis value of less than 2 whereas industrialization is platykurtic as given by the kurtosis value of more than 2. The Jarque-Bera probability values for all the variables are insignificant and this implies that all the variables are normally distributed within 1982 -2018 periods.

Table-1. Descriptive Statistics.

Description	lnCO <sub>2t</sub>	lnEC <sub>t</sub>	lnID <sub>t</sub>	lnUB <sub>t</sub>
Mean	4.481021	26.05638	3.373981	17.55975
Median	4.505899	25.82988	3.368371	17.54718
Maximum	4.706700	26.87453	3.669826	18.40670
Minimum	4.220243	25.40412	2.899944	16.65477
SD	0.143321	0.504118	0.191823	0.515434
Skewness	-0.296651	0.412861	-0.477218	-0.040993
Kurtosis	1.827783	1.670112	2.472710	1.871914
Jarque-Bera	2.732990	3.879830	1.882554	2.025557
Probability	0.254999	0.143716	0.390129	0.363208
Observations	38	38	38	38

Table 2 reported the result of correlation analysis. The result of the analysis indicates that there exists a positive correlation between economic growth, urbanization and CO<sub>2</sub> emissions in Nigeria within the study period. Meaning that increase in economic growth and urban population will cause increase in the rate of CO<sub>2</sub> emissions in the country. While industrialization and CO<sub>2</sub> emissions depicts a negative correlation among them. Most importantly all the correlation coefficients for all the variables are within the benchmark of 0.80 and this signifies that there is no problem of multicollinearity among the independent variables (Pordan, 2013).

Table-2. Correlation analysis.

Variables	lnCO <sub>2t</sub>	lnEC <sub>t</sub>	lnID <sub>t</sub>	lnUB <sub>t</sub>
lnCO <sub>2t</sub>	1.0000	0.6676	-0.4701	0.7812
lnEC <sub>t</sub>		1.0000	-0.8251	0.9650
lnID <sub>t</sub>			1.0000	-0.8156
lnUB <sub>t</sub>				1.0000

#### 4.2. Unit Root Test Results

The application of Toda and Yamamoto approach does not properly need pre-testing of the series for unit root as it does not matter whether all the series are I (0), I (1) and I (2) or combination. Nevertheless, for the determination of the series' order of integration, we utilized Dickey and Fuller (1981) and Phillips and Perron (1988) unit root tests to identify each of the series' order of integration. The outcomes of these unit root tests are reported in Table 3 and the outcomes revealed that CO<sub>2</sub> emissions and economic growth are I (1) whereas industrialization and urbanization are I (0) under ADF. While under PP test CO<sub>2</sub> emissions and economic growth are also I (1) whereas industrialization is I (0) with urbanization being the only I (2) variable. In light of this outcomes of taken combination of order of integration between the variables, Toda and Yamamoto approach is more efficient to be utilized than any other approaches of testing for causality.

Due to the inability of the ADF and PP unit root tests to handling structural breaks in the series, we have equally employed Zivot and Andrews (1992) to serve as a robustness check to the ADF and PP unit root tests results and the results is reported in Table 4. The outcomes of the test revealed that CO<sub>2</sub> emissions is I (0) while industrialization is I (1) and economic growth and urbanization are all I (2). Therefore, the results of Zivot-Andrew structural breaks also revealed the combination of order of integration of the variables. Therefore, the result of Zivot-Andrew structural breaks unit root test result revealed that Toda and Yamamoto long-run non-granger causality test is more efficient than other method of causality.



Table-3. Unit root test results using augmented dickey fuller (ADF) and Phillips Perron (PP).

Variables	At Level				At First Difference				At Second Difference	
	ADF		PP		ADF		PP		PP	
	Constant	Constant & Trend	Constant	Constant & Trend	Constant	Constant & Trend	Constant	Constant & Trend	Constant	Constant & Trend
lnCO <sub>2t</sub>	-1.459 (0.542)	-2.592 (0.285)	-1.130 (0.693)	-2.640 (0.266)	-6.545*** (0.000)	6.447*** (0.000)	-8.440*** (0.000)	-8.343*** (0.000)	-----	-----
lnEC <sub>t</sub>	-0.279 (0.917)	-1.507 (0.808)	0.817 (0.993)	-3.138 (0.112)	-3.808*** (0.006)	-3.730** (0.032)	-3.808*** (0.006)	-3.730 (0.032)	-----	-----
lnID <sub>t</sub>	-1.012 (0.737)	-4.270*** (0.009)	-2.020 (0.277)	-3.098 (0.121)	-6.470*** (0.000)	-6.352*** (0.000)	-9.128*** (0.000)	-8.937*** (0.000)	-----	-----
lnUB <sub>t</sub>	-0.446 (0.890)	-6.060*** (0.000)	-1.802 (0.373)	-2.805 (0.204)	-6.298*** (0.000)	-1.802 (0.373)	-1.862 (0.345)	-1.758 (0.703)	-5.423*** (0.000)	-5.389*** (0.000)

Note: \*\*\*, \*\*, and \* denote 1%, 5% and 10% levels of significant respectively.

Table-4. Zivot-andrews unit root test result.

At Level				
Variables	Constant	Break Point	Constant & trend	Break point
$\ln CO_{2t}$	-5.636 (0)***	2006	-3.494 (0)	1997
$\ln EC_t$	-3.028 (2)	2002	-3.131 (2)	1995
$\ln ID_t$	-3.984 (2)	2001	-4.098 (2)	1992
$\ln UB_t$	-3.511 (1)	2005	-4.599 (1)	1991
At First Difference				
$\ln CO_{2t}$	-6.791 (1)***	2010	-6.178 (1)***	2008
$\ln EC_t$	-4.891 (1)*	2000	-4.247 (1)	2010
$\ln ID_t$	-6.652 (1)***	1998	-6.569 (1)***	1992
$\ln UB_t$	-4.373 (0)	1991	-2.905 (0)	1992
At Second Difference				
$\ln CO_{2t}$	-----	-----	-----	-----
$\ln EC_t$	-5.103 (1)**	2002	-4.277 (1)*	2011
$\ln ID_t$	-----	-----	-----	-----
$\ln UB_t$	-5.088 (3)**	1992	-4.143 (3)*	1993

Note: \*\*\*, \*\* & \* stands for 1%, 5% & 10% levels of significance and values in brackets are the lag lengths.

In order to get the optimum lag that is free from serial correlation and other regression problems, we engaged a mixture of Final Prediction Error (FPE), Akaike Information Criterion (AIC), and Hannan Quinn (HQ) lag selection criteria and they suggested that lag 3 is the best lag while Likelihood Ratio (LR) alone suggest lag 2 and Schwarz Bayesian Criterion (SBC) suggested for lag 1 as offered in Table 5. Therefore, in line with suggestion made by the majority of the criteria, lag 3 is the optimal lag.

Table-5. VAR lag order selection criteria result.

Lag	LogL	LR	FPE	AIC	SC	HQ
0	213.9775	NA	5.00e-11	-12.37360	-11.64073	-12.13067
1	308.5547	141.8657	3.82e-13	-17.28467	-15.81893*	-16.79882
2	331.8493	29.11826*	2.71e-13	-17.74058	-15.54198	-17.01180
3	352.9774	21.12813	2.50e-13*	-18.06109*	-15.12962	-17.08939*
4	364.9353	8.968406	5.15e-13	-17.80846	-14.14412	-16.59383

Note: \* Denotes the optimum lag selected by different criterion.

To examine whether the variables are cointegrated or not even though the Toda and Yamamoto procedure does not necessitate that the variables must be cointegrated, but to be at the safer side, we have employed Johansen and Juselius (1990) test for cointegration and the result is presented in Table 6. The outcome of the test revealed that all the variables are cointegrated as shown by the single cointegrating equation in both the trace statistics and max-eigen value statistics. Therefore, based on this result we have come to a conclusion that all the variables have long run cointegration relationship and they move together in the long run.

Table-6. Johansen and juselius test for cointegration.

Hypothesized		Trace	0.05	Max-Eigen	0.05
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Statistic	Critical Value
None	0.560	55.935 [0.007]***	47.856	28.793 [0.034]***	47.856
At most 1	0.432	27.141 [0.098]	29.797	19.800 [0.075]	29.797
At most 2	0.187	7.341 [0.538]	15.494	7.260 [0.458]	15.494
At most 3	0.002	0.080 [0.776]	3.841	0.080 [0.776]	3.841

Note: Values in [ ] are the probability values.

#### 4.3. Toda and Yamamoto Non-Granger Causality Test Result

Following the identification of cointegration relationship among the variables, the next stage is the estimation of Toda and Yamamoto granger non-causality test through increasing our VAR with the variables' maximum order of integration given as  $d_{\max}$  and the outcomes of this test are offered in Table 7. In line with the core objective of the study, we are going to be concerned about the outcomes of the association between urbanization, industrialization and carbon dioxide emissions.

As we could understand from Table 7, there is a bidirectional causality running from economic growth to CO<sub>2</sub> emissions and this implies that higher economic growth will leads to higher CO<sub>2</sub> emissions and higher CO<sub>2</sub> emissions is associated with higher economic growth. This empirical finding is in conformity with that of Ang (2008) for Malaysia, Zhang and Cheng (2009) for Chindo (2014) in the case of Nigeria. There is also another bidirectional causality running from industrialization to economic growth. This entails that industrialization has significant positive impact on economic growth in Nigeria and this implies that increase in the number of industries enables the increase in economic growth. This finding is consistent with the empirical outcomes of Mahmood et al. (2020) for Saudi Arabia.

Moreover, there exists an independent causality between industrialization and CO<sub>2</sub> emissions and this implies that industrialization is not causing CO<sub>2</sub> emissions for the periods under study and this is not surprising because the country is not well industrialized. This contradict the suggestions of Hong et al. (2019); Dong, Wang, Su, Hua, and Zhang (2019) and Mahmood et al. (2020). Furthermore, there is unidirectional causality running from urbanization to economic growth and this implies that increase in the number of urban populations do increase economic activities that impact positively on the overall economic growth of the country.

Also, there is an existence of unidirectional causality running from urbanization to CO<sub>2</sub> emissions. That is, increase in urban population necessitate the practice of activities that leads to higher CO<sub>2</sub> emissions and this is true, because activities of mankind in the urban cities that include cooking, burning, etc. facilitates CO<sub>2</sub> emissions. This empirical finding corroborates that of Yuan, Yin, Sun, and Chen (2019); Wang and Wang (2017); Mahmood et al. (2020). Similarly, there is an existence of unidirectional causality running from urbanization to industrialization. This means that increase in number of urban populations has some positive association with the concentration of industries in the country.

Table-7. Toda and yamamoto non- granger causality test results.

Null hypothesis	Chi-Square ( $\chi^2$ )	P-value
Economic growth does not cause CO <sub>2</sub> emissions	14.453**	0.013
CO <sub>2</sub> emissions does not cause economic growth	10.962*	0.052
Industrialization does not cause Economic growth	11.836**	0.037
Economic growth does not cause Industrialization	13.265**	0.021
Industrialization does not cause CO <sub>2</sub> emissions	5.385	0.370
CO <sub>2</sub> emissions does not cause Industrialization	4.011	0.547
Urbanization does not cause Economic growth	22.639***	0.000
Economic growth does not cause Urbanization	4.9840	0.417
Urbanization does not cause CO <sub>2</sub> emissions	10.908*	0.053
CO <sub>2</sub> emissions does not cause Urbanization	5.571	0.350
Urbanization does not cause Industrialization	16.940***	0.004
Industrialization does not cause Urbanization	4.149	0.528

Note: \*\* Stands for the 5% level of significant.

## 5. CONCLUSIONS AND POLICY RECOMMENDATION

This paper examined the causal relationship between industrialization, urbanization and CO<sub>2</sub> emissions in Nigeria over 1982-2018 period using Toda and Yamamoto (1995) modified version of non-granger causality. The empirical outcomes of Toda and Yamamoto causality test shows bidirectional causality running from economic

growth to CO<sub>2</sub> emissions and industrialization to economic growth. While unidirectional causality exists running from urbanization to economic growth, urbanization to CO<sub>2</sub> and urbanization to industrialization.

In view of the outcomes of this research paper, it is recommended that the Nigerian government should strategies comprehensive environment plan in the coming years and make the environmental rules and regulations more severe to dodge any inconveniences in the near future. While concentrating on increasing number of urban populations, Nigerian government should consider how it may affect the environment and yield negative net effect. Moreover, it is vital that too much emphasis on urbanization needs to be reviewed since its impacts may not always be positive for the environmental strength in the long run periods. To achieve the aim of greener energy use in the country, the use of energy by fossil fuel consumption from the increasing number of urban populations and industries should be taxed by the government in order to avoid its penalties on the environmental quality at large.

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