DOES TRADE LIBERALIZATION AND FOREIGN DIRECT INVESTMENT INDUCE ENVIRONMENTAL DEGRADATION IN SELECTED WEST AFRICAN SUB-REGIONS?

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Abstract

This study examined the effect of trade liberalization and foreign direct investment on environmental degradation within the selected West African sub-region. The data employed in analyzing the result covers the period 1996 to 2022. Fully modified ordinary least squares and dynamic ordinary least squares were employed in estimating the models. The study's findings indicate a negative and insignificant influence of trade liberalization and foreign direct investment on environmental degradation, indicating that trade liberalization and foreign direct investment reduced environmental degradation. Again, the interaction of trade liberalization and foreign direct investment reduced environmental degradation. Other results confirmed that fossil fuel energy consumption positively enhanced environmental degradation, although renewable energy consumption significantly reduced pollution. Based on the empirical findings, since trade liberalization and foreign direct investment reduce environmental degradation as fossil fuel energy consumption increase environmental degradation, implies that ECOWAS governments institute environmental laws following the race to the top theory to discourage fossil fuel energy usage and push for more renewable energy as it reduces incessant pollution within the region.

JEL classification: F21, F60, Q56

Keywords: Trade Liberalization, FDI, Pollution haven hypothesis, Environmental Degradation,

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1. Introduction

The pursuit of growth and development is of utmost importance, and most African governments are concerned with seeing to it that it is accomplished. The necessity to liberalize trade and promote foreign investment grows as the world embraces the openness of economies. Interestingly, no nation on earth is self-sufficient and has all the resources needed to create the commodities and services its citizens require. Therefore, countries rely on one another to obtain the goods they are unable to create, as trade liberalization makes that gap possible. Interestingly, when economies relax their trade regulations and cut tariffs, then trade liberalization could be profitable (Zhao and Zhang, 2016; Demena and van Bergeijk, 2017; Demena and Murshes, 2018). Similarly, existing literature views foreign direct investment as a crucial indicator of economic growth, a source of employment creation, and a basis of technological advancements

in most host countries (Gutola and Milos, 2022; Odidi & Jagong'o, 2020; Pradhan, Bagchi, Chowdhury, & Norman; 2012, UNCTAD, 2011). For instance, as foreign investment rises, the rise could trigger sustained growth productivity which could lead to a drop in the level of poverty. Importantly, from the foregoing, it can be inferred that trade liberalization and foreign direct investment could be major drivers of global economic growth as examined by Gutola & Milos, (2022), Odidi and Jagong'o, (2020), and Alamro, (2017).

Despite the significance of trade liberalization and foreign direct investment, it is believed that both variables could have the capacity to cause environmental pollution in countries that have weak regulatory policies (Demena & Afesorgborn, 2020). Omri, et al. (2015) and Murshed, et al. (2020) assert that developing countries are susceptible to environmental degradation as a result of weak governments' efforts in implementing regulatory policies that can combat fossil energy usage in the continent. This problem, if not handled well, could cripple the level of environmental quality on the continent and make its goal of achieving quality environmental sustainability a mirage (Chen, *et al.* 2017)

In the empirical literature, the connection between trade liberalization and pollution has been debated extensively, particularly in developed countries. Global trade is often strongly linked with the degradation of the environment, implying that when countries liberalize trade and relax their trade policies, carbon-emitted industries could be permitted to come in through foreign direct investment, thus increasing pollutants in the environment (Shahbaz *et al,* 2017; Zhu *et al*, 2016; Cole *et al*, 2011; Pao & Tsai, 2011). According to Pollution Haven Hypothesis (PHH), countries with free trade and weak governments regulations are highly vulnerable to attracting industries producing "dirty" goods, which make them specialists in producing and exporting "dirty" goods (Demena & Afesorgborn, 2020; Copeland & Taylor, 2004). More so, the intuition behind the PHH is that, given the different levels of stringency of environmental regulations among countries, trade liberalization, and foreign direct investment might lead to specialization in pollution-intensive products in countries with laxness in environmental regulations. Also, some firms from developed and emerging economies, especially China bring their industrial-intensive activities to developing countries in the form of FDI to reduce the cost of production prevalent in developed countries (Demena & Afesorgborn, 2020**).** Consequently, these firms

could cause environmental degradation in the developing economies, since most of the governments in the West African sub-region intentionally lower their environmental standards to attract more foreign investment to enhance their growth (Greaker, 2006; Zhang & Zhou, 2016).
In addition, trade openness, FDI cum environmental degradation is a controversial debate as previous studies have conflicting and contrasting results, leading to theoretical ambiguous results which require further investigation. In addition, studies that examined the relationship between trade liberalization, FDI, and environments have been criticized for unobserved heterogeneity and endogeneity (Demena & Afesorgborn, 2020). This study fills the gaps by using relatively current data as well as dealing with the unobserved heterogeneity and endogeneity biases respectively. This formed the core focus of the study. More so, trade liberalization and FDI could be precursors to environmental degradation in Africa, however, to the best of our knowledge; previous studies done on trade liberalization-FDI and environmental pollution did not beam searchlight into the ECOWAS region. As a result, this study beamed searchlight on selected ECOWAS countries with the aim to (i) analyze how trade liberalization affects environmental degradation in ECOWAS countries, (ii) research the impact of foreign direct investment on environmental degradation, and (iii) look at how the interaction of trade liberalization and foreign direct investment affects the quality of the environment in ECOWAS region, thus making the study a contribution to literature. In the same vein, the findings from the study will not only contribute to empirical knowledge but could serve as a benchmark to control and curtail environmental pollution in the ECOWAS sub-region.

1.1 Stylized Facts on Trade Liberalization, FDI, CO2 Emission, Energy Consumption and Regulatory Quality

Table 1 reports the general condition in selected ECOWAS countries as it concerns the level of environmental degradation caused by trade liberalization, FDI, and fossil fuel energy use. The Table showed that all the selected ECOWAS countries witnessed an unprecedented increase in carbon emissions between 2002 and 2020, except for Nigeria and the Republic of Niger. Meanwhile, the same cannot be said for trade liberalization which has been on a downward trend over the same period. The decline could be attributed to a series of issues like insecurity, an increase in tax rate and embargoes on importations of certain goods as well as the closure of land borders in Nigeria. In the same vein, the data also confirmed a persistent decline in cross-border

investment, meaning that the level of FDI over time has continuously been on a downward trend, particularly in countries like Nigeria and Togo, except for Senegal and Cote d'Ivoire which witnessed a marginal increase. The increase in FDI inflow in the two countries enhanced the level of carbon emission witnessed within the countries.

In line with that, the data further confirmed a persistent increase in energy use, indicating that most of the selected countries in the ECOWAS region had a tremendous upshoot in the consumption of non-renewable energy which could lead to environmental degradation. Despite the increase in fossil fuel energy, Ghana (0.32) and the Republic of Niger (3.59) were able to reduce their consumption of non-renewable energy between 2012 and 2020 respectively. In addition, regulatory quality estimates for the selected ECOWAS countries are largely porous since they are mostly negative, except for Ghana which has improved energy control policies and positive regulation scores between 2012 and 2020. The data, according to Mesagan and Bello (2018); Mesagan and Olunkwa (2022) suggest that government regulation is generally weak in most ECOWAS countries.

Table 1
Stylized Facts for the selected ECOWAS countries

ECOWAS Countries	Carbon Emission CO2 (Metric Ton/capita)			Trade Liberalization (Trade% GDP)			Foreign Direct Investment			Energy Use (% of Total) Fossil Fuel Energy			Regulatory Quality		
	2002	**2012**	**2020**	**2002**	**2012**	**2020**	**2002**	**2012**	**2020**	**2002**	**2012**	**2020**	**2002**	**2012**	**2020**
ANGLOPHONE COUNTRIES															
Ghana	0.36	0.56	0.61	97.48	93.16	38.51	0.95	7.98	2.67	36.02	52.61	52.29	-0.44	0.12	0.0002
Nigeria	0.71	0.57	0.57	40.03	44.53	28.52	1.96	1.55	0.55	19.76	18.76	18.78	-1.21	-0.71	-0.96
FRANCOPHONE COUNTRIES															
Benin Republic	0.29	0.45	0.62	43.76	50.73	44.83	-0.46	2.52	1.11	29.64	36.17	36.77	-0.4	-0.37	-0.375
Cote d'Ivoire	0.39	0.37	0.41	55.9	70.3	42.01	1.17	0.91	1.16	37.84	24.68	25.65	-0.42	-0.76	-0.27
Niger Republic	0.05	0.11	0.09	30.83	45.08	36.17	0.28	8.92	2.62	14.28	29.68	26.09	-0.67	-0.59	-0.74
Senegal	0.44	0.55	0.65	53.14	61.97	60	1.18	1.56	6.04	52.27	45.77	51.06	-0.16	-0.08	-0.21
Togo	0.25	0.33	0.29	72.87	104.41	54.84	3.38	3.13	-0.78	13.41	17.21	17.73	-0.68	-0.84	-0.59

Source: Authors' Compilation from WDI (2023)

This study is segmented into different parts. Section two provides the literature review, while section three shows the method of analysis. Section four presents data analysis and interpretation, and section five concludes the study and provides some policy recommendations.

2. Review of Literature

In the fields of economics and environmental sciences, discussions about issues related to environmental degradation are ongoing. Economic researchers have worked incredibly hard to identify the causes of environmental degradation in developing nations, particularly in Africa. In the meantime, attempts by scholars to reduce environmental degradation in Africa have failed. This study adds to the discussion of how environmental degradation is related to trade liberalization and foreign direct investment in the ECOWAS area, one of Africa's economic engines. Aller et al. (2015) reported that trade liberalization has an adverse impact on environmental quality in specific developing and developed nations with regard to trade liberalization and environmental deterioration. In a similar line, the study by Bernard & Mandal (2016) found that trade liberalization had a favorable and significant impact on the environmental quality in sixty selected emerging nations. In another study, Tang & Yang (2016) employed empirical evidence to confirm that China's influx of foreign direct investment to African countries contributed to severe pollution. Furthermore, Bento & Moutinho (2016) verified that in Italy, the production of renewable electricity decreased pollution over the short and long term, whereas international trade increased pollution over the long term.

Importantly, Abdullahi *et al,* (2017) noted that trade liberalization had a positive impact on Kenya's economic growth. However, Adeel *et al.* (2017) analyzed how FDI, energy use, economic growth, and urbanization affected environmental pollution in nine different Asian nations. Although the result revealed a negative correlation between FDI and environmental pollution, their data supported the idea that economic growth and environmental pollution are positively correlated. Hammami (2017) used the panel regression technique to find that greater FDI inflow, trade liberalization, and energy consumption all led to higher levels of environmental pollution in a few

Middle East/North African (MENA) nations. Nguyen *et al.* (2018) empirical findings supported the hypothesis that Vietnam's economic growth was negatively impacted by carbon emissions. In a similar manner, Liu *et al.* (2018) asserted that FDI has a negative and significant effect on environmental pollution in China by applying the Pollution Heaven Hypothesis and the Pollution Halo Hypothesis. In a different investigation, Solarin and Al-Mulali (2018) discovered that foreign direct investment had no appreciable impact on environmental degradation in China and the USA. Similarly, Jebli *et al.* (2019), reported that foreign direct investment increased China's and India's energy efficiency while lowering their respective carbon emissions.

Kim *et al.* (2019) found that trade liberalization increased carbon emissions in developing countries while reducing carbon emissions in developed nations using the instrumental variable quantile regression technique on the trade-environment nexus for developed and developing countries. In agreement with that, Saud *et al.* (2019) found that trade liberalization, financial development, and foreign direct investment improved environmental quality, despite the assertion that economic growth has a negative impact on environmental quality in BRIS countries. Similar findings were made by Gorus and Aslan (2019), who found that energy consumption and foreign direct investment both increased pollution in MENA nations. According to a related study by Ssali *et al.* (2019), there is short-term bidirectional causation between environmental degradation and energy use, but long-term causality runs from energy use to the environment. Additionally, Mesagan and Olunkwa (2020), using the panel co-integration method, confirmed that while capital investment decreased environmental pollution, energy consumption increased environmental degradation. In a similar line, Peng and Pu (2020) investigated the connection between trade openness and pollution emission in China using the scale composition technique. The outcome showed that trade openness had a detrimental impact on the nation's pollution emissions.

In a different study, Chen et al. (2021) found that trade openness had a large and favourable impact on China's carbon emissions. The effect of FDI and information and communication technology on environmental pollution in significant Asia Pacific nations was examined by Bhujabal, Sethi, and Padhan (2021). The study's conclusions

supported the notion that FDI and ICT were major drivers of environmental degradation in the area. In the same vein, Raza *et al.* (2021) used panel regression approaches to investigate the relationship between trade liberalization and environmental quality in South and East Asian nations. The outcome showed that trade liberalization had a detrimental effect on environmental quality. In another study, Mesagan and Olunkwa (2022) used the Pooled Mean Group (PMG) technique for 18 chosen African countries, and they found that energy use had a short-term negative impact on pollution, but a long-term favourable impact. The outcome further supported the idea that while financial development had a good short-term effect, it had a negative long-term effect on environmental pollution. Similarly, in both the short and long terms, regulatory quality has a negative and considerable effect on pollution. Thuy & Nguyen (2022) confirmed that while foreign direct investment has a negative impact on the quality of the environment, trade openness in developing countries does not contribute to environmental degradation. This was determined using the Bayesian model averaging approach for a sample of 64 developing countries between 2003 and 2017. Despite the region's rising prevalence of environmental degradation, it is clear from the analyzed papers that there are few comparable investigations conducted in ECOWAS. Based on this, our work broadens the boundaries of knowledge and fills a glaring vacuum in the literature.

3. Methodology

3.1 Theoretical Framework and Model Specification

The Environmental Kuznets Curve (EKC) serves as the foundation for the study's theoretical framework. According to the hypothesis, income growth and pollution rise together in the early stages of economic growth, but as income rises to its peak, pollution starts to decline (Dasgupta et al. 2002; Nasreen et al. 2017; Fofack *et al*. 2019). The Inverted-U Kuznets curve, which depicts the connection between a nation's per capita income and pollution production (Andreoni and Levinson, 2001; Farhani and Rejeb, 2012; Nasreen *et al.*, 2017), characterizes this observation. The study includes energy consumption in the environmental degradation pollutants in order to determine the degree of environmental degradation in the trade-FDI nexus since energy consumption is essential to assessing the quality of the environment. Similarly, it is suggested that countries could minimize pollution by putting in emission-reducing technologies as their income and wealth rise since there is a

contemporaneous relationship between economic growth and pollution. The mathematical equation of the EKC theory according to Andreoni & Levinson's (2001) is specified as:

$$\ln(P)_{it} = \alpha_i + \gamma_t + \beta_1 \ln(Y)_{it} + \beta_2 (\ln Y)^2_{it} + \varepsilon_{it} \quad (1)$$

Where *P* denotes environmental pollution, *Y* represents income per capita, α and γ are the intercepts, *i* represents the number of countries, *t* is the time series, and ε is the residual term. The time-specific intercepts account for time-varying omitted variables and stochastic shocks that are common to all countries.

Given the theoretical explanation and empirical literature models employed in work by (Dasgupta *et al*. 2002; Nasreen et al. 2017; Fofack *et al*. 2019; Mesagan & Olunkwa, 2022),
Model 1 is specified as:

$$EVD = \beta_0 + \beta_1 Y + \beta_2 Y^2 + \beta_3 TL + \beta_4 EN + \beta_5 POP + \beta_6 RQ + \beta_7 REC + \varepsilon \quad (2)$$

Where *EVD* denotes environmental degradation proxied with carbon emission (CO2), *Y and Y2* represent income provided in the EKC, *TL* represents trade liberalization proxied with trade as a percentage of GDP, *EN* signifies energy consumption proxied with fossil fuel energy consumption, *POP* is population proxied with urban population growth rate, *RQ* represents a regulatory quality estimate, *REC* renewable energy consumption, $\beta(i, 0,7)$ are the various parameters of the regressors. Equation (2) helps us to determine the effect of trade liberalization on environmental degradation.

$$EVD = \beta_0 + \beta_1 Y + \beta_2 Y^2 + \beta_3 FDI + \beta_4 EN + \beta_5 POP + \beta_6 RQ + \beta_7 REC + \varepsilon \quad (3)$$

Every other variable remained as previously explained while *FDI* represents foreign direct investment proxied with FDI net inflow. Again, equation (3) enables us to establish the effect of foreign direct investment on environmental degradation.

$$EVD = \beta_0 + \beta_1 Y + \beta_2 Y^2 + \beta_3 TLFDI + \beta_4 EN + \beta_5 POP + \beta_6 RQ + \beta_7 REC + \varepsilon \quad (4)$$

Equation (4) shows the interaction effect of trade liberalization and FDI on environmental degradation.

3.2 Sources of Data and Estimation Technique

The Fully Modified Ordinary Least Square (FMOLS) and Dynamic Ordinary Least Square (DOLS) methodologies from Pedroni (2001) were employed in the study as the panel co-integration technique. The panel co-integration method is recommended because it helps in the long term to rectify the endogeneity and serial correlation problems with the pooled OLS. Additionally, the panel co-integration test is undertaken to ascertain the long-run equilibrium relationship between the regressors in order to evaluate the long-run model. The time series data is sourced from World Development Indicators (2022) and World Governance Indicator (2022) respectively for the period 1996 to 2022. The justification for selecting the period and countries was based on data availability.

Table 2: Definition, Measurement, and Apriori Expectation of Variables

S/N	Variable	Definition	Measurement	Apriori
1	EVD	Environmental Degradation	This is the level of environmental pollution proxied with carbon emission	dep
2	Y	Income per capita	Proxied with GDP per capita growth	+
3	TL	Trade liberalization	Captured by trade (% of GDP)	+
4	FDI	Foreign Direct Investment	This is inflows (% of GDP)	-
5	EN	Energy Use	Proxied with Fossil fuel energy consumption	+
6	POP	Population growth	Captured by urban population (% of the total population)	+
7	RQ	Regulatory Quality	Captured by Regulatory Quality Estimate	+
8	REC	Renewable Energy Consumption	This shows the amount of renewable energy consumption	-

Source: Authors' Compilation from WDI (2023)

4. Results and Discussion

This section of the study deals with the analysis and discussion of empirical findings from the study. The section commenced with variable descriptive statistics and panel unit root results for the heterogeneous test (lm *et al.* 2003), and the homogenous unit root test (Breitung, 2001; Levin *et al.* 2002).

Table 3: Descriptive Statistics of the Variables

Variables	Units	Mean	Min.	Max.
EVD	*Metric ton per capita*	0.398	0. 053	0.9056
EN	*% of total energy use*	29.805	12.019	55.164
FDI	*net inflow % of GDP*	2.394	-2.544	18.817
POP	*growth rate (%)*	39.694	15.855	57.985
REC	*% of total final energy consumption*	67.280	36.150	88.680
RQ	*index estimate*	-0.446	-1.351	0.128

TL	*Trade (% of GDP)*	56.794	20.722	116.048
Y	*GDP per capita growth*	1.662	-7.601	12.457

Source: Authors' Compilation from WDI (2023)

Table 3 revealed that the average mean of environmental degradation in the selected ECOWAS countries stands at 39.8%, meaning that the rate of environmental deterioration from ambient concentrations of pollutants and other natural disasters is 39.8%, having a maximum of 0.90 and a minimum of 0.05 pollutant level. Similarly, the average mean for energy use stands at 29.8%. This indicates that non-renewable energy use in the studied countries grows at a rate of 29.8%, which could trigger the rate of environmental deterioration to a maximum level of 55.16 and a minimum level of 12.0. Furthermore, the average mean foreign investment into the region stands at 2.39%, implying that the level of direct investment in the ECOWAS grows at a minimum of -2.5 with a maximum growth of 18.8. In the same vein, the urban population growth over time grows at an average mean rate of 39.6%, indicating that the urban population growth grows between 15.8 and 57.9 annually in the region. Concerning renewable energy consumption, the result confirmed that the average mean for renewable energy consumption stands at 67.2%, with a minimum and maximum consumption of 36.1 and 88.6 respectively. The result showed that policies have been implemented to fast-track the deployment of renewable energy in the region. More so, the result revealed that regulatory quality in the selected countries in the ECOWAS region is weak, indicating that governments from that region need to their regulatory quality score to reduce the incessant increase in pollution. The maximum value of 0.12 for the ECOWAS region is less than the maximum value 2.5 that defines developed areas. In addition, the average mean growth of trade overtime stands at 56.7%, indicating that as countries within the region relax their trade policies, trade grows at a maximum rate of 116.0, although, the increase in trade failed to improve the income per capita for the selected countries in ECOWAS region.

Table 4: Correlation Analysis of the Regressors

Correlation	EVD	EN	FDI	POP	REC	RQ	TL	Y	Y^2
EVD	1								
EN	0.428	1							
FDI	-0.055	0.209	1						
POP	0.677	0.493	-0.069	1					
REC	-0.440	-0.931	-0.154	-0.560	1				

RQ	0.059	0.571	0.100	0.200	-0.549	1			
TL	-0.039	0.137	0.322	0.291	-0.229	0.153	1		
Y	0.177	0.116	0.173	0.167	-0.113	0.086	0.148	1	
Y^2	0.045	-0.061	0.117	0.054	0.079	-0.059	0.091	0.474	1

Source: Authors' Compilation from WDI (2023)

Table 4, revealed the correlation matrix among the variables used. The correlation result presented confirmed that there is an absence of multicollinearity in the study, implying that all the independent variables in the model are not correlated, which indicates that the model is good. However, the highest degree of strong negative correlation amongst the explanatory variables was -0.93 between renewable energy consumption and energy use proxied with non-renewable energy consumption. In the same vein, the result also confirmed that FDI negatively impacts environmental degradation at 5.5%, likewise, trade liberalization is negatively connected with environmental pollution at 3.9%, and both variables have a weak negative correlation with environmental degradation.

Table 5: Panel Unit Root Test

	Homogeneous Unit Root Test				**Heterogeneous Unit Root Test**					
Variables	Levin, Lin, and Chu		Breitung		Lim, Pesaran, Shin		Fisher ADF Test		Fisher PP Test	
	Level	**First Differ**	**Level**	**First Diff**	**Level**	**First Differ**	**Level**	**First Differ**	**Level**	**First Differ**
EVD	-2.147**	-6.785***	-2.280**	-5.90***	-0.807	-7.347***	18.732	78.080***	22.136	134.937***
EN	-3.518***	-6.070***	0.264	-7.59***	-2.149	-6.121***	26.231	62.894***	51.793	103.448***
FDI	0.420	-4.627***	-1.322	-3.61***	-0.382	-7.663***	16.815	80.346***	31.790	153.644***
POP	1.245	-0.885	-0.106	-3.78***	5.384	-0.115	1.474	15.948	12.701	9.732
REC	-3.503***	-6.246***	-1.723**	-6.73***	-1.576	-5.495***	22.353	56.512***	29.835***	108.51***
RQ	0.946	8.791	0.798	-3.18***	-0.562	-4.574***	13.187	46.355***	56.615***	177.77***
TL	-0.834	-5.258***	-1.485	-3.97***	-0.403	-6.746***	12.422	71.906***	14.957	147.68***
Y	-2.981***	-5.737***	-2.91***	-3.39***	-4.45***	-9.093***	47.13**	96.169***	66.644***	176.63***
Y^2	-7.713***	-7.184***	-3.87***	-4.51***	-5.62***	-9.868***	58.56**	105.11***	66.601***	197.99***

****, ** indicate 1% and 5% level of significant*
Source: *Author's Computation (2023)*

Table 5, assert that we accept the null hypothesis at level, meaning that variables are not stationary level, thus confirming that there is a unit root. Based on this, we conducted the first difference stationarity test, which confirmed that all the variables are stationary, indicating that there is no unit root and series are mean reverting and converging towards the long-run equilibrium. In this regard, we proceeded to conduct the panel co-integration test to ascertain the level of equilibrium relationship among variables.

Table 6: Pedroni Residual co-integration test

	Within- Dimension		Between- Dimension	
	Statistic	Weighted Statistic		Statistic
Panel V	-1.8833**	-2.6660	Group rho	2.0250
Panel rho	1.4801	0.7095	Group PP	-0.6790**
Panel PP	0.6601**	-2.9414***	Group ADF	0.8099**
Panel ADF	1.3867**	-2.6094***		

*Note. *** and ** indicate 1%, and 5% levels of significance.*
Source: *Author's Computation (2022)*

The findings within the dimension and between dimensions revealed that panel Philip Perron, panel ADF, and panel V are statistically significant at a 5% level of significance, while the rest estimators are statistically insignificant. This implies that we reject the null hypothesis of no co-integration, and accept the alternative hypothesis that variables are co-integrated in the long run. To further confirm the Pedroni residual co-integration test, the study conducted Kao residual co-integration test.

Table 7: Kao Residual Co-Integration Test

ADF	-2.9188**

*Note. ** indicate 5% level of significance.*
Source: *Author's Computation (2022)*

Kao residual co-integration test suggests that we reject the null hypothesis of no co-integration in the panel. This test further supports the result of Pedroni, which means that there is a long-run relationship between trade liberalization, foreign direct investment, and environmental degradation in selected ECOWAS countries in Africa.

Table 8: Panel Co-Integration Regression
Dependent Variable: Environmental Degradation proxied with carbon emission (metric tons per capita)

Variables	Fully Modified Ordinary Least Square (FMOLS)			Dynamic Ordinary Least Square (DOLS)		
	Model I	Model II	Model III	Model I	Model II	Model III
TL	-0.0008	-	-	-0.0002	-	-
FDI	-	-0.0024	-	-	-0.0004	-
TLFDI	-	-	-0.0172	-	-	-0.0119
EN	-0.0054**	-0.0056**	-0.0058***	-0.0064**	-0.0061**	-0.0060**
POP	-0.0062***	-0.0072***	-0.0072***	-0.0059**	-0.0060**	-0.0059**
RQ	-0.0066	-0.0207	-0.0209	-0.0182	-0.0217	-0.0217
REC	-0.0167***	-0.0173***	-0.0173***	-0.0151***	-0.0147	-0.0147
Y	0.0003	0.0014	0.0012	0.0014	0.0017	0.0017
Y^2	-0.0068	-0.0009	-0.0913	0.0005	0.0005	0.0005
R-Sqr	0.9217	0.9212	0.9207	0.9650	0.9657	0.9657

ADJ R^2	0.9154	0.9149	0.9144	0.9457	0.9467	0.9468

*Note. ** indicate 5% level of significance.* ***Source:*** *Author's Computation (2023)*

Table 8 depicts the panel co-integration regression results, using the panel co-integration techniques. The Fully Modified Ordinary Least Square (FMOLS) and Dynamic Ordinary Least Square (DOLS) result in Model I, confirmed that trade liberalization negatively but insignificant impacts environmental degradation in the selected ECOWAS countries. The implication is that negative trade liberalization suggests that the government tightened its trade policies to discourage importation, stimulate domestic production and reduce the level of pollution through effective environmental laws. However, the consequence of tightened trade policies for countries that depends on each other, could result in increased domestic consumer price, exacerbate inequality, worsening the trade balance among countries, which could lower government revenue, and increase the level of poverty. The result from the two techniques confirmed that foreign direct investment negatively and insignificantly affects environmental degradation. This means that adopting the race to the top theory which does not allow the government to weaken their environmental regulation could help mitigate environmental pollution, as firms will be properly checked before coming to invest in the economies. In addition, adopting the race to the top theory could also help reduce the level environmental degradation to 0.2%.

Regarding the interaction term, the Fully Modified Ordinary Least Square (FMOLS) and Dynamic Ordinary Least Square (DOLS) results showed that trade liberalization interacts with FDI lower pollution by 1.1%, meanwhile, the level of reduction seems to be insignificant. Furthermore, results from the two-panel co-integration techniques confirmed that energy consumption positively and significantly impacts pollution in the selected ECOWAS countries. The consequence of excessive use of fossil fuel energy consumption enhanced the level of pollution which could result in deterioration of the quality of the environment. This result is in agreement with the findings by Lean & Smyth (2010), Jayanthakumaran *et al.* (2012), and Dogan & Seker (2016).

In addition, the result further confirmed that clean energy use asserts a negatively and significantly influence on environmental degradation. This suggests that renewable energy use can significantly reduce the rate of environmental degradation. This result

is in line with the findings by Majeed & Luni (2019), Sharif *et al.* (2020), and Adebayo & Kirikkaleli. (2021). Concerning regulatory quality, the result revealed that the selected countries in the ECOWAS region have a weak regulatory quality to fight environmental pollution, seeing that the two techniques employed, confirmed the negative and insignificant influence on pollution. The result further suggests that the EKC proposition holds for the selected countries when employing FMOLS, but was not found when employing DOLS. From the two results above, it is apparent that the robustness of the result has been confirmed for both techniques. For the panel of countries in the ECOWAS region, both techniques confirmed that trade liberalization and FDI negatively reduce environmental degradation, although the reduction was not significant as expected.

5. Conclusion and Policy Recommendations

Most developing nations, especially those in the ECOWAS region, are now very concerned about issues related to environmental degradation. Investigating these problems was necessary because of the environmental degradation that the area experienced, which had an adverse effect on the ecosystems and biodiversity loss. On the basis of this, the study looked at how trade liberalization and foreign direct investment affected the environment in selected West African sub-regions between 1996 and 2022. The Fully Modified Ordinary Least Square (FMOLS) and Dynamic Ordinary Least Square (DOLS) techniques were employed to analyze variables such as environmental degradation as measured by carbon emissions, energy consumption as measured by fossil fuel consumption, while other variables are income per person, foreign direct investment, population growth, regulatory quality estimate, and consumption of renewable energy. The results of the two-panel co-integration techniques confirmed that trade liberalization and foreign direct investment reduce environmental degradation, but other results affirmed that consumption of fossil fuel energy increased environmental degradation, although, the use of renewable energy greatly lessens the impact of environmental degradation in the region. The result for regulatory quality indicated a negative score, which might be terrible for the region, as it is shown that the selected ECOWAS countries have poor regulatory policies to checkmate the problem of pollution within the region. Regarding policy suggestions, it is important for the West African sub-region to implement effective environmental

laws that reduce the use of fossil fuels and promote the use of more affordable renewable energy sources, as countries liberalize trade and allow for foreign direct investment (Gray 2002)

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