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Industrial Activities and Environmental Degradation in Nigeria

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Abstract: This paper is centered on industrial sector and environmental degradation in Nigeria. In recent times, industrialization has been on the increase thus made greenhouse gases which is part of our atmosphere to increase its concentration and this has posed serious problem to the environment. The broad objective of the study is to examine impact of industrialization on the environmental degradation via; examine the impact of oil and gas production, coal mining and cement production on Carbon dioxide in Nigeria. The study employed relevant secondary data from 1981-2020 The data were sourced from CBN statistical bulletin and World Bank Indicator. The econometric method used were Co-integration, unit root test, diagnostic test was employed as techniques of analysis. Based on the results it is observed that the series are stationary after first difference. The cointegration results showed that there is a long run relationship among the variables in the model. The estimates of the OLS regression revealed coal mining has a positive and significant relationship with CO2emission while cement production and oil and gas production has a negative and significant relationship with CO2 emissions. The error correction mechanism showed that short term deviation from equilibrium is corrected in the succeeding period and equilibrium is restored. The coefficient of determination statistics is 0.55 which means that 55% of the variation in the model is explained and 45% is explained by other factors not included in the model. Recommendations were made amongst others, based on the findings, that Government enact stringent laws and take actions against sectors that are defaulters.

Key words: Industrialization, Environmental Degradation, Carbon Dioxide and Pollution.

Introduction

There are sectors that has contributed to the economy growth in Nigeria which are the Agricultural, Industrial, and Service sector, despite its contribution it has also led to negative externalities which has caused environmental degradation. The exploration and exploitation of the environment dates back to the existence of man on earth Ekundayo (1988). Oil and gas related operations are the most obvious industrial activities. Petroleum exploration has triggered adverse environmental impacts in the Delta region of Nigeria through incessant environmental, socioeconomic and physical disasters that have accumulated over the years due to the growing literature. Limited scrutiny and lack of assessment Achi (2003). Excess gas from drilling associated with natural gas or oil is deliberately burned off, releasing carbon dioxide emission (CO_2) into the atmosphere conversely venting of the gas without burning, releases methane (CH_4) emission (negative externalities). Together, and crudely, these gases make up about 80% of greenhouse gases associated with oil & Gas to date. A number of studies have suggested that, the cement industry has its negative externalities as it contributes about 5% of total anthropogenic CO_2 emissions, worldwide, HERAPT (2014). It has long been known that carbon dioxide emissions contribute to climate change. The exhaust gases from a cement kiln contains are nitrogen oxides (N_2O), carbon dioxide, water, oxygen and small quantities of dust, chlorides, fluorides, sulfur dioxide, carbon monoxide , and still smaller quantities of organic compounds and heavy metals Marlowe et al (2012).

Oil and gas exploration and production has the potential to cause severe environmental degradation, not only to the physical environment, but also to the health, culture, and economic and social structure of local and indigenous communities. Inter-American Commission on Human Rights (2007). However, environmental laws in emerging economies are often ineffective because they are substantively inadequate and or because they are inadequately enforced. This has led to calls by academics, practicing lawyers, human rights and environmental activists for transnational oil companies to voluntarily improve their performance in countries with adequate environmental laws. Oil companies and industry groups have also recognized that international oil companies operating in emerging economies with inadequate environmental laws should adopt best practice. For example, members of the American Petroleum Institute are responsible for "obeying all laws and best practice" as part of the pledge to a program of continuous health, safety and environmental improvements, American Petroleum Institute (2002). Nigeria inability to adhere has led to the increase of these emissions which pollutes our environment .Based on the foregoing, the following questions are often raised; how does the activities from the Industrial sector creates problem in the area of environmental degradation? How much effect does these pollutants (carbon dioxide) has on the environment in Nigeria and is it enough to cause a stir? The main objective of this study is to examine the impact of industrial sector on environmental degradation in Nigeria.

Conceptual Literature

Industrialization:

Industrialization has found its way into numerous literatures. It is a system whereby an economy creates or grows wealth through industries and machines. Industrialization is the process of transforming raw material into consumer goods, producer goods, and services with the help of capital and as well as human resources (Amechi and Azubuike 2004). Today, nations are partitioned into two distinct categories as industrialized and unindustrialized. Developed nation are usually the industrialized nations with very high output figures. Industrialization has a trickle-down effect on every other activity sector of the economy and the aggregate economy.

Aderinto, Akande, Anyawuocha and San (2008) defines industrialization as “a deliberate policy by government to create many industries in a country: the process of industrialization involves the production, increasing use of machinery and power tools, as well as the use of improved technology in production; all of which lead to a higher level of output of goods and services. O‟Sullivan and Sheffrin (2007) defined industrialization as the process of societal and economic change that transforms a human from agrarian to an industrial one. In their view, industries bring about change in three ways: modernization, the development of large scale energy and metallurgy production. These aspects are closely linked to economic growth. They also assert that industrialization brings with it the sociological process of rationalization. Economic growth has been conceived as an increase in per capita income over a period of time (Clunies-Ross, Foresyth, & Huq, 2010; Jhingan, 2005; Abbott, 2003) and it is considered that good governance, good legal framework, availability of natural resource, relative low cost skilled labor and technology are key positive factors stimulating industrialization.

In Jhingan (2011) industrialization is expressed as the process of manufacturing consumer goods and of creating social overhead capital in order to provide goods and services to both individuals and business. In all the literatures above, one word is common “process”. This indicates that the path to industrialization is continuous and happens in stages and organized systemic structures. We can add here that it is the process of changing the indigenous technological structure to incorporate foreign technological structure in order to achieve large scale production and an improvement in the living standard of the average person in the country. Among the factors that promote growth in any economy includes technological progress. The technological progress implies improved methods of production of goods and services which increase output, and is possible by the transition from agrarian to industrialized structures or a combination of agriculture and industry such that the share in total output of industry significantly outweigh that of agriculture.

A good number of economists share the view that industrial policies are important growth stimulating policies. This is a situation where government would take a direct active role in shaping the structure and composition of industry so as to promote growth. Government industrial policies may be in form of hastening the expansion of high productivity industries or to speed up the movement of resources out of low productivity industries. In line with this view, Jhingan adds that "industrialization plays a major role in the economic development of the less developed countries (LDCs). It is a pre-requisite for economic development as the history of advanced countries show. For development to occur the share of the industrial sector should rise and that of the agricultural sector decline". He went ahead to state that "this is only possible through a policy of deliberate industrialization". Economic growth has been conceived as an increase in per capita income over a period of time (Clunies-Ross, Foresyth, and Huq, 2010; Jhingan, 2005; Abbott, 2003) and it is considered that good governance, good legal framework, availability of natural resource, relative low cost skilled labor and technology are key positive factors stimulating industrialization.

Sharp (2002), view economic growth as the long run process that results from the compounding of economic events over time. Similarly, Dwivedi (2002) stated that economic growth means a sustained increase in per capita national output or net national product over a long period of time. It implies that the rate of increase in total output must be greater than the rate of population growth. To measure economic growth, economists generally examine the rate of change in real GDP from one year to the next. Central Bank of Nigeria (2008) stated that GDP is the money value of goods and services produced in an economy during a period of time irrespective of the nationality of the people who produced the goods and services. It is usually calculated without making any allowance for capital consumption (or deductions for depreciation). Also, GDP by expenditure based is the total final expenditure at purchases‟ prices (including the f.o.b. value of exports of goods and services) less the f.o.b. value of imports of goods and services.

Carbon dioxide (CO_2)

Carbon dioxide enters the atmosphere through burning fossil fuels (coal, natural gas, and oil), solid waste, trees and wood products, and also as a result of certain chemical reactions (e.g., manufacture of cement). Carbon dioxide is removed from the atmosphere (or "sequestered") when it is absorbed by plants as part of the biological carbon cycle.

Pollution

Pollution, also known as **environmental pollution**, is the introduction of any substance (solid, liquid, or gas) or form of energy (such as heat, sound, or radioactivity) into the environment at a rate that exceeds the rate at which it can be dispersed, diluted, decomposed, recycled, or stored in some harmless form. The three principal types of pollution, as defined by the environment, are air pollution, water pollution, and thermal pollution. Specific sorts of pollutants, such as noise pollution, light pollution, and plastic pollution, are also of concern in modern civilization. Pollution of any form may harm the environment and animals, as well as have a detrimental influence on human health and well-being.

Industries are responsible for four forms of pollution: air, water, thermal, and noise.

Air Pollution

Air pollution is the contamination of air caused by the presence of chemicals in the atmosphere that is hazardous to human and other living beings' health or cause damage to the climate or materials. Air pollutants include gases (such as ammonia, carbon monoxide, Sulphur dioxide, nitrous oxides, methane, carbon dioxide, and chlorofluorocarbons), particles (both organic and inorganic), and living molecules. Air pollution may cause illnesses, allergies, and even death in people; it can also harm other living species such as animals and food crops, and it can impact the natural environment (such as climate change, ozone depletion, or habitat degradation) or the built environment (for example acid rain). Air pollution may be caused by both human activities and natural phenomena. Air pollution is a major risk factor for a variety of pollution-related disorders, such as respiratory infections, heart disease, COPD, stroke, and lung cancer. Growing research shows that exposure to air pollution is linked to lower IQ scores, decreased cognition, an increased risk of psychiatric illnesses such as depression, and poor perinatal health. Poor air quality has far-reaching consequences on human health, although it mostly affects the respiratory and cardiovascular systems.

Water Pollution

Human activity adds to water contamination as well. Factory chemicals and lubricants are occasionally spilled or leak into streams, leading to water pollution. These substances are referred to as runoff. Chemicals in runoff can harm aquatic life by creating a hazardous environment. Runoff can also contribute to the growth of cyanobacteria, also known as blue-green algae. Cyanobacteria multiply fast, resulting in a hazardous algal bloom (HAB). Harmful algal blooms make it impossible for species like plants and fish to live in the water. They are linked to "dead zones" in the world's lakes and rivers, where little life occurs beneath the surface of the water. It is caused by the discharge of organic and inorganic industrial wastes and effluents into waterways. Paper, pulp, chemical, textile, and dyeing businesses, as well as petroleum refineries, tanneries, and electroplating industries, are the major perpetrators. These industries discharge dyes, detergents, acids, salts, and heavy metals such as lead and mercury, as well as pesticides, fertilizers, synthetic compounds including carbon, plastics, and rubber, into bodies of water. Contaminated water is exceedingly hazardous to human consumption and causes chronic illnesses.

Thermal Pollution

This occurs when hot water from industrial and thermal plants is discharged into rivers and ponds before cooling,. There is a link between soil and water pollution as waste dumped into soil leads to flow of pollutants to ground, as a result the groundwater is also polluted. Thermal pollution is the dumping of hot water into bodies of water. Thermal or nuclear power plants are the principal sources of thermal heat pollution, as are industrial effluents from petroleum refineries, pulp and paper mills, chemical plants, steel mills and smelters, sewage effluents, and biochemical activities. The ambient water temperature is one of the most critical conditions for aquatic fauna and plant survival. Cancers, birth abnormalities, and miscarriages are caused by waste from nuclear power plants, nuclear and weapon production sites. Thermal pollution reduces the amount of dissolved oxygen in the water, which aquatic life requires, damages fish larvae and eggs in rivers, causes the extinction of some fish and macroinvertebrates that have a low tolerance for temperature change, and causes living entities to migrate from their environment.

Noise Pollution

Noise pollution is an unseen threat. It cannot be seen, although it is present both on land and beneath the water. Any undesired or irritating sound that impacts the health and well-being of people and other species is referred to as Noise pollution. Noise pollution is described as repeated exposure to high sound levels that may cause harm to people or other living beings. Sound levels less than 70 dB are not harmful to living beings, according to the World Health Organization, regardless of how long or regular the exposure is. Continuous exposure to sound above 85 dB for more than 8 hours might be dangerous. If you work for 8 hours a day near a major road or highway, you are likely to be exposed to traffic noise pollution of roughly 85 decibels. It can induce hearing loss, increased heart rate, and blood pressure, among other physiological symptoms, in addition to aggravation and rage. Unwanted sound is a source of annoyance and tension. Industrial and construction operations, machinery, manufacturing equipment, generators, saws, and pneumatic and electric drills are the most common sources of noise pollution.

Crude Petroleum and Natural Gas

The petroleum sector is one of the most important sectors in Nigeria. This is because the sector generates the highest amount of revenue to the federal, state and local governments in the country.

According to Ogbonna (2011), the petroleum industry constitutes the major source of income and occupies a strategic position in the economic development of Nigeria.

The Statement of Accounting Standard No. 14 on Petroleum also stated that the petroleum industry is very strategic in the Nigerian economy as the nation's major provider of foreign income and plays a major role in facilitating the economic development of Nigeria. For the past four decades, the petroleum industry in Nigeria has been playing vital and dominant role to the economic growth of Nigeria been the predominant source of revenue, and accounting for over 90% of the total revenue of the country. Petroleum has both direct and indirect effects on the overall level of economic activities, but its impact is felt more in the urban sector where petroleum revenue has been used to stimulate the economic development of the nation. The impact of petroleum on the economy of Nigeria is felt specifically, through direct contributions to the national income and output, the generation of employment and manpower development, the creation of backward and forward linkage effects and other indirect benefits to the economy (Appah, 2010). Oremade (2006) has made the argument that for petroleum profit tax purposes, crude oil sales valued at the prices actually realized by the oil producing company in the world oil market. However, this value has to be compared with the value at the posted price and if the posted price is higher, tax is then based on the posted price. Sales of crude oil for local refining and sales of gas are valued for petroleum profit tax purposes at the actual amount realized on sale.

Coal Mining

Coal is an important source of energy around the world approximately 41% of the world's electricity is generated from outdoor coal combustion, Natalyet al (2014). However, indoor coal combustion is only used for domestic energy purposes. Both indoor and outdoor coal combustion contributes to environmental and health issues, even in the developed world. According to some recent studies, coal-based chemical processing releases CO_2 two to four times more than that of oil-based chemical processing, Ren (2009). In outdoor power generation, the amount of possible heating of coal mainly depends on CO_2 and H2 contents and partially on SO_2. However, in different coal ranks, the ratio of these components varies. Different coal ranks have different amounts of coal: lignite coal has more than 60% carbon content and it increases to 80% for anthracite, Slatick(1994).

During coal combustion both CO_2 and CO gases were mainly emitted as a result of oxidation and they lead to harmful impacts on the environment in the form of global warming and GHG. In addition, these gases are concomitantly correlated with many health issues directly and indirectly including malaria, cardiovascular diseases and asthma. CO_2emissions are considered to be the main cause of about three-quarters of global GHG emission. Fossil fuels account for approximately 90% of the total global CO_2 emissions in 2011,Olivier et. al(2012). Due to continuous CO_2emission and underlying climate change, global warming is correlated with increased overall incidences of flooding and hurricane activity (Gething et al., 2010, Henderson-Sellers et al., (1998); Pielke and Pielke, (1997)Simpsonet.al(1981), having a severe impact on agriculture and the food-web. Furthermore, an extremely hot climate leads to dehydration, cerebrovascular, respiratory, and cardiovascular disease in the developed world, including the US and China Karl (2009), Lan et al.,(2002). Thus, the emission of$CO_2$from coal causes air pollution and plays a key role in global warming and GHG, which directly and indirectly affects human health and the environment.

Cement Production

Clinker is then removed from the kiln to cool, ground to a fine powder, and mixed with a small fraction (about emitted as a byproduct of clinker production, an intermediate product in cement manufacture, in which calcium carbonate (CaCO3) is calcinated and converted to lime (CaO), the primary component of cement. CO_2 is also significant source of global carbon dioxide (CO_2) emissions, making up approximately 2.4 percent of global kiln, or a precalciner, at temperatures of 600900°C, and results in the conversion of carbonates to oxides. The containing materials to produce minerals in the clinker, an intermediate product of cement manufacture.

Specifically,CO_2 is released as a by-product during calcination, which occurs in the upper, cooler end of the is generally the second most common form of cement. Because masonry cement requires more lime than plants are expensive, the number of plants in a country is generally limited (less than 100). Carbon dioxide is emitted during cement production by fossil fuel combustion. However, the $CO_2$from fossil fuels is specifically these sources are the principal raw materials used in the cement production process. Because the production Process Description At higher temperatures in the lower end of the kiln, the lime (CaO) reacts with silica, aluminum and iron accounted for in emission estimates for fossil fuels. Carbon dioxide is released during the production of clinker, a component of cement, in which calcium carbonate (CaCO3) is heated in a rotary kiln to induce a series of complex chemical reactions (IPCC Guidelines). Five percent) of gypsum to create the most common form of cement known as Portland cement. Masonry cement Cement is an important construction ingredient around the world, and as a result, cement production is a CO_2 emission from industrial and energy sources (Marland et al., 1989). Cement is produced in large, capital intensive production plants generally located near limestone quarries or other raw carbonate mineral sources as

CaCO3 + heat CaO + CO_2 →Simplified stoichiometric relationship is as follows: Portland cement, masonry cement generally results in additional CO_2emissions.

Theoretical Literature: The Environmental Kuznet curve

EKC is an inverted-U-shaped relationship between economic growth and measured pollution indicators or environmental quality as economic growth is linked to continuous structural transformation and change. In fact EKC model represents the structural change; as income of an economy grows over time, emission level grows first, reaches a peak and then starts declining due to greater use of natural resources, more emission of pollutants, emphasize to increase in material output. The transition from industrial to service based economy is assumed to result in leveling off and a steady decline of environmental degradation because of increased environmental awareness, higher environmental expenditures, efficient technologies and increased demand for environmental quality. As income moves away from the EKC turning point, it is assumed that transition to improving environmental quality starts. Thus the EKC has another term “stages of economic growth” as economies pass through a transition from agriculture based economies to industrial economies results in increasing environmental degradation and then post-industrial service based economies consequently begin to demonstrate decreases in pollution and environmental degradation. The transition from agricultural to industrial economies results in increasing environmental degradation. The Environmental Kuznets Curve (EKC) hypothesis states that there is an inverted U shaped relationship between economic development and environmental damages. It shows that until a country reaches a turning point, there is continuous environmental degradation, at which point the country reverses the path and starts to experience an environmental improvement Grossman and Krueger (1995).

Empirical Literature

According to Kagan et al (2017), using Augmented Dickey Fuller Regression in his study “Sectorial output, energy use, and CO_2emission in middle-income countries” a striking finding is that higher industrialization has led to a relatively higher level ofCO_2emissions in all middle-income countries. The effect of industrial GDP is positive and significant for all middle-income and higher. Middle-income countries, but not for lower middle-income countries. The results reported in show that the sophisticated service sect.

Empirically, Achike et al (2014), investigated and analyzed the determinants of Carbon Dioxide (CO_2) emission in Nigeria. The study relied on secondary data which covered 40 years (1970-2009). The data were analyzed using Zellner’s Seemingly Unrelated Regression (SURE) model. The results of the analysis show that fossil energy demand or consumption, rents from forestry trade, agricultural land area expansion and farm technology were significant determinants of greenhouse gas (GHG) emission in the study area. On the other hand, the second equation indicated that fossil fuel energy demand was exogenously determined by economic growth rate (proxied by GDP growth rate) and farm technology applied in the country.

Jacqueline et al (2014), conducted a study that revealed that oil and gas industry contribute to biodiversity loss as well as to the destruction of ecosystems that, in some cases, may be unique. Oil industry holds a major potential of hazards for the environment, and may impact it at different levels: air, water, soil, and consequently all living beings on our planet. Other environmental impacts include intensification of the greenhouse effect, acid rain, poorer water quality, groundwater contamination, among others.

Anomohanran (2011), his study focuses on Greenhouse Gas Emissions from Petroleum product combustion in Nigeria. The Methodology used is Reference Approach. Results showed that the average yearly increase in CO_2 emission in the past ten years was 4.7% as against global average rate of 1.9%.It is recommended the good and efficient energy utilization process be put in place in Nigeria.

Odemba (2011) established that carbon emission has positive and significant impact on GDP in Nigeria. A percentage rise in emissions from cement production, bunker fuels, solid fuels, and fossil fuels leads to 0.44, 0.62, 0.56, and 0.71 units rises in real GDP, used as aproxy for growth, respectively.

Leo (2011) experimentally opined that there is a positive relationship between carbon emissions and growth. He said this is due to the fact that emissions result from industrial activities, which enhance growth. The flares associated with gas flaring give rise to atmospheric contaminants. These include oxides of Nitrogen, Carbon and Sulphur (N_2O, CO_2, CO, SO2), particulate matter, hydrocarbons and ash, photochemical oxidants, and hydrogen sulphide (H2S).These contaminants acidify the soil, hence depleting soil nutrient. Previous studies have shown that the nutritional values of crops within such vicinity are reduced. In some cases, there is no vegetation in the areas surrounding the flare due partly to the tremendous heat that is produced and acid nature of soil pH.

According to Sharma (2011), the Environmental Kuznets Curve (EKC) has been used to explain the relationship between the economic activities and the emission of pollutants and between the economic activity and the use of natural resources. Sharma reiterated that energy, such as crude oil, natural gas, and coal, plays a major role in residential and industrial energy needs, transportation, and electricity. The burning of fossil fuel is essential in every country as it is used for the production of goods and services. While it is true that burning of fossil fuel emits a high amount of $CO_2$and pollutes our environment, it has been empirically and theoretically shown that an increase in energy consumption results in greater economic activity David (2011) examined the Capping of Carbon and Methane Emissions in Nigeria using multiple regression analysis. The study suggested how to cap two of the emissions that are prone to Nigeria as a nation. According to the study, Carbon emissions are released from burning fossil fuels that are used to power vehicles, generators while Methane gas is also produced from decomposed waste products of ruminant animals. The study revealed that safety systems such as liners, covers, gas and liquid extraction and monitoring wells to detect contamination can aid in capping Carbon and Methane Emissions in Nigeria.

Batimoore and Tudok (2010) examined the relationship betweeneEnergy and GNP. Pollution has negative effect on growth, while of pollution in some studies is due to the output generated during carbon emissions or there is a rise in industrial activities which generate the pollution, which in turn leads to technology and consumption have positive effects on growth. Even when pollution or carbon that the signs may be positive. They said that shocking positive sign pollution, which contribute positively to growth. Increase in carbon emissions implies that there is a rise in industrial activities which generate the pollution, which in turn leads to increase in growth. A multiple regression used to assess the impact of carbon emissions major sources on economic growth. Emissions from carbon have negative impact on economic growth

Porter and Brown (2009) found out in their study that emissions from fossil fuels have a negative and significant impact on economic growth. They claimed that the negative impact is as a result of low productivity of both land and labour caused by increased carbon emissions. Though in a different study.

Mesih *et al.* (2009) found in their study that carbon emissions from gas flaring or gas fuels and solid fuels have significant impact on economic growth. A unit rise in the emissions of these fuels leads to 0.34 and 0.52 units increases in GDP, respectively. Thus, they found out that emissions have positive impact on economic growth. They added that the major sources of carbon emission in Asia are gas fuels and solid fuels.

Methodology

Research Design

It is the overall strategy and method used to integrate the different components of the study in a coherent and logical way, thereby effectively address the research questions, Guilford (2012). The research design for this study is based on quasi-experimental design which utilizes the ordinary least square (OLS) and co-integration/ECM. This is because the study involved time series data and it is analytical in nature while dependent and independent variables are to be determined.

Model specification 1

The functional relationship of the model is formulated thus

CO_2= f(OGP, COM, CMP) (3.1)

To make equation (3.1) estimable, it is written econometrically as follows:

$CO_2 = \alpha_0 + \alpha_1 OGP + \alpha_2 COM + \alpha_3 CMP + \mu t$ (3.2)

Putting the variables on the same scale and to reduce the problem of multicollinearity, the estimated log-linear form is as follows:

$LnCO_2 = Ln\,\alpha_0 + \alpha_1 Ln\,OGP + \alpha_2 Ln\,COM + \alpha_3 Ln\,CMP + \mu t$ (3.3)

CO_2 = Carbon Dioxide per capita emission proxy for environmental degradation

OGP = Oil and Gas Production

COM = Coal Mining

CMP = Cement Production

α_1, α_2 and α_3 = coefficient or slope

On the apriori expectation is that

$\alpha_1 < 0$, $\alpha_2 < 0$, $\alpha_3 < 0$

Variables in the model

Dependent variable: CO_2

Independent variables: Oil and gas production, coal mining, cement production

Techniques of Data Analysis

This study will utilized the Ordinary Least Square (OLS), the co-integration/error correction and the granger causality test methods

Ordinary Least Square (OLS)

This study will employ the ordinary least squares (OLS) regression analysis .This is so because the estimate of OLS possess the properties of Best, Linear, Unbiased and Efficiency (BLUE).

Augmented Dickey-Fuller Unit Root Test

This involves testing the order of integration of the individual series under consideration. The unit root test that will be used in this study is the Augmented Dickey-fuller (ADF).

Results and Discussion

Summary of Augmented Dickey Fuller Test Result

Variables	ADF State	5% Critical Value	Order of Integration	Assessment
$lnCO_2$	-6.644808	-2.941145	1(1)	Stationary
lnOGP	-5.736438	-2.941145	1(1)	Stationary
lnCOM	-5.356660	-2.943427	1(1)	Stationary
lnCMP	-5.427704	-2.941145	1(1)	Stationary

Source: Author's Computation using E-view

From the results above, the all the variables are stationary of order one. These imply that, a deviation from the point of equilibrium is restored in the lapse of time indicative of a time variant adjustment. Therefore, CO_2, OGP COM, and CMP become stationary after first differences of the series were taken thereby giving the absolute ADF values greater than the critical values at 5% respectively. We can proceed to the test for cointegration.

Johansen Co-integration Test

H_0 = No co-integrating equation

H_1 = H_0 is not true.

Decision: Reject H_0 if the Trace values > 5% critical level and vice versa.

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.663110	56.50384	47.85613	0.0063
At most 1*	0.234900	35.15983	29.79707	0.0196
At most 2	0.113429	4.985360	15.49471	0.8104
At most 3	0.010742	0.410389	3.841466	0.5218

Trace test indicates 1 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: Author's Computation using E-view

From the results above, it could be seen that there is at least two cointegration equation in the models. The hypothesis of no cointegration is rejected. Evidently these results prove that there is a long run relationship among the variables in the model. Therefore, we will estimate the long run regression model and the error correction model.

Ordinary Least Squares Regression Estimation Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNOGP	-2.36E-06	2.55E-05	-0.092582	0.9267
LNCOM	0.008337	0.004664	2.787504	0.0323
LNCMP	-0.000145	0.000169	-0.859507	0.3957
C	0.590387	0.214456	2.752947	0.0092
R-squared	0.5453787	Mean dependent var		0.606283
Adjusted R-squared	0.083269	S.D. dependent var		0.172191
S.E. of regression	0.164866	Akaike info criterion		-0.672731
Sum squared resid	0.978506	Schwarz criterion		-0.503843
Log likelihood	17.45461	Hannan-Quinn criter.		-0.611666
F-statistic	24.180821	Durbin-Watson stat		2.366493
Prob(F-statistic)	0.001182			

Source: Author's Computation using E-view

Interpretation of Results:

From the results above, the following conclusions can be drawn;

Oil and Gas Production (OGP): OGP has negative relationship with the emission of carbon dioxide. The estimate shows that every unit increase in OGP led to -2.36E-06% decrease in carbon dioxide emission for the period under review. The estimate is not statistically significant given the prob value 0.9267 > 0.0.5. This indicates that oil and gas production has no significant effect on the emission of carbon dioxide.

Coal Mining (COM): COM has a positive relationship with carbon dioxide emission (CO_2) given the estimate as 0.008337. This implies that every unit increase in COM for the period under study, led to0.008337% increase in the emission of CO_2. The estimate is statistically significant given the prob value as 0.0323< 0.05. This shows that coal mining has significant effect on the emission of carbon dioxide.

Cement Production (CMP): Cement production has a negative relationship with CO_2 emission. An increase in CMP will lead to a corresponding decrease in the emission of CO_2. The estimate of CMP is given as -0.000145. It implied that, a unit increase in CMP led to 0.000145% decrease in the emission of $CO_2$for the period under review. Given the prob value as 0.3957 > 0.05, we conclude that the estimate is statistically insignificant. This implies that cement production has no significant effect on the emission of CO_2.

Coefficient of Determination (R^2): Given the **R^2= 0.5453787**, 55% of the changes in $CO_2$was explained by the variables in the model while 45% was explained by other variables that are not in the model. The remaining 44% was accounted for by the error term (u_t). The explanatory power of the model is considered acceptable.

Durbin-Watson: The DW statistic is 2.366493 approximately equal to 2, showing evidence of no autocorrelation. According to the rule of thumb, if DW approximately 2, means that the model has no serial correlation (not spurious). This means that the value of the error term in the previous period does not relate with the error in the current period. The model is free from first order serial correlation.

F-Stat: Given the **Prob(F-stat) = 0.001182< 0.05**, the overall model is significant at 5%. To test the overall significance of the regression, F-stat is 24.180821and prob (F-Statistic) is 0.001182. Testing the null hypothesis that the coefficients are equal to zero at 5% level of significance, we reject the null hypothesis since the probability f-statistics is less than 0.05 in each case. We therefore conclude in the overall, the independent variables have significant impact on the dependent variable in the model.

Heteroscedasticity Test

Heteroskedasticity Test: Breusch-Pagan-Godfrey			
F-statistic	3.578255	Prob. F(3,36)	0.3231

Source: Author's Computation using E-view

From the table above, the F-stat is 3.578255 while the probability value of F-ratio is 0.32. According to the rule of thumb, if the probability statistics is less than 0.05, there is heteroscedasticity in the model. However, the probability value is greater than 0.05(i.e. 0.32> 0.05). Therefore, the stochastic conditions of constant mean, variance and covariance (homoscedasticity) is fulfilled. The model is free from heteroscedasticity.

Summary of the Results of the Estimation of the Error Correction Model

Error Correction:	D(LNOIG)	D(LNCOM)	D($LNCO_2$)	D(LNCEMP)	CointEq1
ECM(-1)	0.020122	-0.034992	-0.298595	0.490217	
	(0.06239)	(0.12744)	(0.11768)	(0.21259)	
	[0.32249]	[-0.27458]	[-2.53725]	[2.30595]	
D(LNOIG(-1))	-0.051705	0.281638	0.372331	0.347465	

					1.000000
	(0.18002)	(0.36768)	(0.33954)	(0.61335)	
	[-0.28722]	[0.76599]	[1.09657]	[0.56650]	
D(LNOIG(-2))	-0.068945	-0.507249	-0.119565	-1.042467	
	(0.17821)	(0.36398)	(0.33613)	(0.60718)	
	[-0.38688]	[-1.39362]	[-0.35571]	[-1.71689]	
D(LNCOM(-1))	-0.018771	0.991649	0.043151	0.098193	0.348626
	(0.06544)	(0.13366)	(0.12343)	(0.22297)	(0.08545)
	[-0.28684]	[7.41930]	[0.34960]	[0.44040]	[4.07966]
D(LNCOM(-2))	-0.091330	-0.410461	0.246646	0.128434	
	(0.06085)	(0.12429)	(0.11478)	(0.20733)	
	[-1.50086]	[-3.30254]	[2.14895]	[0.61946]	
D(LNCO$_2$(-1))	0.033507	-0.499371	-0.051017	-0.123851	0.573931
	(0.08969)	(0.18319)	(0.16917)	(0.30559)	(0.25116)
	[0.37359]	[-2.72603]	[-0.30158]	[-0.40529]	[2.28515]
D(LNCO$_2$(-2))	0.017281	0.927685	0.013858	0.379429	
	(0.09824)	(0.20065)	(0.18529)	(0.33471)	
	[0.17591]	[4.62348]	[0.07479]	[1.13359]	
D(LNCEMP(-1))	0.000418	-0.121212	0.048851	-0.126324	-0.014756
	(0.04274)	(0.08728)	(0.08061)	(0.14561)	(0.11970)
	[0.00979]	[-1.38870]	[0.60605]	[-0.86757]	[-0.12328]
D(LNCEMP(-2))	-0.035968	0.054151	-0.037354	-0.486899	
	(0.04314)	(0.08812)	(0.08138)	(0.14700)	
	[-0.83368]	[0.61451]	[-0.45902]	[-3.31223]	
C	0.008836	-0.009357	-0.003774	0.083739	-8.987031
	(0.01463)	(0.02988)	(0.02759)	(0.04984)	
	[0.60406]	[-0.31319]	[-0.13681]	[1.68022]	
R-squared	0.185101	0.755938	0.304078	0.446260	
F-statistic	0.681437	9.291941	1.310826	2.417709	

Source: Author's Computation using E-view

The results above show the estimates of the short and long run equations and the adjustment of short term disequilibrium to the long-run equilibrium. The long run measures any relation between the levels of the variables under consideration while the short-run dynamics measure any dynamic adjustments between the first differences of the variables. The results of the long run estimates are the co-integrating equations indicating a long run relationship among the variables in the model. The error correction model (ECM) are the adjustment coefficients showing a long run convergence of the error after a deviation from equilibrium in the previous year (return to equilibrium). The respective values of the error correction modes are the speed at which equilibrium is restored in the current period. The short run estimates indicate the magnitude of changes in the in the dependent variables attributable to a unit increase or decrease in the explanatory variables in the short run.

From the results, it can be observed that the ECM (-1) coefficient of the D (LNCO$_2$) model has a negative sign. This implies that short run errors that cause disequilibrium in the model converge and equilibrium is restored in the successive period. The deviations are corrected at the speed of

0.298595 leading to a long run. The model is not explosive. However, the estimate is statistically insignificant at 5% given that the probability value is 0.11768 > 0.05.

Residual Diagnostics

Heteroscedasticity Test

H_0 = There is no heteroscedasticity in the model.

H_1 = There is heteroscedasticity in the model.

Decision Rule: If the prob value is greater than 0.05, we accept the null hypothesis and reject the alternative. If otherwise, we reject the null and accept the alternative.

VEC Residual Heteroskedasticity Tests: No Cross Terms (only levels and squares)		
Date: 08/08/23 Time: 12:59		
Sample: 1 40		
Included observations: 37		
Joint test:		
Chi-sq	Df	Prob.
184.2026	180	0.3994

Source: Author's Computation using E-view

From the result above, we accept the null hypothesis. The model has no heteroscedasticity and it is good for estimation.

Serial Correlation Test

H_0 = There is no serial correlation in the model.

H_1 = There is serial correlation in the model.

Decision Rule: If the prob value is greater than 0.05, we accept the null hypothesis and reject the alternative. If otherwise, we reject the null and accept the alternative.

VEC Residual Serial Correlation LM Tests		
Null Hypothesis: no serial correlation at lag order h		
Date: 08/08/23 Time: 12:59		
Sample: 1 40		
Included observations: 37		
Lags	LM-Stat	Prob
1	26.27890	0.0902
2	24.29246	0.0833
3	35.60699	0.0033

Probs from chi-square with 16 df.

Source: Author's Computation using E-view

From the result above, we accept the null hypothesis. The model has no serial correlation and it is good for estimation.

Conclusion

This study focused on industrial sector and environmental degradation on in Nigeria with in the period of 1981-2020. The environment where man live has been a constant concern which has raised lot of questions been aware of the day today increasing economic activities which has led to development and also environmental degradation. The industrial sector been a major contributor to the economy, its increase has led to environmental degradation.

Based on the results it is observed that the series are stationary after first difference. The contingration results showed that there is a long run relationship among the variables in the model.

The estimates of the OLS regression revealed coalmining has a positive and significant relationship with CO_2 emission while cement production and oil and gas production has a negative and significant relationship with CO_2 emissions. The error correction mechanism showed that short term deviation from equilibrium is corrected in the succeeding period and equilibrium is restored. The Granger causality test showed that there is a unidirectional relationship between dependent variable and the independent variables in the root equation of the models.

Recommendations

Based on the findings of this work, the study thereby recommends the following

1. Government should make stringent laws and take actions against sectors that are defaulters.
2. The sectors should employ means to minimize pollution or processing to enhance environmental quality
3. Government should encourage the use of clean technologies such as wind, solar power etc.

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