POLAC MANAGEMENT REVIEW (PMR)
DEPARTMENT OF MANAGEMENT SCIENCE
NIGERIA POLICE ACADEMY, WUDIL-KANO

FOREIGN DIRECT INVESTMENT AND CARBON EMISSION IN NIGERIA: A TEST OF POLLUTION HAVEN AND POLLUTION HALO HYPOTHESIS

Aigbovo, Omoruyi Department of Finance, University of Benin, Edo State, Nigeria

Faith Evbayoboru Idehen Department of Finance, University of Benin, Edo State, Nigeria

Abstract

The study inquiries into the effect of foreign direct investment (FDI) on carbon emission in Nigeria in order to validate or invalidate the pollution haven hypothesis and the pollution halo hypothesis in Nigeria. Time series data on Carbon emission, FDI, Economic growth, financial development, trade openness and urbanization from 1981 – 2022 were analyzed using descriptive statistics, correlation analysis and OLS regression techniques. With CO2 emission as the dependent variable, we estimate regression estimate of the model. Overall, findings from the study seem not to provide evidence that validates the pollution haven hypothesis or the pollution halo hypothesis. Also, trade openness was found not to be a key factor that significantly influences carbon emission in Nigeria while economic growth, financial development and urbanization stimulate CO2 emission in Nigeria. The study recommends that the Nigeria government should come up with policies that promote FDI inflows in Nigeria. Furthermore, Nigeria government should continue to drive economic growth using environmentally friendly policies as this will continue to lower the CO2 emission in Nigeria. Furthermore, banks must ensure that given credit should have a policy on how they will ensure that their activity does not harm the environment. Also, policymakers should strive to slow down the rate of urbanization in other to reduce its detrimental effect on the environment in Nigeria.

Keywords: Carbon Emission, Foreign Direct Investment, Financial Development, Pollution Haven Hypothesis, Pollution Halo Hypothesis

1. Introduction

Foreign direct investment (FDI) has played a key role in the growth and development of developing economies. However, one prominent opposing question about foreign direct investment is whether it is a blessing or a curse to the natural environment of the host country. The activities of multinational companies (MNCs) through FDI predominantly contribute to the increased emissions level of greenhouse gases and other pollutants that causes climate change. Specifically, countries endowed with natural resources and with lax environmental regulations often experience an increase in carbon dioxide emissions levels via FDI. This asserts the prediction that GHG emissions and other ozone-depleting gases emission could rise from 25% to 90% between the years 2000 and 2030, putting the host country into numerous health challenges from the concomitant effects of climate change (Sarkodie, 2018; Bediako, Twerefou & E Codjoe, 2022). The Kyoto Protocol drew attention to trade activities in developing countries, which view FDI as an important strategy for economic growth. FDI inflows to the developing countries have increased, especially in the last three decades, due to increased globalization and the free movement of capital. Developing countries cannot allocate sufficient resources to investments that will contribute to economic development to achieve their growth targets. Therefore, FDI can provide some of the resources required. FDI can assist in a country's development through technology transfer, improved productivity, new management skills, and infrastructure developments. Although FDI contributes to economic growth in the host country, it also raises controversy about environmental quality (Mert & Caglar, 2020).

The environmental economics literature approaches this question through two opposing hypotheses. The first, the pollution haven hypothesis, states that pollution-intensive production activities are directed from developed countries to those with more lax environmental regulations through FDI. Thus, developed economies reduce the costs of adapting to environmental regulations and benefit from a cheap labor force. The other hypothesis, known as the pollution halo hypothesis, claims that companies from the investing developed countries contribute to the host country's reduction of emissions because their production structure relies on green technology, unlike the host country's existing production (Caglar, 2020). Nigeria like many other developing countries is abundant in natural resources which lures Foreign Direct Investment (FDI) making it a worthy host country. Given the vital role played by cross-border flowing FDI in promoting economic growth and development of the host countries, but has also caused environmental degradation in most host countries, an empirical examination of the FDI - carbon emission nexus in Nigeria becomes imperative.

In the literature, the impact of Foreign Direct Investment (FDI) on carbon dioxide (CO_2) emissions is explained by two different hypotheses: Pollution Halo and Pollution Haven Hypothesis. While Pollution Halo hypothesis states that FDI provides advanced technology to countries and accordingly decreases carbon dioxide (CO_2) emissions, Pollution Haven Hypothesis indicates that there is a positive relationship between FDI and CO_2. In this regard, in this study, the impact of FDI on CO_2 emissions in Nigeria is investigated. Although the relationship between FDI and carbon emission has drawn significant attention in several nations, the empirical evidence is contradictory. While some studies support the pollution haven hypothesis (Akbostancı et al., 2007; Kivyiro and Arminen (2014); Seker et al., 2015; Solarin et al., 2017; Gorus and Aslan, 2019; Caglar, 2020), others find stronger evidence for the pollution halo hypothesis (Hao and Liu, 2015; Mert and Boluk, 2016; Balsalobre-Lorente et al., 2019). In addition, some studies (Lee 2013; Shaari et al., 2014) demonstrate that the neutrality hypothesis is more appropriate for explaining the relationship between these two variables. Difference in variables used, scope of the studies, the estimation techniques adopted and how the process was followed, variable measurement bias, could be responsible for this mixed findings, as such there is need for more study. The relationship between FDI and carbon emission, as a result, has not been clarified and is still up for debate among researchers. Furthermore, the majority of the Nigerian studies undertaken did not use the most recent data through 2022. The influence of FDI on carbon emission in Nigeria was thus investigated in this study using the most recent data. By analysing the impact of FDI on carbon emission in Nigeria, this study aimed to bridge these gaps.

The general objectives of this study are to examine the effect of foreign direct investment on carbon emission in Nigeria. Specifically, the objectives of this study are to:

i. ascertain the existence of the pollution haven hypothesis for Nigeria; and
ii. ascertain the existence of the pollution haven hypothesis for Nigeria.

2. Literature Review

2.1 Conceptual Issues

Carbon Emission: Carbon dioxide (CO_2) is a colorless, odorless and non-poisonous gas formed by combustion of carbon and in the respiration of living organisms and is considered a greenhouse gas. Emissions mean the release of greenhouse gases and/or their precursors into the atmosphere over a specified area and period of time. Carbon dioxide emissions or CO_2 emissions are emissions stemming from the burning of fossil fuels and the manufacture of cement; they include carbon dioxide produced during consumption of solid, liquid, and gas fuels as well as gas flaring (Eurostat, 2017).

A greenhouse gas (GHG) is any gas in the atmosphere which absorbs and re-emits heat, and thereby keeps the planet's atmosphere warmer than it

otherwise would be. The main GHGs in the Earth's atmosphere are water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and ozone. GHGs occur naturally in the Earth's atmosphere, but human activities, such as the burning of fossil fuels like coal, petroleum, natural gas as well as large scale deforestation are increasing the levels of GHG's in the atmosphere, causing global warming and climate change (Mackay, 2008).

"Carbon dioxide equivalent" (CO_2e) is a term for describing different greenhouse gases in a common unit. For any quantity and type of greenhouse gas, CO_2e signifies the amount of CO_2 which would have the equivalent global warming impact. A quantity of GHG can be expressed as CO_2e by multiplying the amount of the GHG by its Global Warming Potential (GWP). For example, if 1kg of methane is emitted, this can be expressed as 25kg of CO_2e (1kg CH_4 * 25 = 25kg CO_2e). "CO_2e" is a very useful term for a number of reasons: it allows "bundles" of greenhouse gases to be expressed as a single number; and it allows different bundles of GHGs to be easily compared (in terms of their total global warming impact). However, one word of caution when comparing CO_2e totals is that it is important to know that the same GHGs are included in the totals being compared, in order to be sure that like-for-like comparisons can be made. It is also worth noting that "CO_2e" is also sometimes written as "CO_2eq", "CO_2equivalent", or even "CDE", and these terms can be used interchangeably (Brander, 2012).

Foreign Direct Investment: Foreign Direct Investments (FDI) is capital investments made between nations with the assistance of multinational corporations (MNCs) for bilateral or multilateral economic gains (Choi, 2003). FDI is formally defined as the net inflow of capital used to purchase a long-term management stake (10% or more of the voting shares) in a business that operates in a nation other than the investor. The total of equity capital, reinvested earnings, and other short- and long-term capital makes up this amount (O'Meara, 2015).

2.2 Theoretical Review

Pollution Haven Hypothesis

Pollution haven hypothesis, predicts that as trade and investment obstacles between countries are abolished, the production of pollution-intensive goods by companies that are willing to escape from complying with costly legislation in their own countries will shift to countries with relatively poor environmental policies (Hoffman et.al., 2005; Kellenberg, 2009; Dean et al., 2009; Copeland, 2008). This shift in production may emerge as a result of trade or liberalization of investments. Countries with poor environmental policies have comparative advantage in pollution-intensive production. In addition, weak environmental policies determine the direction of foreign direct investment flows (Copeland, 2008).

The first pollution haven model was developed by Pethig (1976). A model of two countries with identical features except for their environmental taxes was created, making the difference in pollution tax the only factor affecting trade. The northern2 country with high pollution taxes has a comparative advantage in the production of clean goods. The southern country with low pollution taxes has a comparative advantage in the production of pollution-intensive goods. In Pethig's model, the pollution tax was accepted as exogenous. The model does not make any predictions about the countries that have turned into pollution havens. It is not possible for governments to interfere with inputs or outputs in pollution-intensive production as the pollution taxes are exogenous (Copeland, 2008).

Copeland and Taylor (1994) developed the first model of pollution haven that takes internal environmental policy into account. A model of two identical countries was created, where the only difference was that the northern country was richer. They argue that pollution haven will occur under the assumptions that environmental quality claims increase with income and governments are sensitive to the preferences of their citizens while applying pollution policy. South will have comparative advantage over pollution-intensive goods. Commercial liberalization shifts

pollution intensive production to the South, and therefore the relatively poor country turns into pollution havens (Copeland, 2008).

The view that the increase in foreign direct investment will also increase CO_2 emissions is called Pollution Havens Hypothesis. The Pollution Havens Hypothesis can occur in three ways (Aliyu, 2005): First, pollution industries arise through polluting industries to countries with more loose regulations than countries with strict environmental regulations. Second, developed countries throw away hazardous wastes related to industrial and nuclear energy production into developing countries. Third, multinational corporations should obtain unlimited sources of renewable resources such as oil and petroleum products, lumber and other forest resources, etc. in developing countries.

Pollution Halo Hypothesis

Contrary to the pollution haven hypothesis, the pollution halo hypothesis claims that foreign companies use better management practices and advanced technologies that result in clean environment in host countries (Zarsky, 1999). This implies that trends in environmental damage due to foreign direct investment are unsustainable (Asghari, 2013). Pollution Halo Hypothesis suggests that the increase in the amount of foreign direct investments will reduce CO_2 emissions. Multinational corporations (MNC's) that make foreign direct investments will tend to spread clean technology, which is less harmful to the environment as they have more advanced technology than the domestic companies in the host country (Görg ve Strobl, 2004).

These companies contribute to the creation of cleaner environments in host countries through better management practices and more advanced technology (Zarsky, 1999). Thus, it can provide less carbon emissions (Shahbaz et. al., 2011). It can also lead to increased performance of domestic firms due to learning by doing and copying effects (Zarsky, 1999). Multinational corporations tend to share green technologies with domestic companies in the host country (Hoffman, 2005). The Pollution Halo hypothesis suggests that multinational corporations disseminate superior knowledge and apply environmentally friendly practices that improve the environmental performance of domestic companies (Doytch & Uctum, 2016).

2.3 Empirical Review

Caglar (2020) examines the relationship between renewable energy consumption, non-renewable energy consumption, foreign direct investment, economic growth and carbon emissions for the nine countries (i.e., Denmark, Finland, France, India, Italy, Morocco, Norway, Portugal, Sweden) identified in the Climate Change Performance Index (CCPI) 2018 report. This study mainly aims to demonstrate the role of renewable energy consumption and foreign direct investment on CO_2 emissions in countries with high scores in the CCPI using the newly developed bootstrap autoregressive distributed lag (ARDL) approach. Granger causality based on the bootstrap ARDL approach was used to identify causal relationships between variables. Empirical analysis results show only a few cointegration relationships between variables exist. Findings also identified significant long-term relationships between foreign direct investment, renewable energy consumption and economic growth in some countries.

Hao and Liu (2020) investigate the relationship between FDI, foreign trade and carbon dioxide emissions in China. Using a two-equation model adapted from Halkos and Paizanos (Ecol Econ 91:48-56, 2013), the total impacts of FDI and foreign trade on emission are divided into the direct and indirect impacts and estimated accordingly. The estimation results suggest that the total impact FDI on per capita CO_2 emissions is negative. Concretely, the negative direct effect of FDI on carbon emissions dominates the positive indirect effect through FDI's influence on per capita GDP. However, for foreign trade, both direct and indirect impacts on CO_2 emissions are insignificant after taking consideration of potential endogeneity and introducing dynamics.

Mert and Caglar (2020) examine the asymmetric short- and long-run causal links between foreign direct investments and emissions in Turkey over the time period 1974–2018. Using hidden co-integration techniques, we defined and tested the asymmetric pollution haven and asymmetric pollution halo hypotheses. To evaluate the long-run asymmetric causal relationship, we estimated both the crouching error correction model and vector error correction model. We performed a stepwise regression model to estimate the crouching error correction model. The empirical results confirmed an asymmetric causal relationship between positive shocks of foreign direct investments and positive movements in emissions in the short run as well as an asymmetric causal link between negative and positive shocks of foreign direct investments and positive emissions in the long run. Furthermore, the results showed that increases in foreign direct investments led to a decrease in the rate of emission growth in both the short and long run. This finding supports the validity of the asymmetric pollution halo hypothesis in Turkey's case. Policymakers should strengthen their environmental protection laws to protect the quality of their environments as well as implement policies that encourage the use of clean technology and tax incentives that increase foreign direct investment inflows.

Yüksel, Dinçer, Karakuş and Ubay (2020) studied the negative impacts of carbon emission on the foreign direct investments. For this purpose, a comparative analysis is performed for both E7 and G7 countries. In the analysis process, Pedroni panel cointegration (PPC), Kao panel cointegration (KPC), and Dumitrescu Hurlin panel causality (DHPC) analyses are taken into consideration. The findings indicate that carbon emission has a negative influence on foreign direct investments for both country groups. Nonetheless, this relationship is stronger for G7 economies. It is also identified that there is no causality relationship between these variables. It is recommended that the countries should generate appropriate policies to minimize carbon emission problem. Within this context, new tax can be implemented for the companies that lead to high carbon emission. Additionally, governments can give incentives to the projects that aim to decrease carbon emission. In this scope, decreasing tax ratio and providing a technical support can be given as examples.

Hou, Su, Li, Qian, Xiao, and Guo (2021) examine the actual use of FDI and carbon emissions in China from 1997 to 2018. Quantitative analysis was employed to analyze the trends of FDI and carbon emissions in China as a whole and in the respective regions, namely the eastern, central and western regions. Regression analysis was then conducted to analyze the impact of FDI on carbon emissions in China on the national level and regional levels, i.e., in the eastern, central and western regions. The conclusion of this article is that FDI will play a positive role in China's overall carbon emissions. The study has important implications for policy. We recommend that the corresponding investment policies need to be formulated according to the different levels of economic development among the regions.

Abdelgany and Gad-Elhak (2022) examine the validity of the Pollution Haven Hypothesis (PHH), and the pollution halo hypothesis besides the Environmental Kuznets Curve (EKC). Furthermore, estimate to what extent FDI affects environmental pollution in developing countries, including energy consumption and income as further determinants of carbon dioxide emissions. To accomplish this purpose, the research employs an econometric model that utilizes the panel data estimation techniques of pooled OLS, fixed effects, and random effects, in addition to, the dynamic Generalized Method of Moments (GMM) estimator. Moreover, the results are confirmed by using two separate samples, the first sample consists of 30 countries and the second sample consists of 42 countries during the period from 1990 to 2019. The research reveals that results from the first and second samples conform with the pollution halo hypothesis, while the EKC hypothesis does not valid in developing countries. Moreover, both energy consumption and economic growth lead to increasing environmental

pollution, while FDI leads to a decrease in both samples.

Badiako, Twerefou and Codjoe (2022) examine the effect of foreign direct investment (FDI) on environmental quality in West Africa and also test empirically the existence of the pollution haven hypothesis. Using carbon dioxide emission as a proxy for environmental quality, this study employs the random/fixed effects model on ten-year panel data for all the sixteen countries in West Africa. Parallel to the Sustainable Development Goal (SDG) 13, examination of these issues is of great importance as it will help save the environment from the concomitant effects of climate variations and also enlighten policymakers with concrete knowledge as to whether domestic industries or influx of multinational companies is the source of emissions level in West Africa.

Benli and Acar (2022) reexamine the impact of foreign direct investment inflows on carbon emissions in middle-income and OECD countries over the period 1992 – 2017. For that purpose, we employ a two-step system GMM dynamic panel data estimator controlling for endogeneity, omitted variable, and simultaneity in our panels. The empirical results from the analyses show that FDI increases carbon emissions in middle-income countries and provide evidence of the pollution haven hypothesis in developing countries. Our findings suggest that FDI has a small halo effect on advanced economies. Our study also provides evidence of the Environmental Kuznets Curve hypothesis across different panel samples

Huang, Chen, Wei, Xiang, Xu, and Akram (2022) investigate the impacts of FDI inflows on carbon emissions, and further explore the influence channels through the moderating effects of economic development and regulatory quality utilizing panel data for the G20 economies from 1996 to 2018. To produce more robust and accurate results in this study, the approach of the feasible generalized least squares (FGLS) is utilized. Meanwhile, this study also specifies the heteroscedasticity and correlated errors due to the large differences and serial correlations among the G20 economies. The results indicate that FDI inflows are positively associated with carbon emissions, as well as both economic development and regulatory quality negatively contribute to the impacts of FDI inflows on carbon emissions. It implies that although FDI inflows tend to increase the emissions of carbon dioxide, they are more likely to mitigate carbon emissions in countries with higher levels of economic development and regulatory quality. Therefore, the findings are informative for policymakers to formulate effective policies to help mitigate carbon emissions and eliminate environmental degradation.

Apergis, Pinar and Unlu (2022) examine the impact of FDI flows on carbon emissions in Brazil, Russia, India, China, and South Africa (BRICS) between 1993 and 2012 using bilateral FDI flows from eleven OECD countries. According to our empirical results, from which OECD country FDI flows to BRICS countries matters for carbon emissions in BRICS countries. Our results confirm that FDI flows to BRICS countries from Denmark and the UK increase carbon emissions in BRICS countries, confirming the pollution haven hypothesis. On the other hand, FDI that flows from France, Germany, and Italy reduced carbon emissions in the BRICS countries, confirming the pollution halo effect. FDI flows from Austria, Finland, Japan, Netherlands, Portugal, and Switzerland have no significant impact on carbon emissions in BRICS countries. The BRICS countries should promote clean FDI flows by reducing environmental damages, and investing countries should be rated based on their environmental damage in the host countries.

Wang, Yang, and Li (2023) examine the potential structural break in the relationship between FDI and the environment from the perspective of economic scale. The results of the panel threshold estimation for 67 countries of different income groups show that the impact of FDI on carbon emissions shifts from positive to negative at different income level stages, using GDP as the threshold. This conclusion is further verified by the group regression results of the robustness test. When the GDP per capita is below $541.87, FDI shows a significant positive impact on carbon emissions, and this interval corresponds to a wide range of low-income economies today, however,

when the GDP per capita exceeds $541.87, this positive impact almost disappears. The negative impact of FDI on carbon emissions manifests itself once the GDP per capita reaches $46515, and the sample countries corresponding to this interval since 2014 are mainly Switzerland, Iceland, Denmark, Sweden, the United States, Singapore, and Australia.

Kwablah (2023) investigates the heterogeneous effect of sector-level foreign direct investment on carbon dioxide (CO_2) emissions in 36 sampled SSA countries from 1990 to 2016. By using the system GMM estimation technique, the study reveals that industry FDI increases CO_2 emissions validating the pollution haven hypothesis while Agric FDI and service FDI reduce CO_2 emissions. In general, a U shape hypothesis holds for Agric FDI and CO_2 emissions, but an inverted U shape for industry FDI and Industry CO_2 emissions and a linear and negative relationship between services FDI and services CO_2 emissions. Thus, there is a need to evaluate the environmental cost of investment in the industrial sector before granting foreign investors a permit to operate. In addition, there should be specific policies to attract FDI into the agriculture and services sectors to benefit from the positive spillover effect of transfers of cleaner technology.

Amao, Alagidede and Sare (2023) examine the effect of FDI on carbon emissions employing a panel data comprising 30 countries in SSA from 2000 to 2022. The study took into account the mediating and moderating roles of industrialization and trade openness. The study utilized the common correlated effects mean group as the primary estimator and the augmented mean group as the robustness estimator. The findings affirm the need for the government in SSA to strengthen policies governing FDI to reduce carbon emission since FDI inflows positively affect carbon emission, while FDI outflows negatively affect carbon emission. Also, the mediating role results affirm the need for government restructuring policies governing industrialization to reduce carbon emissions in SSA. Lastly, the moderating findings demonstrate the need for effective policies on trade openness to reduce carbon emissions.

3. Methodology

The research design that will be adopted in this study is the longitudinal research design, which is very applicable in the management and social sciences. The longitudinal research design involves the use of secondary data in which responses in the nature of a factor and its effects on individuals are being studied, the researcher does not have the ability or opportunity to vary or manipulate the variables. This inability to manipulate the variables stem from the fact that the variables are inherently non-manipulable or because their manifestations have already occurred (Agbonifoh & Yomere, 1999). All facets of the Nigerian economy were the study's target population for information on probable FDI inflows. The census sample is adopted, that is the entire population constitute the sample. The data used for the study is time series which would be purely secondary in nature and this would be directly obtained from Central Bank of Nigeria (CBN) statistical bulletin (2022) and the World Development Indicator of the World Bank.

3.1 Theoretical Framework

This study built a model underpinned by the pollution haven hypothesis and the pollution halo hypothesis. According to the pollution haven hypothesis, multinationals who find it difficult to internalize environmental pollution in their parent country relocate part of their plant in developing economies with lax environmental regulations and standards to pollute and this will increase carbon emission in the host country. Pollution Halo Hypothesis suggests that the increase in the amount of foreign direct investments will reduce CO_2 emissions. Multinational corporations (MNC's) that make foreign direct investments will tend to spread clean technology, which is less harmful to the environment as they have more advanced technology than the domestic companies in the host country (Görg & Strobl, 2004).

3.2 Model Specification

In analyzing the impact of FDI on carbon emission in Nigeria, this study adapts and modified the empirical model used by Badiako and Codjoe (2022). The model

used by Badiako and Codjoe (2022) to examine the impact of FDI on carbon emission in West Africa is specified as follows:

$lnC0_{2it} = \beta_0 + \beta_1 lnFDI_{it} + \beta_2 lnGDPPC_{it} + \beta_3 lnK_{it} + \beta_4 lnHAVEN_{it} + \beta_5 lnDD_{it} + \mu_{it}$ …..(1)

Where; CO_{2it} is the proxy for the environmental quality variable, measured by CO_2 emission per capita (CO_2) in metric tons. FDI_{it} represents foreign direct investment as a percentage of GDP. This is because 70% of FDI inflow to the West African sub-region goes to the extractive and the industrial sub-sectors. $GDPPC_{it}$ is the gross domestic product per capita. The DD_{it} represents the degree of democracy in West Africa. The $HAVEN_{it}$ represents the interaction term between trade openness and per capita GDP. The interaction term captures the existence of PHH or otherwise. The μit represents a stochastic error term assumed to be normally distributed with zero means. While α represents the individual fixed effect, β_1 to β_5 measures the estimated parameters.

Based on the fact that in this study we will employ time series model and different control variables, this study did not include degree of democracy and the interaction term between trade openness and per capita GDP in our model, the above models are therefore modified to determine the link between FDI and carbon emission in Nigeria.

In view of the above, our model is specified thus;

$C0_2 = \beta_0 + \beta_1 FDI + \beta_2 RGDP + \beta_3 POP + \beta_4 FIND + U_{it}$ (2)

By log linearising the model take the following form

$logC0_2 = \beta_0 + \beta_1 logFDI + \beta_2 logRGDP + \beta_3 logURB + \beta_4 logFIND + U_{it}$ (3)

Where,

$C0_2$ = Carbon Emission

FDI = Foreign Direct Investment

RGDP = Real Gross Domestic Product

URB = Urbanization

FIND = Financial Development

β_0, β_1, β_2, β_3 and β_4 are Parameters to be estimated

U_i = Error term

The a priori expectation is,

$\beta_1 >$ or < 0; $\beta_2 > 0$; $\beta_3 > 0$; $\beta_4 > 0$

β_o is the constant variable, β_1 is the coefficient of foreign direct investment (FDI) which is expected to be greater than or less than zero ($\beta_1 >$ or < 0). That is, a positive or negative relationship with carbon emission. A positive relationship validates the pollution haven hypothesis while a negative relationship validates the pollution halo hypothesis. β_2 is the coefficient of real gross domestic product (RGDP) which is expected to be greater than zero ($\beta_2 > 0$) because it is expected to be positively related to carbon emission. β_3 is the coefficient of urbanization (URB) which is expected to be greater than zero ($\beta_3 > 0$). That is, a positive relationship with carbon emission. B_4 is the coefficient of financial development (FIND) which is expected to be greater than zero ($\beta_4 > 0$) because it is expected to be positively related to carbon emission.

3.3 Measurement and Operationalization of Variables

The measurements of all the variables of the study are presented below:

Table 1: Operationalization and Measurement of Variables

Variable	Item	Abbreviation	Measurement	Previous Study that Utilized the Variable
Dependent	Carbon Emission	$C0_2$	Carbon emission (metric tons per capita (kt)	Alabi et al., (2021)
Independent Variable	Foreign Direct Investment	FDI	Measured as foreign direct investments (FDI) to GDP ratio, i.e., the net inflows of investment in an	Isiksa et al., (2019)
Independent Variable	Real Gross Domestic Product – Economic Growth	RGDP	Economic growth is measured by the Real gross domestic product	Solari, et al., (2017)
Independent Variable	Urbanization	URB	Measured as urban population as a percentage of total population, i.e., the number of people living in urban areas divided by total population.	Kwakwa & Alhassan (2020)
Independent Variable	Financial Development	FIND	Measured as domestic credit to private sector/GDP, i.e., is the finance provided to the private sector by financial institutions divided by GDP.	Hasan et al., (2021)

Source: Author's compilation (2024).

3.4 Method of Data Analysis

The study will adopt the Ordinary Least Square (OLS) econometric technique to analyse the empirical model and examine the effect of FDI on carbon emission in Nigeria.

4. Results and Discussion

4.1 Descriptive Statistics

Table 2 presents the descriptive statistics for the variables. This comprises of the mean values, minimum and maximum values, variance and standard deviation values as well as skewness and kurtosis values of the variables.

Table 2: Descriptive Statistics

	CO_2	FDI	RGDP	FIND	OPN	URB
Mean	0.690000	1.18E+08	84680.64	7341.733	31.51715	37.08119
Median	0.670000	45626766	58796.33	847.7250	33.33991	36.09000
Maximum	0.870000	5.39E+08	236729.6	38952.43	53.27796	52.80000
Minimum	0.460000	1725033.	489.7665	8.570000	7.360217	20.04000
Std. Dev.	0.099951	1.73E+08	81398.91	10706.75	12.38763	9.553366
Skewness	0.086774	1.651668	0.492733	1.371979	-0.270431	0.012890
Kurtosis	2.645878	4.097951	1.674814	3.781129	2.226820	1.980682
Jarque-Bera	0.272162	21.20568	4.772710	14.24408	1.558094	1.819427
Probability	0.872772	0.000025	0.091964	0.000807	0.458843	0.402639
Sum	28.98000	4.97E+09	3556587.	308352.8	1323.720	1557.410
Sum Sq. Dev.	0.409600	1.22E+18	2.72E+11	4.70E+09	6291.591	3741.939
Observations	42	42	42	42	42	42

Source: Author's computations, (2024) using Eviews 9.0.

Carbon dioxide (CO_2) emission has an average of 69.00kt between the periods 1981 to 2022. The maximum and minimum values recorded within the period are 87.0kt and 46.0kt respectively. This means

that between 1980 to 2022, the was a steady highest CO_2 emission is 87.0kt while the lowest was 46.0kt which is unhealthy as it greatly affects the environment and population negatively. These increases in the industrial operations denoted from the increases in CO_2 are backed up with the increases in GDP within the same period of this study. For the other variables, there is a meaningful difference between minimum and maximum value with high standard deviation. All the variables considered are skewed to the right with long tail as indicated by their positive values (except for trade openness that is skewed to the left). Foreign direct investment (FDI) and financial development (FIND) has peaked properties with the kurtosis value that is greater than three (3) an indication that it is not normally distributed while the other variables has a normal distribution property as indicated by the kurtosis value that is less than three (3) which is a bench mark for normal distribution. The Jarque-Berra (J-B) statistic value for FDI and FIND is significant at 1% level in the light of their corresponding probability values an indication that the two variables are not normally distributed. However, the J-B values for the other variables fail the significance test at the 5 percent level as showed in the probability value, an indication that these variables are normally distributed.

4.2 Correlation Analysis

In econometric analysis, it is important to ensure that the independent variables in the model do not have excessive correlation patterns. To understand the correlation among the variables, a correlation analysis was conducted to compute the correlation coefficient and the results presented in Table 3 as follows:

Table 3: Correlation Results

	CO_2	FDI	RGDP	FIND	OPN	URB
CO2	1.000000					
FDI	-0.347055	1.000000				
RGDP	0.138023	0.233594	1.000000			
FIND	-0.389388	0.889982	0.293095	1.000000		
OPN	-0.376327	0.011242	-0.764244	-0.009319	1.000000	
URB	-0.632289	0.770306	-0.127909	0.856296	0.380091	1.000000

Source: Author's computations, (2024) using Eviews 9.0.

In the correlation matrix, a positive relationship is observed between RGDP and CO_2 while FDI, FIND, OPN and URB had negative relationship with CO_2. The correlations among the independent variables indicate that RGDP, FIND, OPN and URN are positively correlated FDI. Also, FIND and RGDP are positively correlated. However, OPN and URB are negatively correlated RGDP while OPN and FIND are negatively correlated. URB and FIND is positively correlated with each other. Also, URN and OPN are positively correlated. An overall consideration of the result of the correlation coefficients indicates the absence of multi-collinearity problem in the empirical estimates since none of the correlation value exceeded 0.90 percent or had perfect correlation.

4.3 Regression Analysis

The multivariate ordinary least squares (OLS) results are presented in Table 4 and it is used to determine the impact of FDI on carbon emission in Nigeria. The result shows an R^2 value of 0.570889 which indicates that about 57 percent of total variation in the dependent variable (CO_2) is accounted for by the explanatory variables (i.e., FDI, RGDP, FIND, OPN and URB). This result remains robust even after adjusting for the degrees of freedom (df) as indicated by the value of adjusted R^2, which is 0.511290 (i.e. ≈ 51%). Thus, the regression has a good fit. The F-statistic, which is a test of explanatory power of the model, is 9.57 with the corresponding probability value of 0.000007, which is statistically significant at 1%. This implies that the five explanatory variables

(i.e., FDI, RGDP, FIND, OPN and URB) have joint significant effect on carbon emission (CO_2) in Nigeria. The Durbin-Watson statistic of 1.63 which can be approximated 2.0 indicates we can completely rule out autocorrelation.

Table 4: Ordinary Least Square (OLS) Estimates Result; Dependent Variable: CO2

Variable	*Coefficient*	*t-statistics*	*Prob.*
C	1.349329	11.03391	0.0000
FDI	3.93E-12	0.028333	0.9776
RGDP	-6.52E-07	-2.545846	0.0153
FIND	1.12E-05	2.893703	0.0064
OPN	-0.001056	-0.675762	0.5035
URB	-0.017627	-4.764586	0.0000
	R^2 = 0.570889		
	Adjusted R^2 = 0.511290		
	F= 9.578876 (0.000007)		
	D.W = 1.639575		

Source: Author's Computation, (2024) using Eviews 9.0.

A close examination of the individual coefficient in the regression result reveals that two of the explanatory variables FDI and OPN fail the significant test at the 5 percent significance level; meaning that they do not have any impact on CO_2 in Nigeria for the period under study. In term of the sign, FDI was positively signed while OPN was negatively signed. The result further shows that RGDP and URB exert a negative and significant effect on CO_2 emission. Furthermore, FIND exerts a positive and significant effect on CO_2 emission. Also, the result also reveals that if all the explanatory variables are zero, there is a significant increase in CO_2 by 1.349329 units as shown by the intercept (constant).

4.4 Discussion of Results and Policy Implications

The study finds that foreign direct investment (FDI) has non-significant positive impact on carbon emission (CO_2). The implication of this finding is that foreign direct investment (FDI) does not play a significant role in CO_2 emission in Nigeria within the studied period. Hence, the study could not confirm validates the pollution haven hypothesis and the pollution halo hypothesis. This result is in agreement with Lee 2013 and Shaari et al., 2014, who reported a non-significant impact of foreign direct investment (FDI) on CO_2 emission, thus could not validate either the pollution haven hypothesis or the pollution halo hypothesis. However, the result from this study is not in consonance with that of Akbostancı et al., 2007; Kivyiro and Arminen (2014); Seker et al., 2015; Solarin et al., 2017; Gorus and Aslan, 2019; and Caglar, 2020 who concluded a significant positive relationship between FDI and Co2 emission as well as that of Hao and Liu, 2015; Mert and Boluk, 2016; and Balsalobre-Lorente et al., 2019 who found a significant negative relationship between FDI and CO_2 emission, thus validating the pollution haven hypothesis or the pollution halo hypothesis in their respective studies.

Also, the empirical findings indicates that the coefficient of economic growth have a significant positive impact on CO_2 emission in Nigeria. The implication of this finding is that economic growth influences CO_2 emission in Nigeria; hence, increase in economic growth reduces CO_2 emission in Nigeria. The result of this study agree with Imran and Nishat (2013) Who submitted significant negative relationship between economic growth and CO_2 emission, thus an increase in economic growth reduces carbon dioxide emission in Nigeria, but contradict those of Guo and Stepanyan (2011) and Polat (2018) who found a significant positive relationship between economic growth and CO_2 emission.

Furthermore, the empirical findings indicates that the coefficient of financial development (FIND) have a significant positive impact on CO_2 emission in Nigeria. This means that financial development is an important factor that influences CO_2 emission in Nigeria. This result is in agreement with the studies of Donia (2012), and Kakhkharov and Rohd (2019) who concluded a significant positive relationship between financial development and CO_2 emission in their respective studies. It however disagreed with that of Polat (2018) who concluded that financial development has no significant effect on CO_2 emission.

Also, the empirical findings indicates that the coefficient of trade openness have a non-significant negative impact on CO_2 emission in Nigeria. The implication of this finding is that trade openness has no significant influence on CO_2 emission in Nigeria; hence trade openness is not a key variable that influences CO_2 emission in Nigeria. The result of this study agree with Imran and Nishat (2013) Who submitted a non-significant negative relationship between trade openness and CO_2 emission, but contradict those of Guo and Stepanyan (2011) and Polat (2018) who found a significant positive relationship between trade openness and CO_2 emission.

Finally, the outcome of the regression result indicates that urbanization (URB) exerts a significant negative effect on CO_2 emission in Nigeria. Hence, urbanization (URB) is a key factor that stimulates CO_2 emission in Nigeria within the studied period. The finding is in tandem with Imran and Nishat (2013) who reported a significant negative relationship between urbanization (URB) and CO_2 emission but contradict those of Guo and Stepanyan (2011) and Polat (2018) who found a significant positive relationship between urbanization (URB) and CO_2 emission.

5. Conclusion and Recommendations

We inquire into the effect of foreign direct investment on carbon emission in Nigeria in order to validate or invalidate the pollution haven hypothesis and the pollution halo hypothesis. In Nigeria, time series data on Carbon emission, FDI, Economic growth, financial development, trade openness and urbanization from 1981 – 2022 were analyzed using descriptive statistics, correlation analysis and OLS regression techniques. Overall, findings from the study seem not to provide evidence that validates the pollution haven hypothesis or the pollution halo hypothesis. Also, trade openness was found not to be a key factors that significantly influences carbon emission in Nigeria while economic growth, financial development and urbanization stimulate CO_2 emission in Nigeria

Based on the empirical findings of this study, the following policy recommendations are suggested for policy action:

(i) Owing to the study's findings, it is imperative for Nigeria government to come up with policies that promote FDI inflows in Nigeria.
(ii) Also, Nigeria government should continue to drive economic growth using environmentally friendly policies as this will continue to lower the CO_2 emission in Nigeria.
(iii) Banks must ensure that given credit should have a policy on how they will ensure that their activity does not harm the environment.
(iv) Policymakers should strive to slow down the rate of urbanization in other to reduce its detrimental effect on the environment in Nigeria.

References

Abdelgany, A. F., & Gad-Elhak., A. G. M. (2022). Effect of FDI on CO_2 emissions: panel study from developing countries. *International Journal of Economy, Energy and Environment, 7*(4), 87-99.

Adelakun, O. J. (2010). Financial sector development and economic growth in Nigeria. *International Journal of Economic Development Research and Investment, 1*(1), 25 – 41.

Akbostancı, E., Tunc, G.I., & Türüt-Aşık, S. (2007). Pollution haven hypothesis and the role of dirty industries in Turkey's exports. *Environmental Development Economics, 12*(2), 297–322

Aliyu, A.J., & Ismail, N.W. (2015). Foreign direct investment and pollution haven: Does Energy consumption matter in African countries. *International Journal of Economics and Management, 9*(Special Issue), 21-39.

Al-Mulali, U., & Tang, C. F. (2013). Investigating the validity of pollution haven Hypothesis in the Gulf Cooperation Council (GCC) Countries. *Energy Policy, 60*, 813-819.

Amao, J. O., Alagidede, I. P., & Sare, Y. A. (2023). Impact of foreign direct investment on carbon emission in Sub-Saharan Africa: The mediating and moderating roles of industrialization and trade openness. *Cogent Business & Management, 10*(3),

Apergis, N., Pinar, M., & Unlu, E. (2022). 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 Pollution Research International, 30*(6),

Asghari, M. (2013). Does FDI promote MENA region's environment quality? Pollution halo or pollution haven hypothesis. *International Journal of Scientific Research in Environmental Sciences (IJSRES), 1*(6), 92-100.

Ayamba, E. C., Haibo, C., Abdul-Rahaman, A.-R., Serwaa, O. E., & Osei-Agyemang, A. (2020). The impact of foreign direct investment on sustainable development in China. *Environmental Science and Pollution Research*, 27(20), 25625–25637

Badiako, F. E., Twerefou, D. K., & Codjoe, E. (2022). Effects of foreign direct investment on environmental quality in West Africa. *West African Journal of Applied Ecology, 30*(2), 87 – 93.

Balsalobre-Lorente, D., Gokmenoglu, K.K., Taspinar, N., & Cantos-Cantos, J.M. (2019). An approach to the pollution haven and pollution halo hypotheses in MINT countries. *Environmetal Science Pollution Research., 5*(2),1–17

Benli, M., & Acar, A. (2022). Foreign direct investment and pollution in middle income and OECD member countries. *Balkan Journal of Social Sciences, 11*(21) 54–62

Caglar, A.E. (2020). The importance of renewable energy consumption and FDI inflows in reducing environmental degradation: bootstrap ARDL bound test in selected 9 countries. *Journal of Cleaner Production, 12*(1),16 - 26

Cheng, Z., Li, L., & Liu, J. (2020). The impact of foreign direct investment on urban PM2. 5 pollution in China. *Journal of Environmental Management*, *265*,

Choi, J. I. (2003). Do foreign direct investment and gross domestic investment promote economic growth *Review of Development Economics*, 5, 44-57.

Copeland, B.R. (2008). *The pollution haven hypothesis. from Kevin P. Gallagher (ed.) Handbook on Trade and the Environment.* Edward Elgar Publishing, Cheltenham, UK, 116-125.

Danladi, D. J., & Akomolafe, K. J. (2013). Foreign Direct Investment, Economic Growth, and Environmental Concern: Evidence from Nigeria. *Journal of Economics and Behavioral Studies, 5*(7), 460 - 468.

Dean, J.M., Lovely, M.E., & Wang, H. (2009). Are foreign investors attracted to weak environmental

regulations? Evaluating the evidence from China. *Journal of Development Economics, 90*, 1–13.

Doytch, N., & Uctum, M. (2016). Globalization and the environmental impact of FDI. CUNY Academic Works, Economics Working Papers, 1-22

Edziah, B. K., Sun, H., Adom, P. K., Wang, F., & Agyemang, A. O. (2022). The role of exogenous technological factors and renewable energy in carbon dioxide emission reduction in Sub-Saharan Africa. *Renewable Energy*, *196*, 1418–1428.

Eskeland, G.S., & Harrison, A.E. (2003). Moving to greener pastures? Multinationals and the pollution haven hypothesis. *Journal of Development Economics, 70*, 1- 23.

Görg, H., & Strobl, E. (2004). Foreign direct investment and local economic development: Beyond productivity spillovers. In: GEP The Leverhulme Centre for Research on Globalisation and Economic Policy, University of Nottingham, 7, 137-157,

Gorus, M.S., & Aslan, M. (2019). Impacts of economic indicators on environ- mental degradation: evidence from MENA countries. *Renewable and Sustainable Energy Reviews, 103*, 259–268

Hao, Y., & Liu, Y.M. (2015). Has the development of FDI and foreign trade contributed to China's CO_2 emissions? An empirical study with provincial panel data. *Natural Hazards*, *76*(2), 1079–1091.

Hoffmann, R., Lee, C., Ramasamy, B., & Yeung, M. (2005). FDI and pollution: A granger causality test using panel data. *Journal of International Development, 17*, 311-317.

Hou, F., Su, H., Li, Y., Qian, W., Xiao, J., & Guo, S. (2021). The Impact of Foreign Direct Investment on China's Carbon Emissions. *Sustainability*,*13*(21),

Huang, Y., Chen, F., Wei, H., Xiang, J., Xu, Z., & Akram, R. (2022). The impacts of FDI inflows on carbon emissions: Economic development and regulatory quality as moderators. *Frontier Energy Research, 11*(2);

Ihsan, R., Chughtai, S., Shahzad, A., & Ali, S. (2022). Does green finance matter for environmental safety? empirical evidence from the atomic power states. *Cogent Business & Management*, 9(1),

Jijian, Z., Twum, A. K., Agyemang, A. O., Edziah, B. K., & Ayamba, E. C. (2021). Empirical study on the impact of international trade and foreign direct investment on carbon emission for belt and road countries. *Energy Reports*, 7, 7591–7600.

Kellenberg, D.K. (2009). An empirical investigation of the pollution haven effect with strategic environment and trade policy. *Journal of International Economics, 78*, 242–255

Kılıçarslana, Z., & Dumru, Y. (2017). Foreign Direct Investments and CO_2 Emissions Relationship: The Case of Turkey. *Business and Economics Research Journal, 8*(4), 647 – 660.

Kivyiro, P., & Arminen, H. (2014). Carbon dioxide emissions, energy consumption, economic growth, and foreign direct investment: causality analysis for sub-Saharan Africa. *Energy*, *74*:595–606

Kwablah, E. (2023). Foreign direct investment, gross domestic product and carbon dioxide emission in sub-Saharan Africa: A disaggregated analysis. *Transnational Corporations Review*, *15*(4), 59-68

Lee, J.W. (2013). The contribution of foreign direct investment to clean energy use, carbon emissions and economic growth. *Energy Policy, 55*, 483–489

Leykun Fisseha, F. (2023). IFRS adoption and foreign direct investment in Sub-Saharan African countries: Does the levels of adoption matter? *Cogent Business & Management*, *10*(1),

Mert, M., Bölük, G., & Çağlar, A.E. (2019). Interralationships among foreign direct investments, renewable energy, and CO2 emissions for different European country groups: a panel ARDL approach.

Mert, M., & Caglar, A. E. (2020). Testing pollution haven and pollution halo hypotheses for Turkey: a new perspective. *Environmental Science and Pollution Research, 27*(26), 32933–32943.

Ogunjumo, R. A. (2015). Foreign direct investment (FDI), economic growth and CO_2 (Carbon Dioxide) emissions in Nigeria (1971-2013). Obafemi Awolowo University

O'Meara, G. (2015). Examining the determinants of foreign direct investment. *Undergraduate Economic Review, 11*(1)

Ominyi, S.O., & Adayi, J. O. (2017). Foreign Direct Investment and Environmental Sustainability in Nigeria. *Journal of Research in Business and Management, 5* (1), 28-34

Orazalin, N. S., Ntim, C. G., & Malagila, J. K. (2023). Board sustainability committees, climate change initiatives, carbon performance, and market value. *British Journal of Management*.

Saibu, O. M., & Mesagan, E. P. (2016). Environmental Quality and Growth Effects of Foreign Direct Investment in Nigeria. *Iran Economic Review, 20*(2), 125-140

Sarkodie, S. A. (2018). The invisible hand and EKC hypothesis: what are the drivers of environmental degradation and pollution in Africa? *Environmental Science and Pollution Research, 25*(22), 21993–22022.

Seker, F., Ertugrul, H.M., & Cetin, M. (2015). The impact of foreign direct investment on environmental quality: a bounds testing and causality analysis for Turkey. Renew Sust Energ Rev 52:347–356

Shaari, M.S., Hussain, N.E., Abdullah, H., & Kamil, S. (2014). Relationship among foreign direct investment, economic growth and CO_2 emission: a panel data analysis. *Int J Energy Econ Policy, 4*(4), 706–715

Shahbaz, M., Nasreen, S., & Talat, A. (2011). Environmental consequences of economic growth and foreign direct investment: Evidence from panel data analysis. *Bulletin of Energy Economics, 2*(2), 14-27.

Shahbaz, M., Nasreen, S., Abbas, F., & Anis, O. (2015). Does foreign direct investment impede environmental quality in high-, Middle-, and low-income countries?. *Energy Economics, 51,* 275-287.

Wang, Q., Yang, T., & Li, R. (2023). Reexamining the impact of foreign direct investment on carbon emissions: does per capita GDP matter?.

Xiong, C., Wang, L., Yang, C., Qu, Q., & Xiang, N. (2019). Measuring the effect of foreign direct investment on CO_2 Emissions in Laos. *Journal of Resources and Ecology, 10*(6), 685–691.

Yüksel, S., Dinçer, H., Karakuş, H., & Ubay, G. G. (2020). The Negative Effects of Carbon Emission on FDI: A Comparative Analysis Between E7 and G7 Countries. Handbook of Research on Sustainable Supply Chain Management for the Global Economy.

Zarsky, L. (1999). Havens, halos and spaghetti: Untangling the evidence about foreign direct investment and the environment. Conference on Foreign Direct Investment and the Environment: The Hague, Netherlands, 28-29 January 1999. 1-25.

Zhang, Q., Naqvi, S., & Shah, S. (2021). The contribution of outward foreign direct investment, human well-being, and technology toward a sustainable environment. *Sustainability, 13*(20), 11430.