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ECONOMIC GROWTH AND POLLUTION IN NIGERIA: AN ECONOMETRIC ASSESSMENT

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Abstract:
This work examined the relationship between economic growth and pollution in the Nigerian context using econometric approach. It utilized secondary (time-series) data culled from World Development Indicators (WDI). The study employed the methodology of descriptive statistics, unit root test and Cointegration. The study unit root test revealed that all variables in this study were stationary at first difference 1(1). However, the Trace and Maximum Eigenvalue showed that there was common stochastic drift among the variables. Hence, the Johansen Test of Cointegration showed that long-run equilibrium relationship existed among the variables utilized. Also, the Normalized Cointegrating Coefficients indicated that carbon dioxide (CO_2) and nitrogen oxide (NO_2) emissions undermined GDP per capita in the long-run while methane (CH_4) significantly promoted it. The study recommended that carbon dioxide ($C0_2$) should be abated by firms and companies by installing sequestration machines and the adoption of pollution emissions friendly production techniques. It also suggested the imposition of Pigouvian tax on combustion emitters by the government while the use of methane (CH_4) oxide has to be encouraged to enhance productivity and output growth.

JEL: O43, O44, R11

Keywords: carbon dioxide, nitrous oxide, methane oxide, Pigouvian tax

1. Introduction

In recent times, it has been observed that the environment plays prominent roles in the development process of any country. Apart from being the physical surrounding for natural habitats, the environment provide the basis for human exploits for agricultural,

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industrial, commercial, technological and tourism development of any society. In line with these reasons, environmental issues now occupy the front burner in academic discourses and other public fora both at the national and international levels. Evidence has also shown that the environment encompasses a wide range of the external circumstances, conditions and the things that affect the existence and development of an individual, organism, group and the society. (Isaichei, 1999)

The 1988 Koko toxic waste dumping brought environmental issues to the front burner in Nigeria. It also led to the establishment of Nigeria Federal Environmental Protection Agency (FEPA), Federal Ministry of Environment (FME) and other relevant agencies, ostensibly to tackle environment related issues. These include issues such as environmental pollution, sanitation, depletion of ozone layer, desertification, flooding, erosion, poverty, bush burning, deforestation, soil conservation etc. All these underscored the fact that environmental issues, especially environmental pollution which forms the basis of this study play pivotal role in the development process of any nation.

According to environmental scholars, environmental pollutions are associated with human activities and albeit persistent human interaction with the environment (Ocheri, 2000; Gbehe, 2004 and Aja 2005). Research had also shown that as the population of a country grows with attendant pressure on the environment especially in the wake of improved technologies; pollution is nevertheless heightened with corresponding effects on lives of people and other living organisms (Ocheri, 2003). It has been observed further that man through industrial, agricultural and the ever increasing urbanization process, security and terrorist activities tend to directly or indirectly pollute the environment. In Nigeria, extractive industries such as mining and oil extraction have the potential to pollute the environment. For instance, large-scale mining and mineral processing can generate significant amounts of air pollutants such as nitrogen oxides (NO_2), sulphur dioxide (SO_2), ozone and particulate matter. The main sources of these air pollutants are petrol engines of heavy machinery, fumes from smelters and refineries, and dust from blasting and earth moving operations. These air pollutants can be carried away over larger distances. At low concentrations, air pollutants are short lived; they are dissipated or absorbed by the environment. However, if toxic emissions are relatively large, they can deposit on the ground as acid rain. Acid rain contributes to soil degradation and can have cumulative negative effects (Menz and Seip, 2004).

Pollution has serious implications for productivity, economic growth and welfare because of its impact on health, resource depletion, and natural calamities linked to climate change. These pollutants can have negative cumulative effects on quality of soil and water sources which in turn affects agricultural output and economic growth (Salomons, 1995; Dudka and Adriano, 1997).

1.2 Objectives of the Study

The overall objective of this study is to investigate the effect of environmental pollution on the economic growth of Nigeria. Consequently, the specific objectives include;

- To examine the effect of Carbon dioxide (CO_2) emissions on GDP per capita in Nigeria;
- To assess the impact of Nitrous oxide (NO_2) emissions on output per capita in Nigeria;
- To investigate whether Methane (CH_4) emissions affect economic growth in Nigeria.

2. Literature Review

2.1 Conceptual Issue

According to Miller (1976), the term environment could be perceived as the totality of external conditions that influence the life of an individual or population, specifically the life of man and other living organisms on the earth's surface. The Federal Environmental Protection Agency (FEPA) Act of 1990, under section 38 also gave a very lucid definition of environment, thus, environment includes water, air, land and all plants and human beings and/or animals living there in and the inter-relationships which exist among these or any of them. In line with this definition, the concept of environment refers to the totality of space, time and socio-cultural settings of man and other living organisms therein.

Also, the term pollution means to make something dirty or no longer pure, especially by adding harmful or unpleasant substances to it. In another development, the committee on pollution of the United States National Research Council (1965) defined pollution as an undesirable change in physical, chemical or biological characteristics of our air, land and water that may or will harmfully affect human life or that of other desirable species, our industrial processes, living conditions cultural assets that may or will waste or deteriorate our raw material resources. Pollution according to the above definition is a disorder within an environment and is a by-product of energy conversion and the use of resources. Ekuri and Eze (1999) also defined pollution as the perturbation and contamination in the value of an object or thing. In the same vein, Jande (2005) sees pollution as to making something dirty or impure, especially by adding harmful or unpleasant substances to it. The main forms of pollution are atmospheric pollution, land degradation and soil pollution, water pollution, and noise pollution. The main sources of atmospheric pollution include combustion of fuels to produce energy for heating and power generation in the household and industrial sectors, exhaust emissions from the transport vehicles that use petrol, diesel oil etc and waste gases, dust and heat from many industrial sites including chemical manufacturers and electrical power generating stations. Three main pollutants of ambient air quality are Sulphur Dioxide (SO_2), Nitrogen Dioxide (NO_2) and Particulate Matter while Carbon dioxide (CO_2) and methane (CH_4) contribute towards the greenhouse gas emission inventory. The main water pollutants are effluents and discharges from industries. The main land and soil pollutants are fertilizers and pesticides (Yuan and Le Sun, 2001). Furthermore, some environmental scholars hold the opinion that human activities as well as natural disasters on the environment can pollute the environment beyond reasonable doubts (Anijah, 2001, Gbehe, 2004 and Ocheri 2003). Omoju (2014) positioned that the impact of pollution is more severe in developing countries, leading to ill health, death and disabilities of millions of people annually. He advanced that man's activity degrade the environment with its attendant consequences on biodiversity.

2.2 Theoretical Literature

2.2.1 The Environmental Kuznet Curve

The Environmental Kuznets Curve (EKC) is often used to describe the relationship between economic growth and environmental quality. It refers to the hypothesis of an inverted U-shaped relationship between economic output per capita and some measures of environmental quality.

The Environmental Kuznets Curve relationship was initially observed for some elements of air pollution (suspended particles and NOx), and the turning point – or the point beyond which increases in GDP per capita lead to reductions in emissions. According to studies, most moderately developed countries can expect to reach their pollution peak by the middle of this century – only 10% are approaching that point now and moderately developed countries' emissions will not return to current levels before the end of the 21st century. One extreme policy implication of the EKC would be to encourage economic growth and avoid costly environmental regulations particularly in developed countries that have gone past their turning point. Some argue that the early implementation of tight environmental regulations could actually harm growth, and cause increased environmental damage in the long run.

Generally, the inevitability of pollution in developing countries has been demonstrated by the Environmental Kuznet Curve. The EKC is a hypothesized relationship between indicators of environmental degradation and income per capita. According to the theory, environmental pollution and degradation increase in the early stages of economic growth, get to a peak point, and reverse in such a way that the environment improves at high income levels. This is based on the fact that developing countries desire industrialization and economic growth and tend to consume more cheap energy. There is also need for developing countries to build roads and rail tracks and develop massive infrastructure to promote economic growth. Such activities that are required at the take-off stage of economic development are substantially energy-intensive.

2.2.2 Limit Theory

The focal drive of the Limit theory is the possibility of breaching environmental thresholds before the economy reaches the EKC turning point. Broadly, the limits theory defines the economy-environment relationship in terms of environmental damage hitting a threshold beyond which production is so badly affected that the economy contracts (Arrow et al, 1996). They classified the drivers of the economy-environment relationship into three effects, viz;

A. The scale effect – economic growth has a negative effect on the environment, where increased production and consumption causes increased environmental damage;
B. The composition effect – the composition of production changes along the growth path: initially economic growth leads to industrialisation (and as the goods balance shifts from agriculture to manufactured products, environmental damage increases) but the balance then shifts from producing manufactured goods to producing services, due to both demand- and supply-side changes, reducing the level of domestic environmental damage.
C. The technical effect – technological developments lead to a change in the environmental impacts of production. Whilst this often means reductions in environmental intensity, for example improvements in energy efficiency, it could also represent technological advances that lead to greater environmental damage (such as through increased energy use). Changes in the preferences of society may also drive changes in environmental damage, for example through encouraging changes in the stringency of environmental regulation of industry.

The relative size of these effects determines the relationship between economic growth and the environment.

2.4 Empirical Literature

The estimation of four airborne pollutants such as suspended particulate matter (SPM), sulphur dioxides (SO_2) oxides of nitrogen (NO_2) and carbon monoxide (CO_2) were measured in terms of kilograms per capita on a national basis, using pooled time-series and cross-sectional data drawn from the 91st edition of World Resources Indicators. The authors found that all the four air pollutants exhibited inverted U-shaped relationship and suggested that in countries with low population densities there would be less pressure to adopt stringent environmental standards and emissions and vice versa (Selden and Song, 1994).

Treating environment as a factor of production and the direct determinant of social welfare, a study by López showed the case of non-homothetic preferences the relationship between economic growth and pollution depends on the elasticity of substitution between conventional factors of production and pollution and on the relative degree of curvature of consumers' utility. According to him, the lower the elasticity of substitution and relative curvature coefficient, increases the more likely it is that pollution increases with income. Under certain conditions, an inverted U-shaped relationship between pollution and income is derived for the non-homothetic preference case (López, 1994). Also, some researchers explored some of the empirical evidence that bears on the likely environmental impacts of an increase in per capita GDP. By using cross-country, they found that emission levels of sulfur dioxide (SO_2) and dark matter suspended in the air increase with per capita GDP at low levels of national income, but decrease with per capita GDP at higher levels of income, that is, (the inverted U-shape relationship). For the mass of suspended particles, however, in any given volume of air, the relationship between pollution and per capita GDP was found to be monotonically decreasing (Grossman and Krueger, 1993). Shafik used a wide range of environmental quality indicators. He found that environmental problems of safe water and sanitation improve with rising incomes. Others worsen and then improve, that is, (particulate and SO_2) and others worsen steadily such as dissolved oxygen, solid wastes, and carbon emissions) (Shafik, 1994). Stokey described of a static model with a choice of production technologies with varying degrees of pollution. Her foremost assumption is that below a threshold level of economic activity, only the dirtiest technology can be used. With economic growth, pollution increases linearly with income until the threshold was passed and cleaner technologies can be used. The resulting pollution income path was therefore inverse-V-shaped, with a sharp peak at the threshold income where cleaner technologies become available (Stokey, 1998). John and Pecchenino's pollution-income relationship also exhibits an inverse-V shape, peaking when the dynamic equilibrium switches from a corner solution of zero environmental investment to an interior optimum with positive investment (John & Pecchenino, 1994). However, the relationship between economic growth and CO_2 emissions were examined by using global panel data. The study found a diminishing marginal propensity to emit carbon dioxide as per capita GDP rises. Despite the diminishing MPE, their forecasts indicated that global emissions of CO_2 will continue to grow. Also, some environmental economists found that the costs of keeping emissions below some standards would increase with higher levels of GDP growth. Therefore, vigorous pollution dynamic can affect economic growth in the short-run (Jorgenson & Wilcoxen, 1993). Time-series data from 1970 to 2005 to test the causality between CO_2 and income in Nigeria were investigated, and it showed that there was no causality between environmental pollution and income changes (Omisakin, 2009).

3.2 Sources of Data

The data utilized in the study were secondary data (Annual time-series data). They were obtained from World Development Indicator (WDI). The data on pollution in Nigeria are not available (na) in 2016 and 2017.

3.3 Model Specification

Drawing from Kuznet pollution-income per capita hypothesis (Kuznet, 1955), a log-linear single- equation model would be utilized. The functional form of the model is given below:

$$GDPPC = F(CARD, NITRO, METH) \quad 1.1$$

The econometric log-linear form of the model;

$$GDPPC_t = \beta_0 + \beta_1 CARD_t + \beta_2 NITRO_t + \beta_3 METH_t + \varepsilon \quad 1.2$$

Where:
GDPPC = Gross Domestic Product per Capita;
CARD = Carbon dioxide emissions (CO_2);

NITRO = Nitrogen Dioxide vehicles emissions (NO_2);
METH = Methane emissions (CH_4);
ε = Stochastic error term;

The parameters to be estimated are, g_0, g_1, g_2 and g_3.

A priori reasoning: $g_1, \ldots, g_3 < 0$. It is expected that the parameters will have inverse relationship with growth. That is, the three air pollutants in the model are expected to negatively drive economic growth.

3.3 Definition of Variables

3.3.1 Carbon dioxide (CO_2)

This is a colorless and odourless gas at atmospheric temperatures and pressures. It is the primary greenhouse gas emitted through human activities. This work employed CO_2 emissions (Metric tons per capita), which is a more useful measurement of carbon emissions per capita *(*person*)* in a particular country.

3.3.2 Methane (CH_4)

Methane is a potent greenhouse gas, second only to carbon dioxide in its capacity to trap heat in Earth's atmosphere for a long time. The gas can originate from lakes and swamps, natural-gas pipelines, deep-sea vents, and livestock. It is the main constituent of natural gas. Methane is a chemical compound with the chemical formula CH_4. This work utilized methane emissions in energy sector (thousand metric tons of CO_2 equivalent)

3.3.3 Nitrous oxide (NO_2)

This is an atmospheric pollutant and greenhouse gas produced by combustions. It is a colourless gas that when inhaled produces loss of sensibility to pain. Here, NO_2 emissions (thousands metric tons of CO_2 equivalent) were utilized.

4. Presentation and Discussion of Empirical Results

Table 1: Descriptive Statistics

	GDPPC	CARB	NITRO	METH
Mean	4.136069	-0.234656	4.337583	4.858947
Median	4.383795	-0.194152	4.306445	4.887677
Maximum	5.637446	-0.032558	4.666813	5.010262
Minimum	2.835254	-0.487615	4.189872	4.702633
Std. Dev.	0.940517	0.145723	0.130563	0.092475
Skewness	-0.039714	-0.438969	1.095145	-0.419718
Kurtosis	1.640295	1.827725	3.023721	1.869908
Jarque-Bera	2.550770	2.949376	6.597159	2.724919
Probability	0.279323	0.228850	0.036936	0.256030
Sum	136.4903	-7.743654	143.1402	160.3453
Sum Sq. Dev.	28.30629	0.679525	0.545497	0.273652
Observations	33	33	33	33

Source: Authors' computation (2017) Using E-View 7.0.

The mean and media are measures of central tendency (or averages) for all the variables. Methane oxide (METH) emission has the highest mean with the value of 4.85, followed by nitro oxide (NITRO) emission with the mean value of 4.33, while gross domestic product per capita (GDPPC) has the mean of 4.13, then carbon monoxide (CARB) with the least mean of 0.23. Also, METH has the highest median value of 4.88, followed by the GDPPC and NITRO with the median values of 4.38 and 4.30 respectively, while CARB has the lowest median value of 0.19.

However, the measure of dispersion or spread in the series is gauged by standard deviation. From the table, the standard deviation for GDPPC, CARB, NITRO and METh are 0.94, 0.14, 0.13 and 0.09 respectively.

The test for normality of the distribution is the Jarque-Bera statistic. The nearer the probability value of a variable to zero, the higher the value of its Jarque-Bera statistic. From the above result, the Jarque-Bera statistics of 2.55, 2.94, 6.59 and 2.72 with the corresponding Probability of 0.27, 0.22, 0.03 and 0.25 only NITRO is statistically significant from zero (alternative hypothesis accepted) while others- GDP, CARB and METH are not statistically different from zero (null hypothesis accepted).

4.2 Correlation Analysis

Correlation analysis tests the direction and strength of relationship between the dependent and independent variables. The result is presented in table 2

Table 2: Pearson Correlation Matrix

	GDPPC	CARB	NITRO	METH
GDPPC	1.000000	-0.236273	0.863592	0.947568
CARB	-0.236273	1.000000	-0.114095	-0.338639
NITRO	0.863592	-0.114095	1.000000	0.827159
METH	0.947568	-0.338639	0.827159	1.000000

Source: Authors' computation (2017) Using E-View 7.0

From table 2, GDPPC has a strong and positive relationship with NITRO and METH, while it has negative correlation with CARB. The positive correlation between GDPPC and dependent variables-NITRO and METH negates theoretical reasoning while its inverse relationship with CARB is expected.

4.3 Units Root Test

The analysis of the result begins with investigating the time series properties of the variables before conducting the Augmented Dickey-Fuller test in any time series analysis. It is important to investigate whether the time series exhibit a trend or not. In order to verify the stationarity status of the variables, the unit root test was employed. Since most macroeconomic variables are not stationary at levels because of the data generating process, the unit root test is crucial to determine the order of cointegration. The number of cointegration is the number of times a variable has to be differenced to make it stationary. This is an essential requirement for cointegration analysis. Besides, the unit root test helps us to avoid spurious regression, which is brought about by the regression of non-stationary variables. The Augmented Dickey fuller were utilized for this exercise and the results were both presented and analysed below.

Table 3: Unit Root Test Results

Variables	ADF Stats	Critical Value of 5%	Optimal Lag*	Remarks	Order of Integration
LGDPPC	-5.413305	-2.951125	0	S	1(1)
LCARB	-5.640321	-2.954021	0	S	1(1)
LNITRO	-3.847976	-2.971853	3	S	1(1)
LMETH	-5.363941	-2.963972	1	S	1(1)

Source: Authors' computation (2017) Using E-View 7.0

*The Akaike Information Criteria (AIC) is used to determine the maximum Lag length of each of the variables.

The result of the unit root test using Augmented Dickey-Fuller as reported in table 4.3 showed that all the variables are non-stationary at levels but they all became stationary after first differencing. Hence, the entire annual time series variables utilised are homogenous of order 1written as 1(1). The decision is informed by the comparison of the Augmented Dickey-Fuller statistics with the Mackinnon critical value obtained at 5 percent significant level. Since all the variables are homogenous of order 1, it becomes imperative that a cointegration test should be conducted. Thus, a multivariate Johansen co-integration is estimated to establish the existence of a long-run equilibrium relationship between the variables utilised.

4.4 Co-integration Test

Having established the time series properties of the data, the study determines the number of co-integration relations in the model. When time series variables are non-stationary, it is important to ascertain if there is no common stochastic drift among the variables. Two or more variables are said to be co-integrated if they exhibit linear combination and long-term equilibrium relationship (Gujarati & Porter, 2009; Iyoha, 2006). The long-run equilibrium relationship between variables could be treated as "equilibrium error" to the short-run behavior of a dependent variable to its long run value. The Johansen's cointegration results using Trace Test and Maximum Eigen Value are contained in table 4 and 5 below;

Table 4: Rank Test (Trace)

Trend assumption: Linear deterministic trend
Series: GDPPC CARB NITRO METH
Lags interval (in first differences): 1 to 2

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.943013	108.6885	47.85613	0.0000
At most 1 *	0.827734	51.38995	29.79707	0.0001
At most 2 *	0.554303	16.21565	15.49471	0.0389
At most 3	0.002662	0.053320	3.841466	0.8174

Trace test indicates 3 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

The trace test shows that there is three (3) cointegrating equation(s). Here, at most three (3), the critical value at 0.05 (3.481466) outweighs the trace statistic of 0.053320, given the p-value of 0.8174 (81.74%), then we accept the null hypothesis that there is error tem or common stochastic drift among the annual time series data utilized in the study. Hence, there is long-run equilibrium relationship among the variables employed.

Table 5: Maximum Eigenvalue

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.943013	57.29859	27.58434	0.0000
At most 1 *	0.827734	35.17429	21.13162	0.0003
At most 2 *	0.554303	16.16233	14.26460	0.0248
At most 3	0.002662	0.053320	3.841466	0.8174

Max-eigenvalue test indicates 3 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values
Source: Authors' computation (2017) Using E-View 7.0

The Eigenvalue statistic revealed there is three (3) cointegrating equation(s). At most three (3), the critical value at 0.05 is 3.481466, which outweighs the Max-Eigen statistic of 0.053320, given the p-value of 0.8174 (81.74%), then we accept the null hypothesis that there is error tem or common stochastic trend among the annual time series data. Hence, we can conclusively say that there is long-run equilibrium relationship among the variables.

Table 6: The Normalized Cointegrating Coefficients

GDPPC	CARB	NITRO	METH
1.000000	-9.93E+08	-4.91E+08	6.661979
	(1.2E+12)	(5.2E+07)	(4.9E+07)

Note: Standard Error in Parentheses.

The table above showed that carbon dioxide and nitrous oxide inversely affect growth per capita, thus validating a priori. This implies that both carbon dioxide (CARB) and Nitrous Oxide (NITRO) emissions undermine productivity and GDP per capita in the long-run. On the converse, methane oxide positively affects per capita GDP. By implication, methane oxide enhances productivity and economic growth in the long-run.

5. Conclusion and Recommendation

This study utilized the unit root test to check for stationarity. The variables in the model; GDPPC, CARB, NITRO and METH became stationary at first difference 1(1). Also, the trace statistic and Maximum Eigenvalue test showed that common stochastic drift or error term exists among the variables. Hence, the Johansen Test of Cointegration revealed that there is long-run equilibrium relationship among the time-series variables employed. More so, the normalized cointegrating coefficient showed that carbon dioxide (CO_2) emissions and nitro oxide (NO_2) emissions undermine GDP per capita while methane (CH_4) emissions significantly promotes per capita GDP in the long-run. By implication, carbon dioxide and nitrous oxide can affect human health, arable land and water bodies, thereby affecting productivity and economic growth while the natural gas generated from methane sources such as livestock dungs, lake and dams etc can used by individuals and firms to improve productivity and economic growth.

In view of the above, the study recommends the following policy options

1. Human activities emitting Carbon dioxide (CO_2) has to be abated by mandating majorly firms and companies to install carbon sequestration machines or to employ carbon dioxide friendly mode of production.
2. Both carbon dioxide and combustions emitters have to be penalized by way imposing Pigouvian taxes on them by the government.
3. The effective use of natural gases from methane generating sources such as livestock, pipelines and lakes and swamps have be promoted and encouraged by the government and energy sector.

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