Impact of population growth on Carbon Dioxide (CO₂) emission: empirical evidence from Nigeria

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Abstract
This paper seeks to examine the impact of population growth on carbon dioxide emission in Nigeria. Time series data from 1975 to 2016 was adopted. Variables such as population, affluence and technology were used as independent variables which were extracted from the IPAT equation. Econometric tools such as Ordinary Least Squares were adopted. The findings show that there is a positive association between CO_2 emission, population and technology whereas affluence has a negative relationship with CO_2. The study concluded that the population growth has a marginal impact on the level of CO_2 emission. The paper recommended that there is need for the government to adopt a climate friendly technology that will minimize the increasing CO_2 emission, improve on its GDP alongside controlling her population growth.

INTRODUCTION
The world human population has been witnessing appreciable growth overtime which can be traced to the 18th century. The population has grown from 1billion in 1804 to about 7.6 billion in 2018. i.e., a major spike in the population growth was recorded during the 20th Century when the world population grew from 1.65 billion to 6 billion. Though, regions that accounted for this figures (7.6 billion) are Asia (4.5 billion), Africa (1.2 billion), Europe (742 million), Latin America and the Caribbean (652 million), Northern America (368 million) and Oceania (41million). Subsequently, countries that are considered as top 10 (ten) with the highest population count are; China (1.4 billion), India (1.3 billion), United State of America (327 million), Indonesia (267 million), Brazil (211 million), Pakistan (202 million), Nigeria (197 million), Bangladesh (166 million), Russia (143 million) and Mexico (131 million). Thus, Nigeria is ranked as the 7th Top populated countries in the world (Worldometer, 2018). By 2050, the world population and that Nigeria is projected to reached 9.7 billion and 410 million respectively.

With these rapid increase in human population over the past three centuries, this has raised concerns among Government and Non-Governmental Organization (NGO's) that the planet may not be able to sustain the present or larger numbers of inhabitants. This is due to the fact that it is associated with many environmental problems such as rising levels of atmospheric carbon dioxide, global warming and pollution etc. In other

words, with a rising population it means more people, more demand for oil, gas, coal and other fuels mined or drilled from below the earth surface and when burnt, spew enough carbon dioxide into the atmosphere to trap warm air inside like a Green house (Scientificamerican,2018). Other social and economic problems associated are; unemployment problem, fall in per capita income, balance of payment problems, increase in price level, pressure on social services, increased demand for resources such as fresh water and food, starvation and malnutrition, consumption of natural resources (such as fossil fuels) faster than the rate of regeneration, and deterioration in living conditions etc.

Despite these numerous problems that are connected with rising population, this paper is limited to the study of atmospheric carbon dioxide emission. Atmospheric carbon dioxide which is also called Carbon acid gas, carbonic anhydrite is a colorless, odorless incombustible gas present in the atmosphere formed during respiration, usually obtained from coal, coke or natural gas combustion, from carbohydrates by fermentation, by reaction of acid with limestone or other carbonates or naturally from springs used extensively in industry as dry ice or carbon dioxide snow in carbonated beverages, fire extinguishers etc (Dictionary.com, 2018).

However, the total world carbon dioxide as at 2016 stood at 35, 753,30 (kt). China, USA, India, Russia and Japan are the world's largest emitters of CO_2 emission which accounted for 51% of the total world population, 65% of the Global Gross Domestic Product, 67% of the total global GHGs (Janssens-Maenhout et al, 2017). Below are the top emitters of CO_2 globally as at the end of 2016.
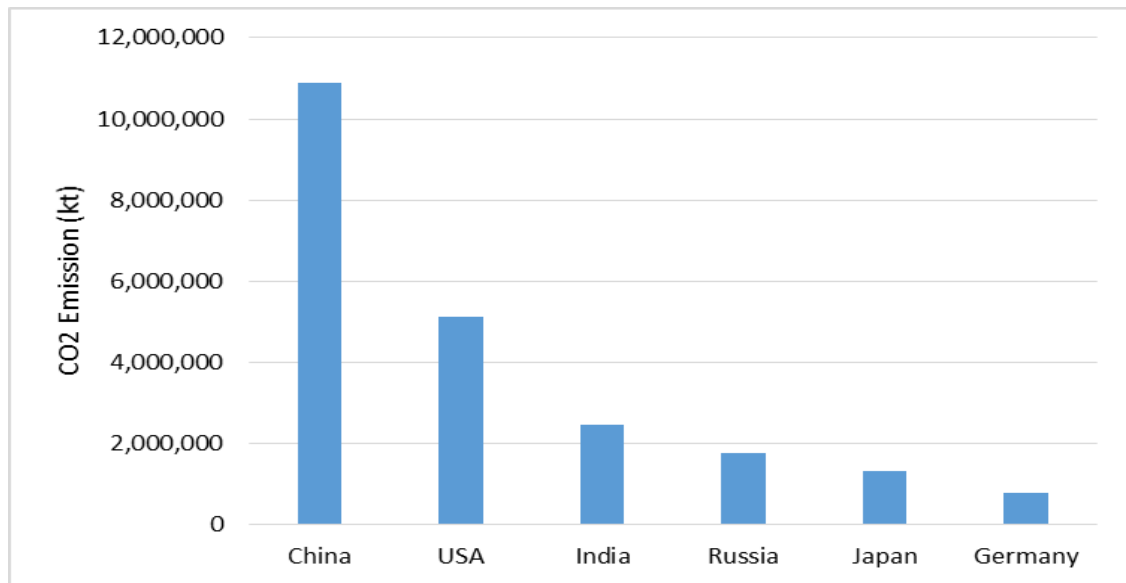

Figure 1: Top emitters of CO_2
Source: Janssens-Maenhout et al., 2017

Figure 1 depicts that china is still the top emitters of CO_2 and also still considered as the country with the highest population. Although, Nigeria is been ranked the 7th highest populated country in the world but it cannot be traced among the 20th highest emitters of CO_2. This scenario has raised some pertinent question as to what factors could be responsible for this performance? And also this has contravene existing literatures such as the works of Engleman (1994); Hamilton & Turton (2002); Gregory & Oded (2016); Shi (2001); Inmaculada, Aurelia & Rafael (2006); Martinez-Zarzoso

(2008) Sanglimsuwan (2012) and Shi (2003) which they stressed a direct relationship between population growth and CO_2 emission. It is against this vacuum that this study was carried out.

LITERATURE REVIEW

Shi (2001) in his study found a direct relationship between population changes and carbon dioxide emissions in 93 countries over a period from 1975-1996. Similarly, Cole & Neumayer (2004) considered 86 countries during the period from 1975-1998 and they found a positive link between CO_2 emissions and a set of explanatory variables including population, urbanization rate, Impact-Population Affluence-Technology, energy intensity and smaller household sizes. More so, Engleman (1994) plotted the long-term growth trends of global industrial emissions of carbon dioxide and population, and found that since 1970 both emissions and population have grown at similar rates.

Inmaculada Aurelia & Rafael (2006) analyses the impact of population growth on CO_2 emissions in European Union countries from 1975- 1999. They concluded that the impact of population growth on emissions is more than proportional for recent accession countries whereas for old EU members, the elasticity is lower than unity and non significant when the properties of the time series and the dynamics are correctly specified. Likewise, Gregory & Galor (2016) in their study concluded that that 1% slower population growth could be accompanied by an increase in income per capita of nearly 7% while still lowering carbon emissions.

In addition, Martinez-Zarzoso (2008) studied countries of different income groups during the period of 1975-2003 and found that the impact of population growth on emissions is slightly different for upper, middle, and low income countries and that urbanization had a very different impact on emissions for low and lower-middle-income countries and upper-middle income countries. Behera and Vishnu (2011) showed that urbanization, population, service sector, industrial sector and GDP per capita had negative effects on environment.

Recently, Sanglimsuwan (2012) estimated the impact of changes in population, GDP and the structure of economy on carbon dioxide emissions for 83 countries from 1980 to 2007. The study suggested that higher population and higher percentage of working-age population lead to higher CO_2 emissions. Hamilton and Turton (2002) concluded that income per capita and population growth are the main two factors increasing carbon emissions in OECD countries, whereas the decrease in energy intensity is the main factor reducing them.

Bruvoll & Medin (2003) covered ten pollutants and find out that in all cases technique effects were dominant in offsetting the increase in scale. They concluded that whereas structural change explains the increase in energy intensity during 1913-70, technical change is the main factor reducing energy intensity after 1970. Shifts in the fuel mix are the main factor explaining carbon emissions per unit of energy used. Stern (2002) used an econometric model to decompose sulphur emissions in 64 countries during the period 1973-1990 and find out that the contribution of input and output effects to changes in global emissions is very modest, whereas technological change considerably reduces the increase in emissions.

However, the existing literatures focused on selected group of countries in which a panel data was adopted, so it will be unfair to generalize their outcome to the context of Nigeria. More so, some of these studies tries to link CO_2 emission to growth and also

adopted a splited data that laspse each other as obtained in the works of Chinda & Abdulrahim (2018), but this study is unique because it is country specific which necessitate the adoption of a time series data and it further covers an extended period without splitting and overlapping the period when compared to existing literatures.

METHODOLOGY

The study employed quantitative method. Time series data was adopted from 1975-2016. The variables of the models was drawn from the works of Dietz & Rosa (1997), which was earlier formulated by Ehrlich (1968) and Holder & Ehrlich (1974) in the form of an equation called IPAT equation.

$$I = PAT \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

More so, a modified or stochastic model of the IPAT equation was adopted for the study which is called STRIPAT (Stochastic Impact by Regression on Population, Affluence and Technology). However, this model was re-modified and re-written as below to fit into the Ordinary Least Square (OLS) function.

$$I = \beta_0 + \beta_1 POP + \beta_2 AFF + \beta_3 TEC + \mu_1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

where

I   = Amount of CO_2 Emissions. This involves Carbon dioxide emissions from industrial processes metric ton stemming from the burning of fossil fuels and the manufacture of cement. It expressed in kilo tons (Kt)

POP = Population size- Total number of Population. This is expressed in numbers (millions)

AFF = Affluence- is proxied by real GDP per capita in constant price (U.S dollar).

TEC = Technology-This refers to CO_2 per unit of technology. It was obtained by dividing the CO_2 by the real GDP (US dollar).

In addition, the data was analyzed using descriptive statistics and other econometric tools like multiple regression.

RESULTS AND DISCUSSION

Result

Table 1 presents summary statistics about the variables used in the econometric analysis for Nigeria.

Table 1. Summary statistics

	CO2	POP	AFF	TEC
Mean	69.09524	114.5000	866.4524	34.56762
Median	70.00000	109.5000	486.0000	35.15000
Maximum	106.0000	186.0000	3222.000	52.90000
Minimum	35.00000	63.00000	154.0000	17.65000
Std. Dev.	23.06915	35.98865	871.0673	11.36724

From the Table 1, it was observed that the maximum value for carbon dioxide (CO_2) in 2016 reached to (106.00) from (35.00) with a standard deviation of (23.06). This depicts a high growth level of carbon dioxide (CO_2) emission in Nigeria despite its low level of technology. The statistics show that the median for population (POP) and Technology (TEC) is less than the mean, which indicates that the values are positively

skewed where as the median of CO2 and TEC, is greater than their mean values, which reveals that their values are negatively skewed.

The regression result (Table 2) shows that there is a strong relationship between the regressand and the regressors with about 99 percent of coefficient of determination. This indicates that 99% variation in carbon dioxide (CO_2) is explained by the model during the period under review. The remaining 1% could be explained by other variables not included in the model.

Table 2. Regression result

CO2	= -1.71791 +	0.01370*POP	− 0.00005.89*AFF	+ 2.004*TEC
Se(β_i)	= (0.1957)	(0.0019)	(-0.00008)	(0.005)
t(β_i)	= (-8.77)	(6.887)	(-0.731)	(391.70)
Prob.(β_i) =	(0.000)	(0.000)	(0.4690)	(0.000)

$R^2= 0.99$ $\check{R}^2$(Adjusted) $= 0.99$ F-Ratio$= 92170.65$ DW$=2.0$

The regression coefficient of population (POP) appeared with the correct sign; this is in line with our *apriori* expectation that population (POP) is positively related to carbon dioxide (CO_2)) emission. For every one percent increase in population (POP) will lead to an increase of 0.01370 percent in carbon dioxide (CO_2) emission. This coefficient has a t-value of 6.887 which is supported by a p-value (0.0000) less than 0.05. Therefore, population (POP) is statistically significant in explaining variation in carbon dioxide (CO_2) emission. Affluence (AFF) has a negative relationship with population (POP) because the regression coefficient appeared with a negative sign (-0.00005). This means that for 1\$ increase in the level of affluence will result to 0.00005 reductions in CO_2 emission. Although, the variable is not statistically significant as depicted with a t-value of 0.731 (i.e., which is less than 1.96) supported by a p-value (0.4690) greater than 0.05.

The regression coefficient of technology (TEC) has a positive sign of (2.004) which implies that a unit increase in TEC will lead to 2.004 increases in CO_2. The coefficient of TEC has a t-ratio of 391.70 which implies that it is statistically significant, supported by a p-value of (0.0000) which is less than 0.05. However, F-ratio is 92,170.5 which is highly significant and implies that the model is adequate in explaining variation in RGDP under the period under review which is further confirmed by p-value < 0.05. The Durbin Watson statistic is 2.0 which depict the absence of serial correlation (Autocorrelation). This decision is buttressed by a rule of thumb which state, DW test statistic values in the range of 1.5 to 2.5 are relatively normal. But values outside this range could be cause for concern. Field (2019) suggests that values under 1 or more than 3 are a definite cause for concern.

Discussions

Firstly, there exists a positive relationship between CO_2 emission and population growth. Although, the impact of increased population is less proportionate to CO_2 emission. The marginal CO_2 emission recorded could be as a result of the gradual emergence of urbanization resulting from human activities. These human activities could be bush burning, ranching, deforestation, rise in number of cars, increased used in generator set due to epileptic power supply etc. but on the other hand, this CO_2 emitted is not proportionate to the population increased because majority of the active

population in Nigeria are unemployed which is estimated to be over 21 million and as such they do not engage in productive economic activities which could be in one way or the other create CO_2 emission. Consequently, this outcome confirms with the works of Hamilton & Turton (2002), concluded that income per capita and population growth are the main two factors increasing carbon emissions in OECD countries and also the works of Cole & Neumayer (2004) which they found a positive link between CO_2 emissions and a set of explanatory variables including population, urbanization rate, Impact-Population Affluence-Technology, energy intensity and smaller household sizes.

Secondly, there exist a positive relationship between CO_2 emission and technology. This is owing to the fact that existing technology been used in the country are not climate friendly. Taking in cognizance, the level of the country level of industrialization, it encourages waste directly via emission or indirectly by altering the consumption pattern and boasting the demand for manufactured goods which invariably means creation of by products which may be detrimental to the environment. For instance, in the oil and gas sector, there are high cases of gas flaring which is due to exploration/refining of crude oil by the oil companies and couple with the crude method of agricultural activities. This could lead to increased CO_2 emission and which will invariably affects the environment. More so, this outcome further corroborates with the works of Cole & Neumayer (2004) as stated earlier.

Lastly, the coefficient for affluence revealed that there is a negative relationship between CO_2 emission and affluence. This is in line with economic theory most especially the works of Kuznet popularly known as the "Environmental Kuznets Curve where CO_2 emission initially worsen but ultimately improve with income. In other words there exist an inverse-U shape relationship between affluence and CO_2 emission. Furthermore, this outcome could be to the fact that as the income of the Nigeria populace gradually increases, they gradually avoid the native or traditional way of their lifestyle which is considered as a factor for higher CO_2 emission and adopt a modern ways of doing thing which will certainly minimize CO_2 emission. For instance, Nigerians are gradually adopting the solar energy and cooking gas etc as alternative to power supply and cooking against the use of generator set and use of fire wood.

CONCLUSION AND RECOMMENDATIONS

Conclusion

Carbon dioxide is a creation of respiration and the burning of organic materials and it is continuously being recycled which is performed by human activities and if the human occupying such location are growing rapidly there exist the propensity of an increased in carbon dioxide emission. In the case of Nigeria it revealed that there exist a positive association between CO_2 emission, population and technology and an inverse relationship exist between CO_2 and affluence. The study therefore concluded that despite the fact that Nigeria been ranked seventh among the world populated countries; its CO_2 emission is still less proportionate to its population growth if juxtaposed with other nations like China, India and USA. However, the level of technological advancement and the changing living conditions of Nigerians having less "native" cooking fires against more air conditioning demands has a played critical role

Policy recommendations

Since there exists a causal relationship between CO_2 emission and technology, there is need for the Nigeria Government to adopt a Climate friendly technology that

will minimize the increasing CO_2 emission most especially in the areas of agriculture, manufacturing and oil/gas.

There is also need to improve the nations' GDP and also to control her population growth. This will invariably improve the per capita income of its citizenry and there is also need enact laws or amend existing laws on environment which will regulate the operations of not just human activities but also the activities of industries that emit CO_2.

More so, the unemployment rate needs to be minimized so that the active unemployed individuals can be engaged in productive activities. This could add up to GDP growth and further boast his/her income status which will lead to adopting technologies that are climate friendly as part of his/her lifestyle. Invariably, this will go a long way in minimizing the level of CO_2 emission in the country.

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