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ANALYSIS OF THE CAUSAL RELATIONSHIP BETWEEN ECONOMIC GROWTH AND ENVIRONMENTAL DEGRADATION IN WEST AFRICA

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Abstract
As climate change continues to cause more concern the world over, analyzing the causal relationship between economic growth and carbon dioxide emissions is paramount in West African sub-region that has been the hardest hit by the menace. This study investigated the causal relationship between economic growth and carbon emissions in West African countries using panel data spanning over 1970 to 2019 and employing the Dumitrescu-Hurlin (2012) panel causality test. After establishing the order of integration of the study's variables and cointegration, the results indicated that economic growth causes carbon emissions in the studied countries without feedback. But trade openness has a bi-directional causal relationship with carbon emission. Foreign direct investment (FDI) and financial development exhibit a unidirectional causal relationship with emissions and the causality runs from FDI and financial development to carbon emissions. However, in the case of population, the unidirectional causality runs from carbon emissions to population. The policy suggestion is that ECOWAS countries should promote conservation policies to curtail pollution while stressing the inflow of green FDI into the region.

Keywords: Carbon dioxide emissions, economic growth, FDI, Trade openness, West Africa

1.0 Introduction
Economic growth have become the major target set by governments around the world as a means of raising income, employment levels and getting people out of poverty (Wang, H., Ang, B. W., and Zhou, P., 2018). Remarkable economic progress are made in the last few decades which provides good conditions for improved socio-economic development in many countries (Thao, 2018). However, there is concern that rising affluence is causing a tremendous damage to environment due to excessive natural resource exploitation and burning of fossil fuel (World Bank, 2020). On the other hand, environmental degradation is a potential factor that cause economic prosperity to change as environmental resource are depleted in form of forest depletion, water contamination, land degradation and air

pollution. This therefore suggests that a causal relationship exists between economic growth and environmental degradation but the nature or direction of the causality can only be confirmed with an empirical investigation.

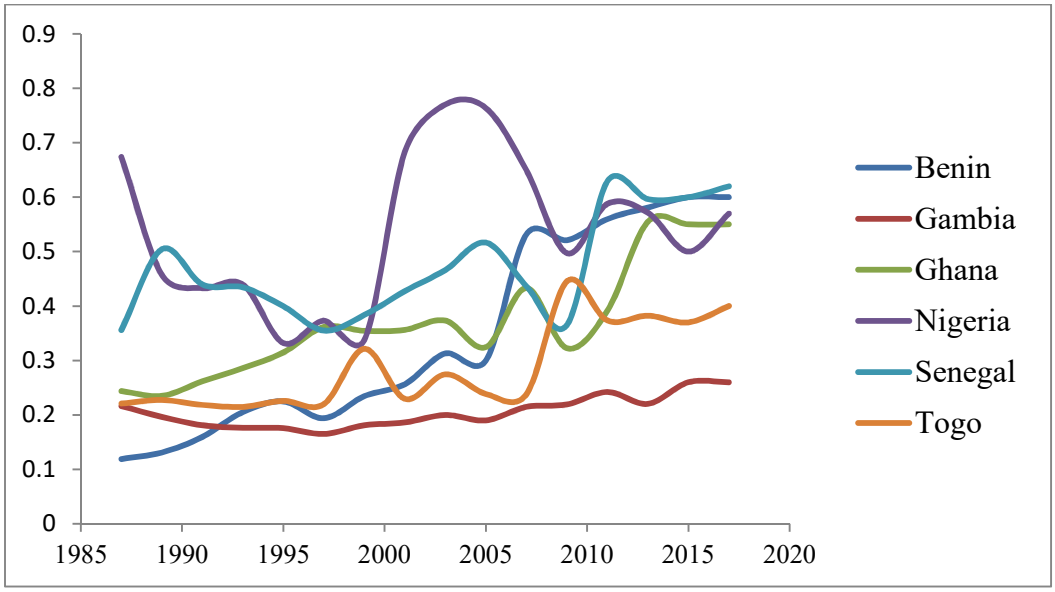

Figure 1: Trends on CO2 emissions in some selected West African countriesSource: World Development Indicators, World Bank (2020)

Investigating the causal relationship between economic growth and environmental degradation is of particular importance in West Africa as this sub-region is the most prone to climate change in the world despite the rapid economic growth recorded in recent years (ECOWAS Commissions, 2020). For example, the sub-region achieved remarkable growth performance in recent years surpassing its counterparts in Africa. In 2014 the region had an economic growth rate of 7.4 percent exceeding the Sub-Saharan African average of 3.2% (African Economic Outlook, 2018). From 2000 until 2014, the real GDP growth rate has been above 5% and the growth in the region in 2016 was pegged at 5.3% (ECOWAS Commission, 2018). The sustainable economic growth brought rapid industrialization in the region, promoting employments and increased income level in many countries. But contrary to the impressive economic growth in the region, environmental quality has been declining over the same period as indicated by increased level of carbon dioxide emissions (henceforth, CO_2 emissions) as depicted in figure 1. This development exposes the region to the devastating effect of climate change which already reflects in drought, flood and erratic rainfall as well as spread of diseases that affect the millions of people which all retard economic growth. Therefore, this study seeks to investigate the causal relationship

between economic growth and environmental degradation in terms of carbon dioxide emissions in the region.

Therefore, this study contributes as follows: First, we use panel data due to its merits of being more informative, having more degree of freedom and provides efficient estimates (Lean & Smyth, 2010). Second, the study employs Dumitrescu-Hurlin (2012) panel causality method to examine the causal relationship between economic growth and environmental degradation represented by CO_2 emissions. Third, we use Pesaran (2004) cross sectional dependence (CSD) test to check whether the countries under investigation are interdependent, the issue that most previous studies ignored. Four, we employed Pesaran-Yamagata (2008) test to verify if homogeneity exists in the panel dataset which many studies have not accounted for. Five, this study focused on the ECOWAS countries that receive little attention from previous studies addressing the issue of environmental degradation and climate change.

The remainder of the paper is structured as follows: Section 2 provides a review of the literature. Section 3 developed the methodology used in the study. Section 4 provides the empirical results and discussions while section 5 offers conclusions and recommendations.

2.0 Literature Review

There are numbers of empirical studies that attempted to examine the causal relationship between economic growth and environmental degradation and these studies can be grouped into four: growth hypothesis; conservation hypothesis; feedback hypothesis; neutrality hypothesis. Regarding the first strand of literature on the growth hypothesis, there is a unidirectional causality between economic growth and environmental degradation with the causality running from environmental degradation to economic growth. Empirical studies abound in the growth hypothesis such as Menyah and Walde-Rufael (2010) for South Africa from 1965 to 2006 using ARDL framework. Sabori et al. (2012) also confirm the growth hypothesis as well as Shahbaz et al. (2015) using fully modified OLS also validate the conservation hypothesis for high-income countries. The second strand of literature falls under the conservation hypothesis which postulates that economic growth causes environmental degradation. For example, Ang (2007) using the vector error correction model validated the conservation hypothesis for France from 1960 to 2000. Jalil and Mahmud (2009) used autoregressive distributed lag model (ARDL) in China from 1975 to 2005 and their results support the conservation hypothesis and the results of Fodha and Zaghdoud (2010) also corroborated their findings. Shahbaz et al. (2015) analysed middle-income countries from 1975 to 2012 using fully modifies OLS and their results show that economic growth causes pollution. Similarly, the study by Kwakwa et al. (2019) and Salahuddin et al. (2020) all reported that economic growth causes environmental degradation in Ghana and South Africa respectively. Interestingly, Acheampong (2018)

using world data from 1990 to 2014 found that economic growth granger cause pollution. Similarly, Alsamara et al. (2018) studied GCC countries from 1980 to 2017 using fully modified OLS and panel mean group and the empirical findings reveal that economic growth granger cause pollution.

The third strand of literature validated the feedback hypothesis of bi-directional causal relationship between economic growth and environmental degradation. In other words, economic growth granger causes environmental degradation and also environmental degradation causes economic growth. Empirical studies that confirmed feedback hypothesis include Choe (2003) for 80 countries from 1971 to 1995 using the panel vector autoregressive technique. Halicioglu (2009) using autoregressive distributed lag model found a bi-directional causal relationship between economic growth and pollution for Turkey from 1960 to 2005. Interestingly, Omri (2013) study for 14 MENA countries from 1990 to 2011 confirmed feedback hypothesis and this is also corroborated by the results of Al-Mulali et al. (2013) for Latin America and Carribbeans over 1980-2008. In line with this also, Mirza and Kanwal (2017) and Alege et al. (2018) both found a bi-directional causal link between economic growth and pollution in Pakistan and South Africa respectively. The last strand of literature is based on the neutrality hypothesis which postulates that economic growth neither causes environmental degradation nor does pollution causes economic growth. For example, Soytas et al. (2007) study for United States of America found no causal relationship between economic growth and environmental degradation. Again, Soytas and Sari (2009) study confirmed the neutrality hypothesis for China from 1960 to 2007. Other studies that revealed no causal relation between economic growth and environmental degradation include Zhang and Cheng (2009) for China from 1960 to 2007; Shahbaz et al. (2015) for low income countries; Hassan et al. (2018) for Pakistan from 1970 to 2014.

However, none of the previous studies mentioned above focus on West African sub-region despite the fact that is has been reported as the most prone to climate change in the world. In addition, the previous panel studies failed to investigate whether or not the countries are homogeneous. In other words, the aforementioned literatures failed to investigate whether common policy approaches could be applied across the countries they studied. Therefore, this study fill in such gaps by: First, focusing on the West African countries that receive little attention from previous studies. Second, we employed Pesaran-Yamagata (2008) test to verify if homogeneity exists in the panel dataset so that common policies can be deployed in addressing carbon emissions. Third, we use Pesaran (2004) cross sectional dependence (CSD) test to check whether the countries under investigation are interdependent, the issue that most previous studies ignored. Four, our study used second generation unit-root and cointegration tests as against the first generation techniques used in the previous studies.

3. Methodology

This study uses annual data from 1970 to 2019 for six countries in the West Africa sub-region namely Benin, Gambia, Ghana, Nigeria, Senegal and Togo. There are reasons why the choice of the countries is restricted to six. First, data availability is the major reason for the selection because some countries like Liberia and Seira Lione are not having available data due probably to civil wars they have undergone for a long time. Other countries that have not witnessed civil war are not having the data for the variables used in this study. Second, these six countries cover a larger part of the economic activities in the region. For example, Nigeria alone constitutes 70 percent of the region's GDP and the country together with Ghana makes about 81 percent of region's export dominated by crude oil. Therefore, these countries together could give good picture of economic activities taking place in the region. Third, population pressure is one of the major drivers of environmental degradation and these selected countries combined constitute about 75% of the region's population. Four, the selected countries generate larger portion of the greenhouse gasses in the region. Therefore, the choice of these countries is enough to analyze the issue of economic growth and environmental degradation in the region.

The choice of the variables used in the study is guided by the environmental Kuznets curve (EKC) literature that postulates an inverted U-shaped pattern between economic growth and pollution. Appropriate measurements and proxies are utilized to ensure that the results obtained from the analysis of the data are valid for achieving the objectives of the study. The dependent variable in this study is environmental degradation where carbon dioxide (CO_2) emissions are used as a proxy. On the other hand, the independent variables are: economic growth (GDP) in line with the EKC hypothesis; trade openness and foreign direct investment following the pollution-haven hypothesis; financial development in line with finance-led growth hypothesis; population (POP) following the stochastic impact regression on population, affluence and technology (STIRPAT) model of environment. Table 1 provides the variables measurement and data source. There are many indicators of environmental degradation as provided in different empirical studies but CO_2 emissions happened to be the most widely used proxy (Allard et al., 2018).

Table 1: Variables, Measurement and Data Source

Variables	Measurement	Source
CO_2	Carbon dioxide emissions (metric tons per capita)	World Development Indicators
GDP	Economic growth per capita (2010 constant USD)	World Development Indicators
TO	Trade openness (exports + imports % of GDP)	World Development Indicators

FDI	Foreign Direct Investment (in million USD)	World Development Indicators
FD	Financial development (domestic credit % of GDP)	World Development Indicators
POP	Population (in millions of people)	World Development Indicators

Source: Author's compilation, 2022

We test for the causal relationship between economic growth and CO_2 emissions as proxy for environmental degradation using the following equation:

$$CO_{2_{it}} = \delta\, GDP_t^{\alpha_1}\, TOP_t^{\alpha_2}\, FDI_t^{\alpha_3}\, FD_t^{\alpha_4}\, POP_t^{\alpha_5} \quad (1)$$

where, CO_2 is carbon emissions proxy for environmental degradation, GDP is per capita income, TOP is trade openness, FDI represents foreign direct investment, FD is financial development, POP stands for population. The data sources are mentioned in Table 1. The natural logarithm form of all the variables shown in Eq. 1 is taken to aid the interpretation of coefficients as elasticities. In addition, the model is set as panel because it has the advantage of controlling for serial correlation and individual heterogeneity inherent in time series and cross-section models. Taking the above into consideration yields Eq. 2 as:

$$CO_{2_{it}} = \alpha_0 + \alpha_1 GDP_{it} + \alpha_2 TO_{it} + \alpha_3 FDI_{it} + \alpha_4 FD_{it} + \alpha_5 POP_{it} + \mu_{it} \quad (2)$$

To analyze the causal relationship among the variables in the model using the heterogeneous panel causality approach proposed by Dumitrescu and Hurlin (2012). The merits of this approach are that it produces consistent results even with small samples and cross-sectional dependence, same integration order of the series and unbalanced panels and panels with differentiated lag order. This heterogeneous panel causality equation is specified as:

$$W_{N,T}^{HNC} = \frac{1}{N}\sum_{i=1}^{N} W_{it} \quad (3)$$

where, the W_{it} represents the Wald statistics for the country *i* indicating the first statistic obtained from the simple mean of Wald statistics individually. The second test is obtained from the standardized statistic for $W_{N,T}^{HNC}$ statistic using the estimated values from the mean and variance of each Wald statistic with small sample for *T* given as:

$$Z_{N,T}^{HNC} = \frac{\sqrt{N}\left[W_{N,T}^{HNC} - \sum_{i=1}^{N} E(W_{i,t})\right]}{\sqrt{\sum_{i=1}^{N} var(W_{i,t})}} \quad (4)$$

4.0 Findings and Discussions

As a first step in panel estimation, cross-sectional dependence in the panel data is tested using Pesaran (2004) Cross-Sectional Dependence (CSD) test which follows an N(0, 1) distribution. Table 2 gives the results of the CSD test where null hypothesis is rejected implying that each of the series contains cross-sectional dependence. This signifies that shock occurred in one country is transmitted to the others. Furthermore, Pesaran and Yamagata (2008) test for homogeneity condition among the variable in this study is employed. The homogeneity estimation result is based on the adjusted delta tilde, where the rejection of the null hypothesis will permit for the heterogeneity panel estimation condition. Therefore, both tests are important as it helps in choosing the appropriate unit root test. The result accept the null hypothesis of homogeneity implying that the countries under study share common features.

Table 2: Cross-sectional dependence and homogeneity tests

Variables	Statistics	
Pesaran (2004) CSD test		
CO_2	10.551*	(0.000)
GDP	9.946*	(0.000)
TO	-0.411*	(0.000)
FDI	15.961*	(0.000)
FD	6.091*	(0.000)
POP	2.466*	(0.010)
Pesaran-Yamagata (2008) test		
$\tilde{\Delta}$	-0.332	0.840
$\tilde{\Delta}$-adjusted	-0.338	0.835

Notes: * represents significance level at 1% level, and $\tilde{\Delta}$represent the delta statistic
Source: Author's computation with Stata 14

Table 3: Test of Normal Distribution

Variables	Skewness	Kurtosis	Shapiro-Wilk		Shapiro-Francia	
			Statistics	p-value	Statistics	p-value
EF	0.242	2.429	0.978*	0.000	0.981*	0.001
CO_2	0.984	3.453	0.920*	0.000	0.921*	0.000
GDP	0.482	2.137	0.934*	0.000	0.936*	0.000
GDP^2	0.628	3.636	0.911*	0.000	0.912*	0.000

TO	-1.369	6.497	0.916*	0.000	0.914*	0.000
FDI	-1.490	4.069	0.772*	0.000	0.774*	0.000
FD	-0.886	3.762	0.946*	0.000	0.948*	0.000
POP	0.354	2.669	0.963*	0.000	0.966*	0.000

Notes: * represents significant at 1% level.
Source: Author's computation with Stata 14

It is paramount to check whether the data is normally distributed or not before the actual implementation of the regression approach (Salman et al., 2018). The Shapiro-Wilk (Royston, 1992) and the Shapiro-Francia (Royston, 1983) normality tests are used in this study to test the normality of the data. The two tests have the same assumption but only differ in terms of the interpretation of the coefficients. Shapiro-Wilk test, which is a correlation-based algorithm, assumes that the higher the normality of data the more closely its value to 1. The results of these two tests are reported in Table 3 and base on the p-statistics the null hypothesis of normality of data is rejected at 1% level of significance leading to the conclusion that the data is not normally distributed.

Table 4: Panel unit root test with cross-sectional dependence

	At level		At first difference	
Variables	CIPS (*t-bar)*	*p-value*	CIPS (*t-bar)*	*p-value*
EF	-0.431	0.333	-2.902*	0.001
CO_2	-0.523	0.699	-3.113*	0.000
GDP	-0.792	0.811	-4.221	0.000
GDP^2	-0.766	0.808	-5.143*	0.000
TO	-0.443	0.352	-4.443*	0.000
FDI	-0.403	0.304	-3.831*	0.000
FD	-0.331	0.975	-4.941*	0.000
POP	-0.583	0.745	-3.884*	0.000

Note * denote the rejection of null hypothesis at 1%.
Source: Author's computation with Stata 14

In table 4 the results of the panel unit root tests are presented. Since the variables are affected by cross-sectional dependence CIPS unit root that account for cross-sectional dependence is utilized. The results of the CIPS unit root tests confirmed the presence of unit root for all the series at level but when checked at first difference they become stationary. Cointegration is confirmed using the Westerlund (2007) cointegration that fixes cross-sectional dependence as in Table 5. The results reported that Gt and Pt statistics could not accept the null hypothesis thus confirming existence of cointegration/long-run association among the variables under investigation.

Table 5: Westerlund cointgeration test results

	Statistic value	z-value	p-value
CO2 emissions			
G_t	-4.024*	-3.029	0.001
G_a	-19.261	-0.604	0.273
P_t	-10.011*	-3.437	0.000
P_a	-16.947	-0.987	0.162

Note *, **, *** represents significance at and 1%, 5% and 10% respectively.
Source: Author's computation with Stata 14

The causal relationship between carbon emissions and the independent variables are analyzed using the Dumitrescu and Hurlin (DH) panel causality test as reported in Table 6. The result indicates a unidirectional causal relationship between GDP and CO_2 emissions with the causality running from GDP to carbon emissions consistent with the studies by Kwakwa et al. (2019) for Ghana and Salahuddin et al. (2020) for South Africa. This validates the conservation hypothesis that suggests rising economic prosperity causes pollution. Natural resource abundance is the key component of the economic growth in the West African countries and they largely depend on the extraction of these resources for exports expansion and the unsustainable exploitation of natural resources in developing countries causes CO_2 emissions (Akram, et al., 2020).

In the case of trade openness, bidirectional causal link is traced with carbon emissions. This result is in line with that of Farhani (2014) but contrast with Boutabba (2014) and Omri et al. (2015) who documented a unidirectional causal link between the two variables. This result portrays that increased trade openness in West African sub-region is causing carbon emissions and in turn increased carbon emissions causes trade expansion. It is reported that trade in the sub-region is dominated by energy consuming and polluting

products such as vehicles, machineries, electric and electronic appliances, oil, etc. Fuel alone account for 24% of the region imports while about 75 percent of export is crude oil (ECOWAS Commission, 2018). Given this import and export composition, trade expansion would cause carbon emissions. In turn, rising carbon emissions and the consequent climate change would make authorities to restrict import of certain products in favour of environmentally friendly ones such as solar panels and rechargeable batteries as well as other energy efficient products. Furthermore, in most cases authorities imposes heavy levies on undesirable products and this would cause the trade pattern to change.

Table 6: Dumitrescu and Hurlin (DH) panel causality test

Causal Relation	W-statistic	p-value	Direction
GDP does not granger cause CO2	4.734*	0.003	Unidirectional
CO2 does not granger cause GDP	3.340	0.170	
TOP does not granger cause CO2	5.417*	0.000	Bi-directional
CO2 does not granger cause TOP	3.688***	0.079	
FDI does not granger cause CO2	5.591*	0.000	Unidirectional
CO2 does not granger cause FDI	2.560	0.612	
FD does not granger cause CO2	4.554*	0.006	Unidirectional
CO2 does not granger cause FD	2.309	0.819	
POP does not granger cause CO2	3.143	0.250	Unidirectional
CO2 does not granger cause POP	5.158*	0.000	

Note: *, **, *** denote statistical level of significance at 1%, 5% and 10% respectively. ll tests are based on an intercept and the Newey and Kenneth (1994) procedure for selecting the bandwidth order. The p-values are based on the asymptotic normal distribution.
Source: Author's computation with Stata 14

The panel causality results in Table 6 indicates that there is unidirectional causality between FDI and carbon emissions and this implies that the activities of multinational firms causes pollution in the host communities. The discovery of oil and minerals in West African states tremendously help in attracting huge amount of FDI into the region and would cause changes in the level of pollution in the region. The empirical results for causality further reveal that a unidirectional causal relationship exists between financial development and carbon emissions. The causality runs from financial development to carbon emissions and previous studies by Boutabba (2014), Alsamara et al. (2018) reported similar findings. ECOWAS countries have made effort to increase the level of their financial development in a bid to make credit more readily available to the real sector. Increasing availability of funds would cause carbon emissions via increased economic.

There exists unidirectional causal relationship between population and carbon emissions with the causality running from carbon emissions to population. This validates the claim that the developing countries are more vulnerable to climate change and its devastating impact (African Development Bank, 2020). Climate change due to rising greenhouse gasses induces severe strains on rainfall and consequently declining agricultural output leading to food insecurity and hunger that affect millions of population in the sub-region. ECOWAS population growth rate (2.4) is the fastest in African continent and this has resulted in a quadrupled increase in population from 70 million to 327 million people between 1950 and 2018. With current population growth rate ECOWAS population will be around 806 million people in the next thirty years (UN ESA, 2019) and population explosion would cause carbon emissions. Similarly, according to ECOWAS Commission (2018) currently, half of the population are living in urban areas and that urbanization in the region will range from around 46.2% to 63.8% by 2030 implying that more than half the region's population will live in urban areas and this causes carbon emissions. Countries like Senegal, Benin, Ghana and Nigeria have reach 47.7%, 47.9%, 56.7% and 51.2% urbanization level respectively (African Development Bank, 2019).

5.0 Conclusion and Recommendations

In this study, we investigated causal relationship between economic growth, trade openness, financial development, population and environmental degradation in West African countries by employing the DH panel causality with data spanning from 1970 to 2019. After establishing the order of integration of the variables and cointegration, the causality results indicated the existence of a unidirectional causal relationship between economic growth and carbon emissions in the countries. But, trade openness has bi-directional causal relationship with carbon emission. Foreign direct investment and financial development exhibit a unidirectional causal relationship with emissions and the causality runs from FDI and financial development to carbon emissions. However, in the case of population, the unidirectional causality runs from carbon emissions to population. This study recommends that ECOWAS countries should promote conservation policies to curtail pollution in the region. Furthermore, it emphasizes the pursuance of environmentally friendly FDI that will support the region in harnessing the vast potentials of solar, biomass and hydro energy and achieve low pollution as well as redirecting private sector credit toward sustainable projects.

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