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The impact of industrial output on environmental degradation in Ecowas countries

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Abstract
This study investigates the impact of industrial output on environmental degradation in some selected ECOWAS countries from the year 2007 to 2020 for seven countries. The study employed Pedroni residual based approach of panel cointegration test to investigate the presence of long term relationship between industrial output and environmental pollution, which is proxied by CO_2 emission. The results of the study validate the presence of long-run relationship between industrial output and environmental pollution. In addition, the study used the fully modified Ordinary Least Square (FMOLS) model estimation technique to estimate the model The results obtained from the model from the estimation revealed that industrial output and Urban population have positive but not significant impact on the quantity of CO_2 emissions, while foreign direct investment and GDP have negative but insignificant impact on the quantity of CO_2 emission in the five selected West African countries. By implication, an increase in industrial output and urban population will increase the quantity CO_2 emissions on the environment and consequently causing environmental degradation in the West African countries.

Keywords: industrial output, environmental degradation, CO_2 emissions

1. Introduction

Over the years, West African countries have developed strategies of shifting their economies gradually from the traditional agricultural economy to a modern and industrialized economy. This is a remarkable move since industrialization is widely acknowledged as the prerequisite for sustainable economic growth and development. However, the increased industrial activity is usually associated with environmental pollution through carbon dioxide (CO_2) emission. This issue of environmental pollution resulting from increasing industrial output had recently become a topic of debate among environmental economists. The environmental Kuznets curve (EKC) by Simon Kuznets was the starting point of study on the link between environmental quality and economic productivity. The theory states that at early stage of economic growth and higher income per capita, environmental quality decline due to increasing pollution emissions resulting from increased production. But in the long run the trend reverses, so that higher per capita income level and rising economic growth is associated with cleaner environment. This implies that at first stage of economic growth, there is positive relationship between the growth of output and environmental pollution but at later stage of output growth, there is an inverse relationship between the growth of output and environmental degradation. By implication, the Environmental Kuznets hypothesis suggests that West African Countries who are currently at their early stage of economic development must be ready to face the problem of environmental degradation in the course of achieving economic prosperity in the short run. Many factors have been identified as the causes of the increasing environmental degradation in developing economies but gas emissions resulting from industrial production process is the leading factor. Evidence from recent studies across the globe confirmed the significant impact of energy consumption on industrial output (see Anwar *et al* (2022) [4]; Busah *et al* (2021); Armean *et al*. (2021) [5]; Adedoyin *et al*. (2020) [1]; see also Davis *et al*. (2019). Invariably, increasing urban population and increased industrialization have engendered the quantum of energy usage in most developed economies compared to less developed economies.

However, environmental laws and the adoption of new technologies are reducing the environmental impact of industrial output in developed economies. On the other hand, in the quest for attaining higher level of economic development, developing countries comprising of many countries in west Africa have formulate policies that promote local production such as import substitution strategies and export promotion strategies along Foreign direct investment. Whereas, many industries from Developed economies with the sole aim of maximizing profit at minimum operation cost take advantage of weak environmental laws in the west African countries to set up their industries in the name of foreign direct investment. This rendered the sub-region to become a "Pollution haven" (see Adu and Denkyirah, 2017) [2]. Invariably, as more industries are established without consideration for their contribution to the quantity of gas emissions on the environment, the quality of life of the residents of these might be endangered countries in the long run.

This work is structured to investigate the impact of industrial output on environmental pollution in the selected Economic community of West African Countries (ECOWAS). It also aims to investigate if expansion of output will reduce the level of environmental degradation in the long run as suggested by the EKC. The work is therefore organized as follows; this section provides the introduction of the study. Section two gives the review of related literature, while section three gives the research methodology. Section four gives the presentation and discussions of the results, while section five will gives the summary and conclusion of the study.

2. Review of related literature

The bulk of existing studies on the environmental degradation can be classified into two categories. The ones that centered on the influence of energy consumption on the environment while on the other side, there are studies that focus on the influence of output growth on the environment using various economic variables such as gross domestic product, economic growth, share of manufacturing to GDP, gas consumption, CO_2 emissions. The findings from various studies across regions revealed mixed results.

Adu and Denkyirah (2017) [2] used dataset from some countries in West Africa to investigate the influence of economic growth on environmental degradation with a view to confirm the existence of EKC in the region. The findings from the study showed that the economic growth in the region is associated with significant increase in environmental pollution in the short run and also economic growth does not lead to reduction in the volume of environmental pollution in the long run. By implication, there is no presence of EKC in West Africa countries. Akinsola *et al*. (2022) employed the autoregressive distributed lag (ARDL) to investigate the presence of EKC in Africa. The findings from the study validated the existence of Environmental Kuznets Curve in the long run when the entire panels of the countries were estimated. The results from the analysis showed the existence of positive but not significant relationship between industrialization and environmental degradation when individual panel was estimated. This implies that the influence of industrial output on environmental degradation differ across regions.

Radoine *et al*. (2022) investigate the impact of urbanization and the growth of output on environmental pollution in some countries of West Africa. The findings from their study revealed that manufacturing output, urban population, financial innovation and foreign direct investment have direct impact on environmental pollution in the countries. In other words, increase in manufacturing output, urban population, and financial development as well as increase in foreign direct investment increased the volume of environmental pollution in West African Countries.

Bosah *et al*. (2021) employed panel co-integrated test and Pool Mean Group ARDL (PMG-ARDL) approach to investigate the influence of energy used and ouput growth on environmental pollution for 15 selected economies. The results from the study revealed that energy consumption increases the volume of environmental pollution significantly in both the short run and the long run. The findings from the study also revealed that the growth of output in the economies increases the volume of environmental degradation in the long run. This implies that there is no evidence of the EKC in the countries. Wang *et al*. (2020) employed the dynamic unrelated seemingly Regression (DUSR) estimation techniques to examine the impact of industrialization and urban population on environmental quality and found that industrialization and increasing urban population lead to environmental pollution. Yao *et al*. (2019) [10] employed the techniques fully modified ordinary least square (FMOLS) and dynamic ordinary least square (DOLS) to examine the impact of renewable energy consumption and output growth of some selected developed and developing economies on environmental pollution. The results confirmed the existence of EKC in the countries. The results further revealed that renewable energy consumption reduced the volume of environmental pollution in both categories of countries under studied.

In addition to the above, a study by Liu *et al*. (2018) [8] employed a dynamic panel approach to study the effect of the output of manufacturing industries on environmental degradation in China and found that manufacturing output enhances environmental pollution in China. Rauf *et al*., (2018) [9] investigates the impact of industrial output and energy consumption on the environment in Chinese economy. The findings from the study show that the industrial output have a positive impact on the environment while energy consumption have a negative impact on the environment. In another study, Rauf *et al*., (2018) [9] investigate the presence EKC hypothesis in some selected economies of Asia, Africa and Europe. The results of the study revealed that the influence of output on environment differ across regions.

Theoretical Review

The work adopted the Environmental Kuznets Curve (EKC) hypothesis which states that countries will have to grow rich first before they can afford to become cleaner by reducing the level of environmental pollution. That is, countries evidence has shown that economies with high levels of Income per capita have been able to control air pollution than developing countries. The rationale for selecting this theory is based on the fact that the growth of industrialization could be injurious to the environment. This is because the process of industrial production would lead to the release of pollutants which could lead to environmental degradation.

3. Methodology

This study used data observations between 2007 and 2020 to

examine the influence of industrial output on environmental degradation in 5 selected West African countries. The data observation of all variables were obtained from the database of the World Bank i.e World Development indicators (WDI). Industrial output is proxied with industrial output including value-added. Environmental degradation is measured in the study by the estimated value of CO_2 emissions per capita. This measure had been adopted in various studies on the environment and energy studies as a measure of environmental degradation. The measure takes into consideration how the process of industrialization in a country lead to environmental degradation. This is because the release of unwanted chemicals from manufacturing plants in the course of production pollutes the environment.

Specification of Empirical model

The paper primarily focuses on the effect of industrial output on environmental degradation from selected West African countries. The key variable is industrial output. Foreign direct Investment is measured as the total net flow of foreign investment in the country expressed in US dollars. Urban population, consumption of energy and net direct investment from foreign countries are taken as control variables. The study employed panel data analysis by drawing insight from the work of Ndubisi (2018) which explained the relationship between Capital Flow and the Growth of economies in selected Sub-Saharan Africa. To analyze the link between environmental degradation and industrial output, we have constructed and adopted the models as:

$$LCO_2 = \beta_0 + \beta_1 EC + \beta_2 FDI + \beta_3 LINDOUT + \beta_4 LURB + \mu_t \quad (1)$$

Equation (1) implies that Environmental degradation (ED) is a function of Industrial output (Y), Foreign Direct Investment (F), urban population (U)

Where,
LCO_2 = log of CO_2
LGDP = log of GDP
LFDI = log of FDI
(LINDOUT) = log of industrial output
LURB = log of URB i.e urban population (% of the total population)
The model essentially states that environmental degradation proxied by CO_2 emissions is a function of Industrial output, foreign direct investment, urban population and gross domestic product.
Since the study employed a panel data for estimation, we re-write equation (1) in panel form as follows:

$$LCO_{2\ I,t} = \beta_0 + \beta_1 LGDP + \beta_2 LFDI_{i,t} + \beta_3\ LINDOUT_{i,t} + \beta_{4L} URB_{it} + \mu_{it}$$

4. Presentation of results and discussions

Table 1: Descriptive Statistics

	LCO2	LFDI	LGDP	LINDOUT	LURP
Mean	-1.057989	0.726065	24.40530	24.20153	3.870383
Median	-1.080564	0.729717	24.07181	23.01466	3.854224
Maximum	-0.534524	2.247777	26.86928	28.70795	4.032008
Minimum	-1.505826	-2.536050	22.88662	21.21565	3.709148
Std. Dev.	0.284300	0.885070	1.258489	2.501578	0.091511
Skewness	0.097506	-0.920213	1.004548	0.676682	0.151806
Kurtosis	1.741848	5.326207	2.664470	2.089205	1.821142
Jarque-Bera	3.984902	21.62942	9.919975	6.541974	3.642970
Probability	0.136361	0.000020	0.006098	0.037969	0.161785
Sum	-62.42138	42.83782	1439.913	1427.890	228.3526
Sum Sq. Dev.	4.687932	45.43426	91.86005	362.9578	0.485708
Observations	59	59	59	59	59

***Source*:** Author's computation via E-view 9

From the results in table 1 above, the Jaque-Bera statistics shows values less than 10%, im[plying that all the variables were normally distributed except foreign direct investment whose value is greater than 10%. The skewness statistics were positive for all the variables except for foreign direct investment, all variables were skewed to the right implying that they all had a long right tail. Kutorsis which measures the level of sharpness of the distribution revealed that all the variables were platykurtic in nature as their values are less than 3, except for foreign direct investment with value greater than 3, which implies that it is leptokurtic.

Multicollinearity test

Correlation is used to check if there is multicollinearity among the variables in order to avoid spurious results. This study adopted Iyoha's (2004) argument as adopted by Tella *et al*. (2017) which posit that multicollinearity occurs among variables when the results of the correlation coefficient is greater than 0.95.

Table 2: Correlation Matrix

	CO2	FDI	GDP	INDOUT	URP
CO2	1.000000	-0.159455	-0.550902	0.363616	-0.542231
FDI	-0.159455	1.000000	-0.274768	-0.111371	0.393440
GDP	-0.550902	-0.274768	1.000000	-0.222801	-0.157846
INDOUT	0.363616	-0.111371	-0.222801	1.000000	-0.346448
URP	-0.542231	0.393440	-0.157846	-0.346448	1.000000

***Source*:** Author's computation via E-view 9

The correlation between CO_2 emissions and foreign direct investment is negatively low, on one hand and that with industrial output was positively low, while it is negatively high with urban population and gross domestic product. The correlation between foreign investment (FDI) with co2 emission, gross domestic product (GDP) and industrial output were negatively low, while it was positively low with urban population. The correlation between gross domestic product with foreign direct investment, industrial output and urban population were negatively low but negatively high with CO_2 emissions. The correlation between industrial output foreign direct investment, gross domestic product and urban population were negatively low but positively low with CO_2 emissions. Lastly, the correlation between urban populations with CO_2 emissions was negatively high, while it is negatively low with gross domestic product and industrial output, but the correlation between urban population and foreign direct investment was positively low.

Unit root test

This test is a pre-estimation test for staionarity of the variables under investigation. Augmented Dickey Fuller (ADF) and Phillp Perron (PP) unit root tests were employed to check for the stationarity or trend of the variables under consideration. The results in table 3 revealed that all the variables were not stationary at their levels, indicating the presence of unit root in the series. The variables were further checked for their stationarity at first difference. The results from the table revealed all the variables were integrated of order 1. This implies that all the variables became stationary after taking their first difference. Since the results revealed that all the variables are I(I), we therefore proceed with co-integration test. This is to check for the presence of long run relationship among the variables. This validates the adoption of panel cointegration test.

Table 3: Unit root tests results

Variables	1st difference (ADF)		1st Difference (PP)	
	Statistics	Prob.	Statistics	Prob.
Co2 emissions	0.0054	0.0128**	0.0060	0.0010***
GDP	0.0869	0.0134**	0.0304	0.0142**
FDI (% GDP)	0.9655	0.0421**	0.3140	0.0300**
Industry VA	0.4885	0.0288**	0.1009	0.0272**
Urban (% pop)	0.08944	0.0008***	0.7617	0.0047**

Note: *, **, *** represent 10%, 5%, and 1% significant level respectively.

Panel cointegration result

Panel cointegration test is a test for checking whether there is longrun relationship among the variables used in the study or not. This study employed pedroni residual cointegration test which include four tests that are within group and three test between groups. The pedroni residual cointegration test is used to test for the presence of long-run relationship among the variables used in the panel.

Table 2: Pedroni Panel Residual cointegration test

Within Group				Between-Groups
	Statistics	Weighted Statistics	Statistic	
Panel V	-0.277	-0.357	Group rho	2.549618
Panel rho	1.138	1.291	Group PP	-2.714104**
Panel PP	-2.351*	-1.702**	Group ADF	-1.206335
Panel ADF	-1.255	-1.455		

Note: * and ** indicate 1%, and 5% significant level respectively.

The results obtained from the table above revealed that the within group dimension reports that Phillip Perron is statistically significant while the other estimators are not statistically significant. This simply implies that panel Phillip Perron statistics failed to accept the null hypothesis of no cointegration, which indicates that all the variables in the model are cointegrated in the long-run. This implies that there is evidence of long-run relationship between environmental degradation and industrial output in West African countries. Furthermore, since it has been established that there is presence of long-run relationship among the variables, then we proceed to estimate the coefficients of the model using the panel cointegration estimation.

Panel cointegration estimates

The panel cointegration estimate is used to determine the effects of the explanatory variables on the dependent variable. The cointegrating vector is estimated using the Fully modified Least square (FMOLS). Table 4 shows the coefficients of explanatory variables for the selected countries and Co2 emissions, the dependent variable.

Table 4: Fully modified OLS results

Dependent Variable: LCO2				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LINDOUT	0.229814	0.452969	0.507349	0.6144
LFDI	-0.064535	0.031893	-2.023512	0.0491
LURP	0.148532	1.902218	0.078084	0.9381
LGDP	-0.456685	0.912927	-0.500243	0.6194
R-squared	0.904387	Mean dependent var		-1.074359
Adjusted R-squared	0.887003	S.D. dependent var		0.287492
S.E. of regression	0.096640	Sum squared resid		0.410933
Long-run variance	0.012744			

***Source*:** Author's computation via E-view 9

The Fully modified least square results for the selected countries shows that industrial output and urban population have positive but not significant impact on the emission of CO_2 in ECOWAS countries. The findings from the study further revealed that foreign direct investment has negative but not significant impact on the emission of CO_2 in the countries. However, the positive relationship between industrial output and the emission CO_2 confirmed the Environmental Kuznets Curve which suggests that higher industrial activities will increase the volume of environmental pollution in developing countries. The implication of these results is that, a unit increase in foreign direct investment will reduce the volume of CO_2 emissions by 6 percent while a unit increase in the population in the urban area will increase the volume of CO_2 emissions by 14 percent. On the other side, a unit increase in industrial output will increase the volume of emission of CO_2 by 22 percent. The results revealed that industrial sector was seen as a source of the volume of CO_2 emissions in the region but the results revealed that foreign direct investment and gross domestic product have negative but not significant impact on the emission of CO_2 which means that the method of production used in the region capable of reducing the rate of environmental degradation in West African sub-region.

5. Summary and Conclusion

The study investigate the effectt of industrial output on environmental degradation in selected West African countries over the period of 2007 to 2020 for five West African countries, Nigeria, Ghana, Benin, Senegal, and Cameroon. The study employed a panel data cointegration technique to access the properties of the time series using panel unit root test. The results of the panel unit root test revealed that all the data series were not stationary at their respective level but became stationary after their first difference. Furthermore, the study employed Pedroni residual based panel cointegration test to investigate the long run relationship between industrial output and environmental degradation, which is measured by co2 emission. The results of the panel cointgration test validate the presence of long-run relationship among the variables. In addition, the study explored the fully modified OLS (FMOLS) estimation technique for the analysis. The results obtained from the panel FMOLS for the selected West African countries revealed that industrial output and Urban population have positive impact on the emission of CO_2, while the foreign direct investment and gross domestic product have negative impact on the co2 emission in the seven selected West African countries. By implication, increase in industrial output and urban population will increase the quantity of CO_2 emissions on the environment and consequently causing environmental degradation in the West African countries. However, the implication of the negative relationship between foreign direct investment and environmental degradation means that an increase in foreign direct investment will reduce the level of CO_2 emission to the environment.

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