EFFECT OF FOREIGN DIRECT INVESTMENT ON ENVIRONMENTAL QUALITY IN WEST AFRICA

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ABSTRACT

The study empirically examines the impact of foreign direct investment (FDI) on environmental quality and tests the validity of the Pollution Haven Hypothesis in West Africa. The study uses annual panel data for 16 West African countries, spanning from 1996 to 2022. The study employs two estimation techniques (for robustness check), namely, panel-corrected standard errors (PCSE) and feasible generalized least squares (FGLS). The results reveal that FDI has a negative effect on West African environmental quality before the turning point; thus, after the threshold level, the effect changes positively. The results confirm the validity of the pollution haven hypothesis in West Africa. Based on the results, policymakers in the region should adopt threshold-based environmental policies, encourage sustainable economic growth, and strengthen monitoring and enforcement of environmental regulations.
Keywords: Environmental Quality, Pollution Heaven Hypothesis, Foreign Direct Investment
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1. INTRODUCTION

The commitment to preserving a sustainable environment has led to the formulation of the 2030 United Nations Sustainable Development Goal (SDG) 13 agenda, designed to take immediate action against climate change and its repercussions (Adeleye et al., 2023). Consequently, in tackling climate change, it becomes crucial to understand its determining factors, with one of them being carbon dioxide (CO_2) emissions (Elum & Momodu, 2017; Awan et al., 2022). Carbon emissions primarily originate from the combustion of fossil fuels within various sectors such as active power generation, transportation, residential, and industrial activities (Huynh et al., 2020). These emissions, commonly referred to as "greenhouse" gases, would ideally be absorbed by space. However, they become trapped by absorbing solar energy, leading to the heating of the earth and contributing to global warming (National Geographic 2019). This entrapment of heat is recognised as the "greenhouse effect," serving as a prominent illustration of environmental degradation.

The increasing global concern regarding climate change and environmental degradation due to the continuous harmful effects of greenhouse gas emissions remains prominent. CO_2 emissions, a significant component of greenhouse gases (GHG), are a key contributor to escalating global warming and resultant climate change impacts, including rising temperatures and sea levels due to water thermal expansion (Köksal, 2020; Weinin, 2022). According to the Intergovernmental Panel on Climate Change sixth assessment report (IPCC, 2019), CO_2 is responsible for 76% of GHG emissions, and its release from macroeconomic activities such as manufacturing and energy consumption contributes to its increase in atmospheric concentration.

International organizations across the globe consistently strive to mitigate the adverse consequences of global warming, as evident in initiatives like the Kyoto Protocol agreement of 1997, formally known as the United Nations Framework Convention on Climate Change (UNFCCC). This protocol aimed to combat the detrimental effects of global warming by implementing mechanisms such as the Green Climate Fund and fostering collaborations like the European Environment Agency and the Partnerships in Environmental Management for the Seas of East Asia. Another significant stride was the endorsement of the Paris Agreement in 2015, a substantial commitment involving greenhouse gas emission reduction and adaptation strategies, with the objective of limiting global average temperature increase to below 2°C. For this aspiration to materialize, earnest endeavours to adhere to stringent carbon limits of 2°C or lower demand robust climate policies that impose substantial carbon pricing. This approach would act as a deterrent, compelling the transition towards renewable energy and the decarburization of the worldwide economy (Ahmed et al., 2021).

The existing literature extensively used the concept of pollution haven hypothesis (PHH) to examine the linkage between FDI and environmental pollution. This hypothesis implies that as countries attract more foreign direct investment, the environmental consequences may become more pronounced due to potentially lax regulatory frameworks or differing environmental standards practices (Huynh et al., 2020).Therefore, the objectives of this study are threefold: (i) investigate the impact of FDI on environmental quality; (ii) examine if the Pollution Haven hypothesis holds in West Africa; and (iii) determine the turning point. After this introduction, the rest of the study is structured as follows: the "Review of Existing Literature" section reviews the literature; the "Methodology" section outlines the data and model estimation techniques; the "Results and Discussions" section interprets and discusses the results, while the "Conclusion and Policy Recommendations" section concludes with policy recommendations.

2. LITERATURE REVIEW

Researchers make significant efforts to investigate the factors responsible for environmental pollution. Early empirical studies generally identified environmental pollution as a result of consumption and production activities. For this reason, these studies generally focused on the impacts of economic growth (GDP) on environmental pollution (Zayyana and Mlumfashi, 2023). The increasing interest in the subject has led to the expansion of the relevant literature. In this regards, macroeconomic, social, and political phenomena have been used to explain the causes of environmental pollution. In this section, the empirical review will focus on how FDI is contributing to environmental pollution within the framework of pollution haven hypotheses.

The study by Destek and Okumus (2019) investigates the validity of the pollution haven hypothesis for the period from 1982 to 2013 in ten newly industrialized countries. The study examines the relationship between FDI, real income, energy consumption, and ecological footprint with the second-generation panel data methodology to account for cross-sectional dependence among newly industrialized countries. The results show that increased energy consumption and economic growth lead to an increase in ecological footprint. Moreover, the U-shaped relationship between foreign direct investment and ecological footprint is confirmed in newly industrialized countries. Similarly, Shao et al. (2019) investigate the existence of the pollution haven hypothesis (PHH) and test the casual relationship between inward foreign direct investment (FDI) and environmental pollution, as well as other potential influencing factors of environmental performance. To this end, panel vector error correction model (VECM) and panel co-integration tests were conducted for two country groups, the BRICS and the MINT, during 1982–2014. Empirical results illustrate a bidirectional and positive causality between FDI inflows and GDP per capita for both groups, implying a virtuous circle of FDI-growth nexus. More importantly, both the BRICS and MINT countries illustrate bidirectional and negative causality between FDI inflows and environmental pressures. Such findings indicate the pollution haven hypothesis does not stand in this case.

Halliru et al. (2020b) examine the pollution haven hypothesis for CO_2 emissions and ecological footprint using variables such as sustainable economic growth, energy consumption, human capital, and bio-capacity in six ECOWAS countries' data from 1970–2017. The study employs the Pooled Mean Group (PMG) technique, and the empirical results support the pollution halo hypothesis for CO_2 emissions and the Pollution Haven Hypothesis (PHH) for ecological footprint. Similarly, Guzel and Okumus (2020) examine the validity of the pollution haven hypothesis in ASEAN-5 countries, covering the period 1981–2014. According to the results of the CCEMG and AMG estimators, the validity of the PHH is confirmed in ASEAN-5 countries. The increase in foreign direct investment (FDI) increases environmental degradation in these countries.

Singhania and Saini (2021) explore the interrelationship between FDI, institutional factors, financial development, and sustainability by revisiting the pollution haven hypothesis over the period of 1990–2016, covering 21 developed and developing countries with high carbon emissions. The study uses dynamic panel data estimations by applying the generalised method of moments (GMM) and system-generalised methods of moments (Sys-GMM) over sample countries. The results indicate that FDI has a significant positive impact on environmental degradation. There is evidence of the pollution haven hypothesis, especially in developing countries. In the same vein, Bouzahzah (2022) investigates whether the FDI inflows affect CO_2 emissions for a set of 40 African countries. The study applies Panel ARDL and the three estimators: pooled mean group (PMG), mean group (MG), and dynamic fixed effect estimator (DFE), but also Granger causality and Dumitrescu and Hurlin causality for annual data from 1988 to 2016. Long-term results indicate the link between FDI and pollution is relatively complex. In general, the PHH does not seem to be validated.

Furthermore, Asogwa et al. (2018) investigated the factors that most effectively account for the differences in renewable energy use and carbon emission intensity in Sub-Saharan Africa. They identified population density as a crucial factor influencing the regeneration of renewable energy. Similarly, Ikhide (2021) explored the impact of both renewable and fossil energy consumption on Nigeria's economic growth. The findings revealed that fossil fuel energy consumption positively contributes to economic growth, whereas renewable energy consumption has a negative effect on economic growth in Nigeria. Agu and Obodoechi (2021) delved into the interplay among CO2 emissions, temperature changes, productivity, and labor supply in Nigeria. Their results indicated that both labor supply and CO2 emissions have significant and positive effects on agricultural output in the country. Additionally, Onyechi and Ejiofor (2021) and Oyedele and Oluwalaiye (2023) separately investigated the impact of energy consumption on CO2 emissions in Sub-Saharan Africa and Nigeria, respectively. Both studies found a positive correlation, demonstrating that energy consumption contributes to an increase in CO2 emissions.

At this juncture, what proves to be a common trend in the literature reviewed is that the Pollution Haven hypothesis is valid in those countries, despite the hypothesis's inability to ascertain the precise turning point of the event in question. The above-mentioned weaknesses inform this study's attempt to bridge the gap by exploring the impact of FDI flows on environmental pollution in West Africa. This study also aims to determine the turning points of the event in question in West African countries. The study achieved its aim by employing panel-corrected standard errors (PCSE) and feasible generalised least squares (FGLS) estimation techniques. To the best of our knowledge, this is the first study to adopt this approach using data from West Africa.

3. METHODOLOGY

3.1 Data and Sources

This study employs annual panel data of 16 West African countries from 1996 to 2022. The dependent variable is carbon emissions (CO_2) measured in metric tons per capita. The main independent variable are foreign direct investment (FDI) net inflows measured in current US$. Guided by the pollution haven hypothesis (PHH), the anticipated sign for the coefficients of foreign direct investment (FDI) is positivity both prior to and following the threshold level (turning point). This is crucial to substantiate the presence of the pollution haven hypothesis in West Africa. Additionally, there are two control variables directly related to CO_2 emissions: renewable energy (REN) and regulatory quality (RQ). These variables are expected to have respective negative effects on CO2 emissions. Table 1 provides the variable codes, descriptions, expected signs, and sources of the data.

Variables	Description	Signs	Sources
CO_2	CO_2 emissions (metric tons per capita)	N/A	World Bank (2023)
FDI	Foreign direct investment, net inflows (current US$)	+/+	World Bank (2023)
REN	Renewable energy consumption (% of total final energy consumption)	-	World Bank (2023)
RQ	Regulatory quality: estimate (from −2.5 to 2.5)	-	World Bank (2023)

Source: Author's compilations (2024)

3.2 Model Specification

Following Adeleye et al. (2023), we start with specifying a baseline model with carbon emissions (CO_2) expressed as a linear function of control variables which are renewable energy (REN) and regulatory quality (RQ):

$$lnCO_{2it} = \beta_0 + \beta_1 REN_{it} + \beta_2 RQ_{it} + \varepsilon_{it} \qquad (1)$$

To achieve the first and second objectives of investigating the impact of FDI on CO2 emissions and whether the pollution haven hypothesis is valid in West Africa, we include both the level and square of FDI into model (1):

$$lnCO_{2it} = \beta_0 + \beta_1 REN_{it} + \beta_2 RQ_{it} + \delta_1 lnFDI_{it} + \delta_2 lnFDI^2{}_{it} + \mu_{it} \qquad (2)$$

where CO_2 is the per capita carbon dioxide emissions; FDI is the foreign direct investment and FDI^2 is its square. The control variables are: REN is the renewable energy and RQ is the regulatory quality. βs,θsand δsare the parameters to be estimated; ε,and μare the error terms, the subscripts i and t denote the country i and the time period respectively.

To fulfill the third objective of identifying the turning points, we compute the first derivatives of models (2) concerning FDI, setting them to zero. Given that the variables are in logarithms, we subsequently apply the antilog (exponent) to the turning point to acquire the actual values. This process ensures confirmation that the real values of the turning points fall within the specified range for those variables (Adeleye et al., 2023).The FDI turning point of this curve is computed by $\hat{\tau} = (0.5\ \delta_1/\delta_2)$. In general, the turning point is when the first derivative of model (2) with respect to FDI is equated to zero.

3.3 Estimation Techniques

The empirical analysis starts with the summary statistics and correlation analysis, followed by the application of the cross-sectional dependence test among the countries to determine the suitable methods to apply. The risk of cross-sectional dependent panels is very high due to the close proximities of the units and given the possibility of sharing common features. In the event of cross-sectional dependence (CSD) in the data, biased estimates and inferences will occur (Pesaran2004). To forestall such, the study engages the Pesaran (2004, 2007) test for cross-sectional dependency (CD) which can be applied to small and large panels. The null hypothesis of no CSD which can be rejected at the 1%, 5%, and 10% significance levels is expressed as:

$$CD = \sqrt{2T/N(N-N)}\left(\sum_{i=1}^{N-1}\sum_{k=i+1}^{N}\hat{\rho}_{i,k}\right) \tag{3}$$

In the event of cross-sectional dependence, the data is subjected to second-generation unit root tests to avoid spurious results. The cross-sectional augmented Im, Pesaran, and Shin (CIPS) developed by Pesaran (2007) is engaged. The CIPS test, which is the augmented variant of Im et al. (2003) unit root test, is expressed as:

$$CIPS(N,T) = \hat{T} = N^{-1}\sum_{i=1}^{N} t_i\,(N,T) \tag{4}$$

where N and T are the numbers of cross-sections and years, respectively. The left-hand side of Eq. (6) is the unit root test for heterogeneous panels, while on the right-hand side, the term ti is the ordinary least squares (OLS) t-ratios employed in cross-sectional averaged augmented Dickey-Fuller (ADF) regression. As a preliminary check, we also used the Maddala and Wu (1999) first-generation unit root test which assumes cross-sectional independence. Thereafter we assess whether a long-run relationship exists among the variables using the second-generation panel cointegration tests proposed by Westerlund (2007). This technique is suitable in the presence of CSD in the data, and the null hypothesis of no cointegration can be rejected at the 1%, 5%, or 10% significance levels.

Finally, given the presence of cross-sectional dependence in the data and cointegration among the variables, this study employed thepanel-corrected standard errors (PCSE) to estimate the parameters of models. These estimation techniques not only addresses cross-sectional dependence but also controls for heteroscedasticity and serial correlation, and enhance the accuracy of the estimated parameters (Arellano & Bond, 1991). For robustness checks and to observe the consistency of the results, we also deployed the feasible generalized least squares (FGLS) estimation technique.

4. RESULTS AND DISCUSSION

4.1. Results of Pre-estimations Tests: Correlation, CSD, PURT, and Cointegration Tests

The summary of descriptive statistics and pairwise correlation among the variables are presented in Table 2. The results show that the minimum and maximum values of FDI are -$883.6 and $8841 respectively. From the pair wise correlation reported on the lowest panel of Table 2, all the variables with the exception of renewable energy (REN) indicate significant positive association with CO_2 emissions. None of the regressors exhibit a perfect linear relationship, as evidenced by correlation statistics below 0.80 for all variables. Consequently, there is no indication of multicollinearity among the regressors.

Table 2: Descriptive statistics and pairwise correlation analysis

Variable	CO2	FDI	REN	RQ
Mean	0.321	492.5	69.071	-0.653
Std. Dev.	0.238	1131	20.543	0.385
Minimum	0.044	-883.6	20.78	-1.856
Maximum	1.074	8841	94.99	0.269
Observations	448	480	457	384
	Pairwise correlations			
lnCO2	1.000			
	(0.000)			
lnFDI	0.449	1.000		
	(0.000)			
REN	-0.725	-0.192	1.000	
	(0.000)	(0.000)		
RQ	0.334	0.188	-0.597	1.000
	(0.000)	(0.000)	(0.000)	

***p < 0.01, **p < 0.05, *p < 0.10; P-values in parentheses ( )ndln: natural logarithm.

The Pesaran (2004) CD test result presented in Table 3 reject the null hypothesis of no cross-sectional dependence at the 1% significance level, suggesting that any shock in one country may be transmitted to other West African countries. The presence of cross-sectional dependence highlights the interconnectedness or shared influences among these nations, indicating that economic shocks or changes in one country could have spillover effects on neighboring countries within West Africa.

To examine the stationarity of the variables, the Maddala and Wu (1999) first-generation unit root test which assumes “cross-sectional independence” and Pesaran (2007) second-generation unit root test that presumes “cross-sectional dependency” are deployed. The outcomes from both tests indicate that all the variables with the exception of lnFDI and RQ are stationary after taking the first difference. The Westerlund(2007)cointegration results indicate a long-run relationship among the variables exist in models (1) and (2).

Table 3: Results of CSD, Panel Unit Root, and Cointegration Tests

	Pesaran (2004) CSD	Maddala and Wu (1999)		Pesaran (2007) CIPS	
Variables		Level	1st Diff	Level	1st Diff
$lnCO_2$	25.333***	-0.047	-17.942***	-1.522	-5.435***
lnFDI	33.837***	-2.517***	N/A	-2.055***	N/A
REN	27.169***	1.841	-18.105***	-1.097	-5.478***
RQ	1.795*	-1.158	-14.445***	-1.774	-4.597***
Westerlund (2007) cointegration test					
Models:		(1)	(2)		
Variance ratio:		0.2024	-1.609**		

***p<0.01, **p < 0.05, *p < 0.10,ln: natural logarithm, N/A: not applicable, CO2: carbon emissions, GDP: real GDP per capita, FDI: foreign direct investment; REN: renewable energy, RQ: regulatory quality, panel unit root and CSD tests performed using the Stata17.

4.2. Results of PCSE and FGLS Estimations

The results of estimated coefficients of models (1 and 2) are presented in table 4. The models are estimated using the PCSE and FGLS estimation techniques with each as robustness checks. The interpretations and discussion restricted to models (2) that address the core objectives of the study. The results in table 4 reveal that the contribution of FDI, a 1% increase in foreign direct investment will decrease carbon emissions by 0.3 to 0.6% (see columns [2]). The result in this sense surmises that opening markets through foreign direct investment and trade reduced the adverse effect of carbon emissions in West Africa. Thus, the transfer of clean energy and better regulatory strategies from the inflows of foreign direct investment can improve a quality environment (at initial stage). However, the square term of the FDI-emissions relationship is positive and statistically significant which validates the pollution haven hypothesis. The results show that a 1% increase in FDI inflows contributes positively to carbon emissions by 0.1 to 0.2% (see columns [2]).

Table 4: Results of PCSE and FGLS Estimated Coefficients ((DepVar: $\ln CO_2$)

	PCSE, Main Analysis		FGLS (Robustness)	
Variables	[1]	[2]	[1]	[2]
REN	-0.0272***	-0.0302***	-0.0303***	-0.0311***
	(-23.07)	(-26.43)	(-19.16)	(-32.30)
RQ	-0.0308	-0.419***	-0.341***	-0.413***
	(-0.540)	(-6.620)	(-4.019)	(-8.657)
lnFDI		-0.579***		-0.311***
		(-3.664)		(-2.786)
$\ln FDI^2$		0.0192***		0.0106***
		(4.493)		(3.421)
Constant	0.415***	4.454***	0.493***	2.565**
	(4.879)	(3.015)	(5.508)	(2.558)
Threshold		31.038		39.400
Number of Country	16	16	16	16
Wald Test	557.8	1611	457.1	1649

*** p< 0.01, ** p < 0.05, * p < 0.1; z-statistics in parentheses ( ); ln natural logarithm; GDP:real GDP per capita, FDI: foreign direct investment; REN: renewable energy, RQ: regulatory quality, panel coefficients and threshold estimations performed using the Stata17.

The turning point results indicated in Figs. 1 and 2, the threshold point occurs between $31 and $39 billion FDI net inflows, from which carbon emission begins to rise. The implication of this is that at the early stage of development, West African countries enjoys environmental quality through inflows of FDI but declines after the threshold point is attained. Thus, at the early stage, the result supports the *halo effect hypothesis; thereafter, the pollution haven hypothesis sets in.* Moreover, the positive increasing effect may be due to the relocation of polluting firms from high-income countries with quality regulation to low-income West African countries with less stringent environmental regulation (Guzel and Okumus2020). The environmental pressure of FDI is unsurprising because the West African countries in this study are non-high-income countries with increased pollution. These results support the finding of Esmaeili (2023). Contrarily, Halliru et al. (2020b) found evidence of inverted U-shaped pattern of FDI- emissions relationship. The discrepancies might be due to the scope under coverage, the analytical technique, and the choice of control variables.

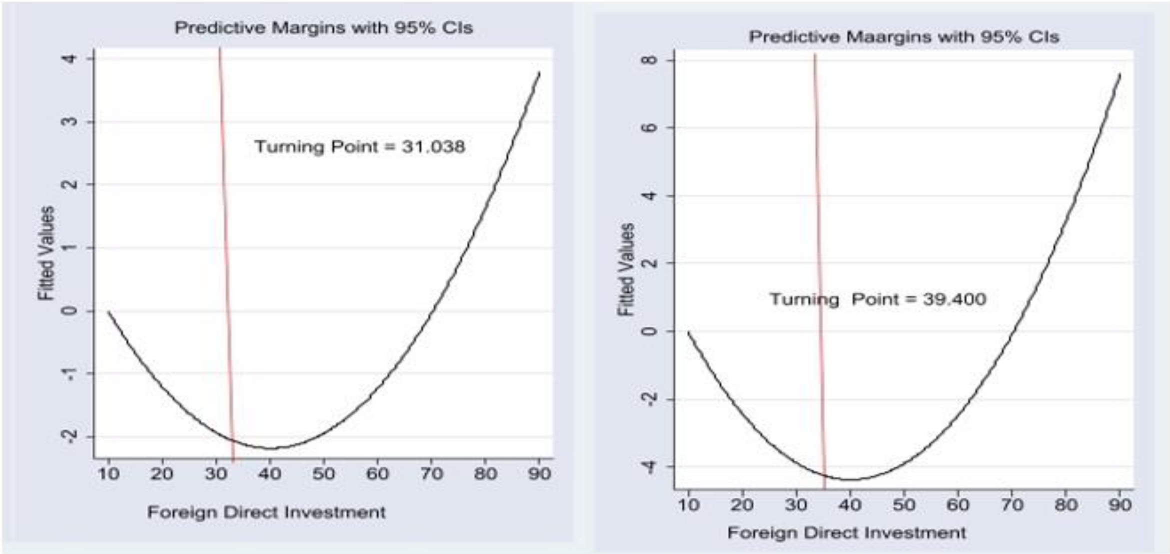

Fig. 1: Turning points of FDI-emissions nexus from PSCE and FGLS technique.

5. CONCLUSION AND POLICY IMPLICATIONS

The relationship between environmental pollution and macroeconomic variables especially foreign direct investment has fueled recent debates. As such, this study contributes to the discourse by engaging a panel data of 16 West African countries covering 1996–2022. Using a blend of robust econometric techniques from panel-corrected standard errors (PCSE) and feasible generalized least squares (FGLS) estimation techniques, our results provide sufficient evidence to address the study objectives. We find that (1) a U-shaped FDI-Kuznets curve is present in West Africa; and (2) the inverted U-shaped turning points are when FDI inflows are $31 and $39 billion, respectively.

In relation to the existing studies, this study makes significant contributions to the literature in four strategic areas. Firstly, it validates the existence of a U-shaped FDI-emission nexus while controlling for renewable energy consumption and regulatory quality variables. Secondly, it provides sufficient evidence that substantial inflows of foreign direct investment contribute to environmental pollution. Lastly, it employs two robust estimation techniques (PCSE and FGLS) to support the findings.

In light of the perceptive conclusions this study offers, several key recommendations can be proposed to guide policy and decision-making for promoting sustainable economic development, foreign direct investment, and environmental quality in West Africa: Firstly, recognizing the adverse impact of substantial foreign direct investment on environmental quality, policymakers should implement a comprehensive set of measures to mitigate these negative effects. Strategies may include the establishment of stringent environmental standards and regulations that foreign investors must adhere to, ensuring that their operations align with sustainable practices. Additionally, promoting transparency and accountability in the FDI approval process can help scrutinize the environmental implications of proposed investments. Policymakers should actively engage with foreign investors to encourage the adoption of eco-friendly technologies and practices, fostering a responsible and environmentally conscious approach to foreign direct investment. This multifaceted approach aims to harness the benefits of FDI for economic growth while safeguarding the environment and promoting sustainability.

Finally, policymakers should consider the adoption of threshold-based environmental policies. This entails establishing policies that are responsive to specific thresholds or turning points identified in the relationship between foreign direct investment and environmental quality. Additionally, there is a need for more research in this area, such as the incorporation of lagged dependent variables through the use of dynamic and short-run estimators. It would also be interesting to include all the 54 African countries and conduct a panel sub-sample analysis. Looking at the above will reveal more information in the research area, thus helping policymakers make more informed decisions.

REFERENCES

Adeleye, B. N., Akam, D., Inuwa, N., James, H. T., & Basila, D. (2023). Does globalization and energy usage influence carbon emissions in South Asia? An empirical revisit of the debate. *Environmental Science and Pollution Research*, *30*(13), 36190-36207.

Ahmed, Z., Zhang, B., & Cary, M. (2021). Linking economic globalization, economic growth, financial development, and ecological footprint: Evidence from symmetric and asymmetric ARDL. *Ecological Indicators*, 5(3), *121-137*.

Apergis, N., Pinar, M., &Unlu, E. (2023). How do foreign direct investment flows affect carbon emissions in BRICS countries? Revisiting the pollution haven hypothesis using bilateral FDI flows from OECD to BRICS countries. *Environmental Science and Pollution Research*, *30*(6), 14680-14692.

Arellano, M., & Bond, S. (1991). Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *The review of economic studies*, *58*(2), 277-297.

Asogwa, I. S., Ugwuanyi, C. U., &Anumudu, C. N. (2018). Determinants of Renewable Energy Use and Carbon Emission Intensity in Sub Sahara Africa. *Journal of Economics and Allied Research*, *2*(2), 66-77.

Awan, A., Abbasi, K. R., Rej, S., Bandyopadhyay, A., &Lv, K. (2022). The impact of renewable energy, internet use and foreign direct investment on carbon dioxide emissions: A method of momentsquantile analysis. *Renewable Energy*, *189*, 454-466.

Bekun, F. V., Agboola, M. O., & Joshua, U. (2020). Fresh insight into the EKC hypothesis in Nigeria: accounting for total natural resources rent. *Econometrics of Green Energy Handbook: Economic and Technological Development*, 6(2), 221-243.

Bouzahzah, M. (2022). Pollution haven hypothesis in Africa: does the quality of institutions matter?. *International Journal of Energy Economics and Policy*.

Destek, M. A., &Okumus, I. (2019). Does pollution haven hypothesis hold in newly industrialized countries? Evidence from ecological footprint. *Environmental Science and Pollution Research*, *26*, 23689-23695.

Elum, Z. A., &Momodu, A. S. (2017). Climate change mitigation and renewable energy for sustainable development in Nigeria: A discourse approach. *Renewable and Sustainable Energy Reviews*, *76*, 72-80.

Esmaeili, P., Lorente, D. B., & Anwar, A. (2023). Revisiting the environmental Kuznetz curve and pollution haven hypothesis in N-11 economies: Fresh evidence from panel quantile regression. *Environmental Research*, *228*, 115844.

Guzel, A. E., &Okumus, İ. (2020). Revisiting the pollution haven hypothesis in ASEAN-5 countries: new insights from panel data analysis. *Environmental Science and Pollution Research*, *27*, 18157-18167.

Halliru, A. M., Loganathan, N., Sethi, N., & Hassan, A. A. G. (2020). FDI inflows, energy consumption and sustainable economic growth for ECOWAS countries: The pollution haven hypothesis approach. *International Journal of Green Economics*, *14*(4), 327-348.

Huynh, C. M., Nguyen, V. H. T., Nguyen, H. B., & Nguyen, P. C. (2020). One-way effect or multiple-way causality: foreign direct investment, institutional quality and shadow economy?. *International Economics and Economic Policy*, *17*, 219-239.

Ikhide, E. E. (2021). Alternative energy consumption and economic growth in Nigeria. *Journal of Economics and Allied Research, 6*(1), 1-20.

ImKS, Pesaran MH, Shin Y (2003) Testing for unit roots in heterogeneous panels. *Econometrics* 115(1):53–74.

IPCC (2019) Sources of CO2. In: Gale J, Bradshaw J, Chen Z, Garg A, Gomez D, Rogner H-H, Simbeck D, Williams R, Toth F, van Vuuren D, El Gizouli I, Hake JF (eds) IPCC Special Report on Carbon Dioxide Capture and Storage. IPCC, pp 75–105.

Köksal, C., Işik, M., &Katircioğlu, S. (2020). The role of shadow economies in ecological footprint quality: empirical evidence from Turkey. *Environmental Science and Pollution Research*, *27*, 13457-13466.

Maddala GS, Wu S (1999) A comparative study of unit root tests with panel data and a new simple test. Oxford Bull Econ Stat 61:631– 652

Musah, M., Mensah, I. A., Alfred, M., Mahmood, H., Murshed, M., Omari-Sasu, A. Y., ...&Coffie, C. P. K. (2022). Reinvestigating the pollution haven hypothesis: the nexus between foreign direct investments and environmental quality in G-20 countries. *Environmental Science and Pollution Research*, 1-18.

National Geographic (2019) Carbon dioxide levels are at a record high. Here's what you need to know. Retrieved from https://www.nationalgeographic.com/environment/global-warming/green house-gases/

Onyechi, T. G., & Ejiofor, C. C. (2021). Decarbonizing Nigeria's Energy Mix: The Role of Renewable Energy Consumption. *Journal of Economics and Allied Research*, *6*(2), 12-22.

Oyedele, O., &oluwalaiye, O. B. (2023). Energy Consumption, Co2 Emission and Population Health in Sub-Saharan Africa. *Journal of Economics and Allied Research (JEAR)*, 8(3), 180-207.

Pesaran MH (2004) General diagnostic tests for cross section dependence in panels. University of Cambridge, Faculty of Economics, Cambridge Working Papers in Economics No. 0435.

Pesaran MH (2007) A Simple unit root test in the presence of cross section dependence. J Appl Econ 22

Shao, Q., Wang, X., Zhou, Q., &Balogh, L. (2019). Pollution haven hypothesis revisited: a comparison of the BRICS and MINT countries based on VECM approach. *Journal of Cleaner Production*, *227*, 724-738.

Singhania, M., & Saini, N. (2021). Demystifying pollution haven hypothesis: Role of FDI. *Journal of Business Research*, *123*, 516-528.

Weimin, Z., Sibt-e-Ali, M., Tariq, M., Dagar, V., & Khan, M. K. (2022). Globalization toward environmental sustainability and electricity consumption to environmental degradation: does EKC inverted U-shaped hypothesis exist between squared economic growth and CO2 emissions in top globalized economies. *Environmental Science and Pollution Research*, *29*(40), 59974-59984.

Westerlund J (2007) Testing for error correction in panel data. Oxford Bulletin of Economics and Statistics 69(6):709–748.

Zayyana, H. and A.H. Malumfashi (2023). Revisiting the Environmental Kuznets Curve Hypothesis with The Role of the Shadow Economy in Nigeria. *Journal of Economics and Allied Research (JEAR)*, 8(4), 1-13.