



Is West Africa a Pollution Haven, Pollution Halo, or Resource Haven? Evidence from Two Alternative Tests

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Abstract. The environmental consequences of foreign direct investment (FDI) remain contentious, with the pollution haven hypothesis (PHH), pollution halo hypothesis (PHoH), and resource haven hypothesis (RHH) offering competing explanations. This study examines whether West Africa functions as a pollution haven, pollution halo, or resource haven, using panel data from sixteen West African countries covering 2014–2024. Unlike previous studies that relied on a single empirical specification, the study employs two complementary models: one to distinguish between the PHH and PHoH by estimating the effect of FDI on environmental quality (EQ) and another to jointly evaluate the PHH and RHH by examining the effects of environmental regulation enforcement (ERE) and natural resource endowments (NRE) on FDI inflows using fixed-effects estimation with Driscoll–Kraay standard errors. The results showed that FDI was significantly associated with higher EQ, supporting the PHoH, whereas ERE was not significantly associated with FDI inflows, providing no support for the PHH. Natural resource and labour endowments were positively associated with FDI inflows, while stronger ERE was associated with a stronger positive relationship between NRE and FDI, providing support for the RHH. The findings suggest that sustainable development in West Africa depends on stronger environmental governance, more effective natural resource management, and increased support for environmentally sustainable investment.

Keywords: environmental degradation, environmental regulation, environmental quality, environmental regulations enforcement, ownership–location–internalization (OLI) paradigm, resource-seeking hypothesis

JEL Classification: F21, F18, Q56, O55, Q32, Q53

1. Introduction

The increasing integration of the global economy has intensified the cross-border movement of capital, technology, and production, making foreign direct investment (FDI) a key driver of economic growth and international economic integration. As countries intensify their efforts to attract multinational enterprises, understanding the factors that influence firms' location decisions has become an important concern for both researchers and policymakers. Among these factors, environmental regulation and natural resource endowments have attracted considerable attention because of their implications for environmental sustainability and long-term development. While investment liberalization can stimulate capital inflows, technological diffusion, and productivity growth, it may also encourage pollution-intensive production or unsustainable resource exploitation, particularly in developing economies characterized by weak institutions and limited regulatory enforcement.

Dunning's ownership–location–internalization (OLI) paradigm provides one of the most influential frameworks for explaining multinational enterprises' investment decisions (Dunning, 1979; Dunning, 2001). According to the paradigm, firms undertake FDI when they possess ownership-specific advantages, identify favourable location-specific advantages in the host economy, and benefit from internalizing their operations. Among these components, the location (L) advantage is particularly relevant because it explains why multinational enterprises choose one investment destination over another. However, the OLI paradigm does not specify which host-country characteristics constitute the most important location advantages. Consequently, several competing hypotheses have emerged to explain how location-specific advantages influence FDI, three of which are the *pollution haven hypothesis* (PHH), *pollution halo hypothesis* (PHoH), and *resource haven hypothesis* (RHH), also known as *resource-seeking hypothesis*. The PHH argues that multinational firms are attracted to countries with weak environmental regulations because lower compliance costs increase profitability (Copeland and Taylor, 2004). In contrast, the PHoH contends that FDI enhances environmental quality through the transfer of cleaner technologies, superior management practices, and environmentally efficient production processes (Eskeland and Harrison, 2003; Prakash and Potoski, 2006; Wheeler, 2001). A third perspective, the RHH posits that multinational enterprises are motivated primarily by abundant natural resource endowments rather than differences in environmental regulation (Adams and Klobodu, 2018; Collier and Venables, 2011; Dunning and Lundan, 2008; Heckscher, 1919; Ohlin, 1933). These three hypotheses, therefore, represent alternative explanations of the location-specific advantages emphasized in the OLI paradigm.

The relevance of these competing perspectives is particularly evident in West Africa. The region possesses abundant deposits of crude oil, natural gas, gold, bauxite, iron ore, cocoa, timber, and other strategic resources while simultaneously

exhibiting relatively weak but heterogeneous environmental regulatory systems. In recent decades, governments across the region have implemented investment-friendly reforms, including trade liberalization, tax incentives, and regulatory reforms, to attract foreign capital. As a result, FDI inflows have increased substantially, particularly in pollution-intensive sectors such as mining, petroleum refining, cement manufacturing, and other extractive industries (UNCTAD, 2022). Countries including Nigeria, Côte d'Ivoire, and Ghana have experienced sustained growth in manufacturing and resource-based FDI, raising concerns over whether multinational firms are attracted primarily by weak environmental regulations, abundant natural resources, or opportunities for technological upgrading (Adenle et al., 2017).

These concerns are reinforced by the region's environmental challenges. Environmental regulation and enforcement remain relatively weak across many West African countries (Adeleke et al., 2021; Biala et al., 2026a; Biala and Ibrahim, 2025), while rapid industrialization has intensified pressures on ecosystems already threatened by climate change, biodiversity loss, land degradation, and pollution (Biala and Adeniyi, 2024; Biala et al., 2024; UNEP, 2019). If multinational firms are attracted mainly by weak environmental standards, competition for FDI may induce governments to further relax environmental regulations, creating a "race to the bottom" that undermines sustainable development (Copeland and Taylor, 2004; Wheeler, 2001). Conversely, if FDI facilitates the diffusion of cleaner technologies and better environmental practices, foreign investment may improve environmental performance despite increased industrial activity (Eskeland and Harrison, 2003; Zarsky, 1999). Alternatively, if natural resource abundance is the principal attraction, FDI location decisions may depend more on resource availability than on environmental regulatory conditions. Distinguishing among these competing explanations is therefore essential for designing investment and environmental policies that promote both economic development and environmental sustainability.

Despite extensive research on the relationship between FDI, environmental regulation, resource availability, and environmental quality, empirical evidence remains inconclusive. While some studies find little or no evidence that multinational enterprises systematically relocate to countries with weaker environmental regulations (Biala et al., 2026a; Eskeland and Harrison, 2003), others conclude that pollution-intensive industries are attracted to countries with less stringent environmental standards (Cole and Elliott, 2005; Copeland and Taylor, 2004; Naqvi et al., 2023; Özs Salman et al., 2025). Similarly, a growing body of evidence supports the PHoH by demonstrating that FDI contributes to cleaner production technologies and improved environmental performance (Benzerrouk et al., 2021; Eskeland and Harrison, 2003; Liu et al., 2024). In contrast, studies supporting the RHH argue that natural resource endowments remain the dominant

determinant of FDI in many developing economies. Collectively, these conflicting findings suggest that environmental regulation, technological upgrading, and natural resource abundance each represent plausible but competing explanations of the location-specific advantages emphasized in the OLI paradigm.

Although these hypotheses have been widely investigated, the existing literature exhibits several important limitations. First, most studies examine the PHH, PHoH, and RHH independently or compare only two of them, resulting in a fragmented understanding of the determinants of FDI. Second, despite the centrality of location-specific advantages in Dunning's OLI paradigm, few studies explicitly integrate these competing hypotheses within a unified theoretical framework. Third, most empirical studies evaluate the PHH using a single empirical specification – either by examining the impact of FDI on environmental quality or by estimating the effect of environmental regulation on FDI inflows. Consequently, little is known about whether these complementary approaches lead to consistent conclusions regarding the validity of the hypothesis. Fourth, empirical evidence has focused predominantly on Asia and Latin America, with comparatively limited attention devoted to West Africa despite its growing importance as a destination for resource-based and manufacturing FDI (Mert and Bölük, 2016; Wagner and Timmins, 2008). These limitations constrain understanding of the factors driving FDI into West Africa and their implications for environmental sustainability.

This study addresses these gaps by developing a unified empirical framework for evaluating the PHH, PHoH, and RHH within the location dimension of Dunning's OLI paradigm. The study makes three principal contributions to the literature. First, it contributes theoretically by integrating the three competing hypotheses as alternative explanations of location-specific advantage within the OLI paradigm, thereby providing a more coherent framework for analysing multinational firms' investment decisions. Second, it contributes methodologically by employing two complementary empirical approaches to evaluate the PHH. The first estimates the effect of FDI on environmental quality to distinguish between the PHH and the PHoH, while the second estimates the influence of environmental regulation on FDI inflows – the classical Pollution Haven specification – and extends this model by incorporating natural resource endowments to simultaneously evaluate the RHH. This complementary modelling strategy provides a more robust assessment of whether multinational firms are attracted primarily by weak environmental regulation, cleaner production opportunities, or abundant natural resources. Third, the study contributes empirically by providing comprehensive evidence for West Africa using panel data and Driscoll–Kraay estimation. Collectively, these contributions advance understanding of the determinants of FDI and their environmental implications in developing economies.

2. Literature Review

2.1. Theoretical Foundations

The relationship between FDI, environmental regulation, resource endowments, and environmental quality has been widely examined within the international business, environmental economics, and development literature. Three prominent hypotheses dominate this debate: the PHH, the PHoH, and the RHH. Although these hypotheses are often investigated separately, they represent alternative explanations of the location-specific advantages that influence multinational enterprises' investment decisions. Consistent with Dunning's ownership–location–internalization (OLI) paradigm, firms are expected to choose investment locations that maximize expected returns by exploiting favourable host-country characteristics. In this context, environmental regulation and natural resource endowments constitute important location-specific advantages that may influence both the destination of FDI and its environmental consequences.

The PHH argues that differences in environmental regulatory stringency influence the international location of pollution-intensive industries. Specifically, multinational enterprises are expected to relocate production to countries with relatively weak environmental regulations in order to reduce compliance costs and improve competitiveness (Copeland and Taylor, 2004). If this proposition holds, countries with weaker environmental governance should attract greater inflows of pollution-intensive FDI and experience increased environmental degradation. By contrast, the PHoH contends that FDI can improve environmental quality by facilitating the transfer of cleaner production technologies, advanced managerial practices, and higher environmental standards from multinational enterprises to domestic firms (Eskeland and Harrison, 2003; Zarsky, 1999). Under this perspective, FDI generates positive technology spillovers that outweigh the environmental costs associated with increased industrial activity.

A third perspective attributes FDI location decisions primarily to differences in countries' factor endowments rather than environmental regulation. Rooted in the Heckscher–Ohlin theory of comparative advantage (Heckscher, 1919; Ohlin, 1933), the RHH argues that multinational enterprises are attracted to locations endowed with abundant natural resources because proximity to raw materials reduces production and transportation costs. Consequently, resource-rich economies are expected to receive greater inflows of resource-seeking FDI, particularly in extractive and other resource-intensive industries. Unlike the PHH, which emphasizes regulatory arbitrage, the RHH suggests that natural resource availability constitutes the primary location-specific advantage driving multinational investment.

Although these hypotheses appear to offer competing explanations, they are not necessarily mutually exclusive. The relative importance of environmental regulation and natural resource endowments is likely to depend on the characteristics of the host economy, the institutional environment, and the sector receiving investment. For example, resource abundance may dominate investment decisions in mining and petroleum industries, whereas environmental regulation may be more influential in pollution-intensive manufacturing. Similarly, the environmental consequences of FDI may differ depending on whether multinational firms transfer cleaner technologies or relocate environmentally harmful production processes. Consequently, whether a country functions as a pollution haven, pollution halo, or resource haven is ultimately an empirical question that requires the simultaneous evaluation of these competing mechanisms rather than examining each hypothesis in isolation.

2.2. Empirical Evidence on the PHH, PHoH, and RHH

Empirical evidence on the relationship between FDI, natural resource availability, environmental regulation, and environmental quality remains inconclusive. While a substantial body of literature has examined the PHH, the PHoH, and the RHH, the findings differ considerably across countries, sectors, and empirical approaches. These inconsistencies suggest that no single hypothesis universally explains multinational firms' location decisions or the environmental consequences of FDI. Rather, the validity of each hypothesis appears to depend on the institutional, economic, and industrial characteristics of the host economy.

A large body of empirical research supports the PHH by showing that differences in environmental regulation influence the location decisions of multinational enterprises. Studies such as Copeland and Taylor (2004) and Cole and Elliott (2005) argue that pollution-intensive industries are more likely to relocate to countries where environmental regulations are relatively less stringent, thereby increasing pollution in host economies. More recent evidence reaches similar conclusions. Apergis et al. (2023), using bilateral FDI flows from OECD countries, reported that foreign investment contributed to higher carbon emissions in host countries characterized by relatively weak environmental standards. Likewise, Kılavuz et al. (2024) found that differences in environmental regulatory stringency continued to influence investment location decisions among major emerging economies, while Avazdahandeh (2024) reported evidence consistent with the pollution haven mechanism in China–European Union investment relations. Collectively, these studies suggest that multinational firms may exploit regulatory differences when locating pollution-intensive production. A recent study by Biala et al. (2006b) also found that FDI was associated with environmental deterioration, supporting the PHH.

However, equally compelling evidence challenges the universality of the PHH. Eskeland and Harrison (2003), using firm-level data on U.S. multinationals, found little evidence that firms systematically relocate production to countries with weaker environmental regulations. Instead, foreign-owned firms were generally more energy-efficient than domestic firms and often employed cleaner production technologies. Similar conclusions have been reported by Gao et al. (2022), who showed that FDI improved environmental quality through technology spillovers and production efficiency, and by Liu et al. (2024), who found that outward Chinese investment generated environmental improvements in Belt and Road Initiative countries where technological capability and institutional quality were relatively strong. These findings are more consistent with the PHoH, suggesting that multinational enterprises may transfer cleaner technologies and superior environmental management practices to host countries.

Rather than supporting one hypothesis over the other, these conflicting findings indicate that the environmental consequences of FDI are highly context-specific. Several factors appear to explain these differences. First, institutional quality influences both firms' compliance behaviour and governments' ability to enforce environmental regulations. Countries with stronger institutions are more likely to attract environmentally responsible investment and to benefit from technology spillovers, whereas weak governance may permit pollution-intensive production to flourish. Consistent with this argument, Kinda (2010) demonstrated that governance quality significantly affects FDI inflows in sub-Saharan Africa, while Bouzahzah (2022) found that institutional quality moderates the relationship between FDI and environmental degradation in African countries. Similarly, Afolabi (2023) showed that although natural resource exploitation increased carbon emissions, stronger regulatory quality substantially mitigated these environmental effects. These studies suggest that institutional effectiveness may determine whether FDI generates pollution haven or pollution halo outcomes.

Second, methodological differences also contribute to divergent conclusions. Existing studies differ substantially in their choice of environmental indicators, measures of environmental regulation, estimation techniques, and levels of analysis. Some measure environmental quality using carbon dioxide emissions, whereas others employ ecological footprint, environmental performance indices, or pollution intensity. Likewise, environmental regulation is variously proxied by environmental policy indices, institutional quality indicators, regulatory expenditures, or governance measures. These measurement differences, together with variations in econometric techniques and sample composition, partly explain why empirical findings remain inconsistent across studies.

While considerable attention has focused on the environmental consequences of FDI, an alternative strand of literature argues that multinational firms are motivated primarily by access to natural resources rather than differences in

environmental regulation. The RHH predicts that countries with abundant mineral, energy, and other natural resource endowments will attract greater inflows of resource-seeking FDI because proximity to raw materials reduces production and transportation costs. This perspective appears particularly relevant for developing regions rich in extractive resources. Empirical studies increasingly support this proposition. Evidence from resource-rich African economies indicates that natural resource endowments exert a stronger influence on FDI location decisions than environmental regulatory differences, especially within mining, petroleum, and other extractive industries. These findings suggest that resource abundance may dominate regulatory arbitrage in explaining multinational investment decisions in many developing economies.

Overall, the empirical literature suggests that the PHH, PHoH, and RHH should be viewed as complementary rather than mutually exclusive explanations of multinational enterprises' location decisions. Collectively, existing evidence indicates that FDI is influenced by the interaction of environmental regulation, technology transfer, and natural resource endowments, with the relative importance of each factor varying across institutional settings, industrial structures, and stages of economic development. Consequently, no single hypothesis provides a universally applicable explanation of the relationship between FDI and environmental outcomes.

Despite these advances, important gaps remain. Conceptually, the literature is fragmented, as most studies examine the PHH, PHoH, or RHH in isolation or compare only two of these perspectives, with limited effort to integrate them within a common theoretical framework. Methodologically, empirical studies typically rely on a single modelling approach, either assessing the environmental consequences of FDI or examining whether environmental regulation influences FDI inflows, thereby providing only a partial evaluation of the competing hypotheses. Moreover, relatively few studies assess the role of natural resource endowments jointly alongside environmental regulation, making it difficult to determine whether multinational firms are motivated primarily by regulatory arbitrage, technology-related environmental improvements, or resource-seeking considerations. The diversity of empirical findings further reflects differences in institutional quality, environmental governance, measurement of environmental regulation, environmental indicators, and econometric techniques, suggesting that conclusions are highly context-specific and not readily generalizable across regions. These limitations are particularly pronounced in West Africa, where abundant natural resources coexist with heterogeneous environmental regulatory systems and increasing dependence on FDI. Existing evidence for the region remains limited, with most African studies treating the continent as a homogeneous entity.

This study addresses these theoretical, methodological, and contextual gaps by developing a unified empirical framework within the location dimension of

Dunning's OLI paradigm to simultaneously evaluate the PHH, PHoH, and RHH. Unlike previous studies, it adopts two complementary empirical specifications to assess the PHH by examining both the environmental effects of FDI and the influence of environmental regulation on FDI inflows, while simultaneously incorporating natural resource endowments to evaluate the RHH. By integrating these complementary perspectives within a single analytical framework, the study provides a more comprehensive assessment of the determinants and environmental implications of FDI in West Africa. The following section describes the data, variables, and empirical strategy employed to achieve these objectives.

3. Methodology

This study rests on Dunning's OLI paradigm, which explains why multinational enterprises undertake FDI (Dunning, 1979; 2001). According to the paradigm, FDI occurs when firms possess ownership-specific advantages, identify favourable location-specific advantages in the host country, and benefit from internalizing their operations rather than using market transactions. Among these components, the location (L) advantage is central to this study because it explains the host-country characteristics that influence multinational firms' investment decisions. The OLI paradigm, however, does not specify which location attributes are most important, thereby providing a broad theoretical framework within which competing explanations of FDI location decisions can be examined.

Within this framework, the PHH, PHoH, and RHH represent alternative explanations of location-specific advantage. The PHH argues that weak environmental regulation attracts pollution-intensive FDI by reducing compliance costs (Copeland and Taylor, 2004), whereas the PHoH contends that FDI enhances environmental quality through the transfer of cleaner technologies and improved management practices (Prakash and Potoski, 2006; Wheeler, 2001). In contrast, the RHH posits that abundant natural resource endowments are the primary attraction for foreign investors, irrespective of environmental regulatory conditions (Adams and Klobodu, 2018; Collier and Venables, 2011). By integrating these competing hypotheses within the location dimension of the OLI paradigm, this study provides a unified theoretical framework for assessing whether FDI in West Africa is driven primarily by regulatory arbitrage, environmental upgrading, or resource-seeking behaviour.

The OLI paradigm in *Figure 1* depicts the determinants of FDI inflows and, hence, environmental quality in West African countries. Ownership advantages (firm-specific assets like patents and technology) enable multinationals to engage in FDI that improves environmental outcomes, supporting the PHoH. Location advantages (host-country attributes such as natural resources and environmental regulations) explain why West Africa may attract resource-seeking or polluting

FDI. Internalization advantages (gains from internal control over contracts) lead firms to choose FDI to avoid stricter home-country regulations, reflecting the PHH.

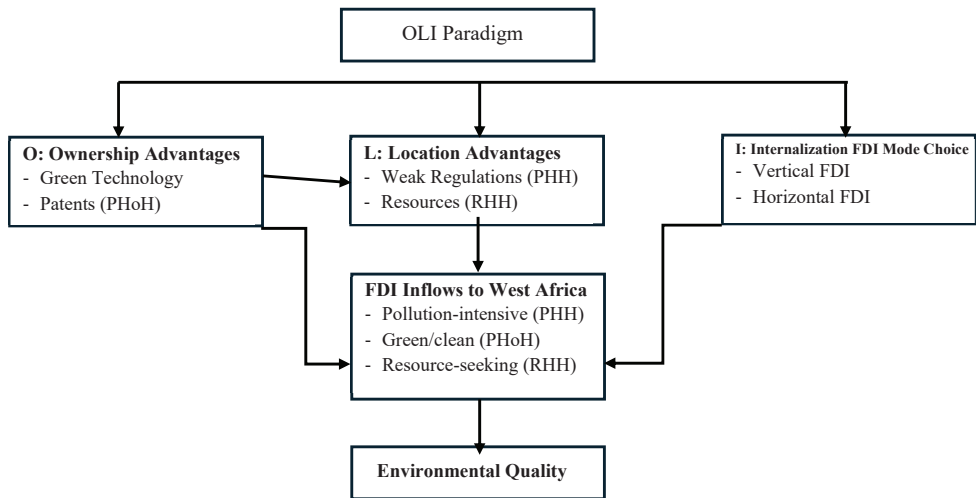


Figure 1. *OLI paradigm for PHH, PHoH, and RHH*

3.1. Model Specification

The OLI paradigm can be expressed mathematically to explain the relationship among environmental regulation, resource availability, FDI, and environmental quality. The recursive theoretical model is specified as follows:

$$EQ_i = f(FDI) = f(ERE, NRE, X), \tag{1}$$

where EQ denotes environmental quality, ERE represents the enforcement of environmental regulations in the host jurisdiction, NRE refers to natural resource endowments, X is a vector of other factors that may influence environmental quality, and ϵ is the stochastic error term. To address the objectives of this study, the theoretical framework is further extended by incorporating additional explanatory variables into the empirical specification to improve the robustness and explanatory power of the estimated model.

Unlike previous studies that evaluate the PHH using a single empirical specification, this study adopts two complementary modelling approaches. The first estimates the environmental impacts of FDI on environmental quality to distinguish between the PHH and PHoH, whereas the second estimates the influence of environmental regulation on FDI inflows and subsequently extends the model by incorporating natural resource endowments to jointly evaluate the RHH.

Together, these complementary models provide a more comprehensive assessment of the location-specific advantages underlying FDI in West Africa.

Pollution Haven / Halo Model

To evaluate the PHH and the PHoH, this study examines whether FDI inflows are associated with a deterioration or improvement in environmental quality, particularly in countries with relatively weak environmental regulation. Consistent with the existing literature, the baseline empirical specification estimates the impact of FDI on environmental quality while controlling for other relevant determinants. The model is expressed as:

$$EQ_{it} = \beta_0 + \beta_1 FDI_{it} + \beta_2 Z_{it} + \mu_i + \lambda_t + \varepsilon_{it}, \quad (2)$$

where: FDI denotes FDI inflows to country i in year t ; EQ represents the indicator of environmental quality (CO₂ emissions); Z is a vector of control variables; i and t denote country and year respectively; μ_i captures unobserved country-specific effects; λ_t represents time-specific effects; and ε_{it} is the idiosyncratic error term. A positive and statistically significant coefficient ($\beta_1 > 0$) implies that FDI contributes to environmental degradation, thereby supporting the PHH. Conversely, a negative coefficient ($\beta_1 < 0$) suggests that FDI enhances environmental quality, providing evidence in favour of the PHoH.

Given that the PHH also argues that differences in the stringency of environmental regulations influence the location decisions of multinational firms, an alternative specification is estimated to investigate whether environmental regulation enforcement affects FDI inflows into West African countries. The alternative model is specified as:

$$FDI_{it} = \alpha_0 + \alpha_1 ERE_{it} + \alpha_2 Z_{it} + \mu_i + \lambda_t + \varepsilon_{it}, \quad (3)$$

where ERE denotes environmental regulation enforcement. This alternative specification provides a robustness check for the PHH by directly assessing whether the strength of environmental regulation influences foreign investment decisions.

Pollution Haven / Resource Haven Model

To examine the RHH, measures of natural resource endowment (NRE) and labour endowment (LAB) were incorporated into Equation (3), resulting in the following specification:

$$FDI_{it} = \alpha_0 + \alpha_1 ERE_{it} + \alpha_2 NRE_{it} + \alpha_3 LAB_{it} + \alpha_4 Z_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (4)$$

This specification enables the simultaneous assessment of the Resource Haven and Pollution Haven Hypotheses while also serving as a robustness check for the latter. Unlike Equation (2), which evaluates the PHH through the effect of FDI on environmental quality, Equation (4) approaches the hypothesis from the perspective of environmental regulation by examining its influence on FDI inflows. The PHH is supported if $\alpha_1 < 0$, indicating that stricter environmental regulation discourages foreign investment. Conversely, $\alpha_1 \geq 0$ suggests that environmental regulation does not deter FDI inflows significantly, thereby rejecting the hypothesis.

Following previous empirical studies, including Benzerrouk et al. (2021) and Liu et al. (2024), the baseline specifications were extended by incorporating additional control variables and an interaction term between environmental regulation enforcement and natural resource endowment. The resulting empirical models are specified as follows.

Environmental quality model:

$$EQ_{it} = \beta_0 + \beta_1 FDI_{it} + \beta_2 GDP_{it} + \beta_3 ERE_{it} + \beta_4 NRE_{it} + \beta_5 POP_{it} + \beta_6 TOP_{it} + \beta_7 URB_{it} + \beta_8 ENER_{it} + \beta_9 (ERE_{it} * NRE_{it}) + \mu_i + \lambda_t + \varepsilon_{it} \quad (5)$$

Total FDI inflows model:

$$FDI_{it} = \alpha_0 + \alpha_1 ERE_{it} + \alpha_2 GDP_{it} + \alpha_3 NRE_{it} + \alpha_4 LAB_{it} + \alpha_5 INFR_{it} + \alpha_6 TOP_{it} + \alpha_7 EXC_{it} + \alpha_8 ENER_{it} + \alpha_9 (ERE_{it} * NRE_{it}) + \mu_i + \lambda_t + \varepsilon_{it} \quad (6)$$

In equations (5) and (6), FDI denotes FDI inflows, ERE represents environmental regulation enforcement, NRE refers to natural resource endowment, LAB captures labour or human resource endowment (proxied by labour cost or wage rates), GDP is gross domestic product per capita, EXC is the exchange rate, TOP denotes trade openness, POP represents population, URB is the urbanization rate, INFR measures infrastructure quality, and ENER denotes energy intensity.

The selected control variables account for the principal economic, institutional, and structural determinants of FDI identified in the literature. GDP per capita captures market size and economic development, with a positive coefficient expected if larger or more prosperous economies attract greater foreign investment and exhibit stronger environmental performance. Trade openness reflects the degree of integration into international markets, where a positive coefficient implies that countries with fewer trade barriers are more attractive to foreign investors. Natural resource endowment is included to control for resource-seeking investment, with a positive coefficient providing support for the RHH by indicating that resource-rich economies attract higher levels of FDI.

To examine whether abundant natural resources alter the influence of environmental regulation on FDI and environmental quality, an interaction term between

environmental regulation enforcement and natural resource endowment ($ERE \times NRE$) is incorporated into both models. This interaction provides a means of reconciling the PHH and RHH by assessing whether the effect of environmental regulation depends on the availability of natural resources.

A summary of all variables employed in the empirical analysis, including their definitions, measurements, expected signs, and data sources, is presented in *Table 1*.

Table 1. *Details of the variables used for estimation*

Variable	Definition	Measurement	Data Source
Environmental quality (EQ)	The state of the natural environment in terms of pollution and environmental degradation.	Carbon dioxide (CO ₂) emissions excluding LULUCF per capita (t CO ₂ e/capita)	World Development Indicators
Foreign Direct Investment (FDI)	Cross-border investment in which a foreign investor acquires a lasting ownership interest and managerial control in a domestic enterprise.	Total FDI inflows as % of gross domestic product	World Development Indicators
Environmental regulation enforcement (ERE)	The extent to which environmental laws and regulations are effectively implemented and enforced by government institutions.	Enforcement of Environmental Regulations (EER) score	Mo Ibrahim Foundation
Natural Resource Endowment (NRE)	The abundance of commercially exploitable natural resources available in a country.	Total natural resource rents (% of GDP)	World Development Indicators
Labour endowment (LAB)	The availability of labour resources for productive economic activities.	Labour force participation rate, total (% of total population ages 15–64).	World Development Indicators
Trade openness (TOP)	The degree to which an economy is integrated into international trade through exports and imports.	This is measured by trade (exports + imports) as % of GDP	World Development Indicators
GDP per capita (GDP)	The average economic output or income per person, representing market size and the level of economic development.	GDP per capita in constant 2015 US dollars	World Development Indicators

Variable	Definition	Measurement	Data Source
Energy intensity (ENER)	The amount of energy required to produce one unit of economic output, reflecting the energy efficiency of an economy.	Energy use (kg of oil equivalent) per \$1,000 GDP (constant 2021 PPP)	World Development Indicators
Infrastructural Quality (INFR)	The availability and quality of basic infrastructure supporting economic activity and investment.	Access to electricity as % of population	World Development Indicators
Exchange Rate (EXC)	The value of a country's currency relative to those of its major trading partners, reflecting international price competitiveness.	Real effective exchange rate index (2010 = 100)	World Development Indicators
Population (POP)	The number of people residing in a country, representing the size of the domestic market and the potential demand for goods, services.	The total number of people residing in a country	World Development Indicators
Urbanization (URB)	The proportion of a country's population residing in urban areas, reflecting the level of urban development and population concentration.	Urban population as % of total population	World Development Indicators

3.3. Data and Estimation Techniques

Annual panel data covering the period of 2014–2024 were collected for 16 West African countries as follows: Benin, Burkina Faso, Cabo Verde, The Gambia, Ghana, Guinea, Guinea-Bissau, Côte d’Ivoire, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, and Togo. All data used in the analysis were obtained from the World Bank’s World Development Indicators (WDI), except the Enforcement of Environmental Regulations (EER) scores, which were sourced from the Mo Ibrahim Foundation database. Natural resource endowment was measured using total natural resource rents (% of GDP), which represent the share of national income derived from oil, natural gas, mineral, forest, and coal rents.

The analysis began with preliminary diagnostic tests to determine the appropriate panel estimation technique. Tests for cross-sectional dependence, panel unit roots, heteroskedasticity, serial correlation, normality, and multicollinearity were conducted to examine the statistical properties of the data. Cross-sectional dependence was assessed because economic and environmental shocks may spill

over across West African countries, while panel unit root tests ensured that the estimated relationships were not spurious. Multicollinearity was evaluated using the Variance Inflation Factor (VIF).

Both fixed-effects (FE) and random-effects (RE) models were estimated, and the Hausman specification test was used to guide model selection. Although the test favoured the random-effects model, the fixed-effects estimator was retained because it controls for unobserved time-invariant country characteristics, such as geography, institutional quality, and historical factors, which are theoretically expected to be correlated with FDI, environmental regulation, and environmental quality. Diagnostic tests further revealed heteroskedasticity, serial correlation, and cross-sectional dependence. Consequently, the fixed-effects model was estimated using Driscoll–Kraay (DK) standard errors, which provide robust inference in the presence of these econometric problems (Driscoll and Kraay, 1998).

Although the empirical models are grounded in the OLI paradigm and the PHH, PHoH, and RHH, potential endogeneity arising from reverse causality and omitted variables cannot be entirely ruled out. Given the relatively small panel (16 countries over the period of 2014–2024) and the absence of a dynamic specification, fixed-effects estimation with DK standard errors was considered more appropriate than System GMM. Accordingly, the estimated coefficients should be interpreted as conditional associations consistent with the theoretical hypotheses rather than definitive causal effects.

4. Results and Discussion

4.1. Preliminary Analysis of Results

4.1.1. Descriptive Statistics

Table 2 reports the descriptive statistics for all variables used in the empirical analysis covering 16 West African countries over the 2014–2024 period. Environmental quality (EQ), measured by CO₂ emissions per capita, recorded a mean value of 0.62 tonnes, with considerable cross-country variation (standard deviation = 0.8) and values ranging from 0.09 to 3.34 tonnes. This wide dispersion suggested substantial heterogeneity in environmental performance across the region, with the highest-emitting country producing nearly 36 times more CO₂ per capita than the lowest-emitting country. FDI inflows averaged 3.8% of GDP during the study period. However, the variable exhibited considerable volatility, with values ranging from -2.6% to 24.0% of GDP, reflecting episodes of both net divestment and substantial investment inflows across the sampled countries.

Table 2. Descriptive statistics of the key variables for the 16 West African countries

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
EQ	176	0.616	0.78	0.092	3.341
FDI	176	3.789	4.126	-2.575	23.999
NRE	176	8.5	5.417	0.002	26.181
TOP	176	62.683	20.049	30.588	115.765
LAB	176	64.308	9.899	47.03	83.415
GDP	176	4.326	3.437	20.805	15.844
ENER	176	83.165	33.84	44.203	187.964
URB	176	45.631	11.711	16.219	68.412
INFR	176	51.285	25.379	9.4	100
EXC	176	92.424	17.041	63.908	142.624
POP	176	25220099	48778367	512326	232,700,000
ERE	176	61.01	18.783	29.1	85.7

Notes: Obs. = number of observations; Std. Dev. = standard deviation; Min. = minimum; Max. = maximum.

Natural resource endowments (NRE) had an average value of 8.50% of GDP, with a minimum of 0.002% and a maximum of 26.181%. This finding confirmed that although West Africa is generally resource-endowed, the distribution of natural resources varied markedly across countries. Trade openness (TOP) averaged 62.683% of GDP, indicating a moderate degree of integration into international markets, while labour force participation (LAB) recorded a relatively high mean of 64.308%, consistent with the region’s youthful and economically active population. Environmental regulation enforcement (ERE) had a mean score of 61.01, with values ranging from 29.1 to 85.7. These statistics indicate notable differences in the strength of environmental regulatory frameworks across the region, with some countries exhibiting relatively weak regulatory systems, whereas others have comparatively stronger environmental governance arrangements.

4.1.2. Correlation Analysis

The correlation analysis revealed several relationships that were broadly consistent with theoretical expectations. Environmental quality (EQ) was positively and significantly correlated with infrastructure quality ($r = 0.748$, $p < 0.01$) and trade openness ($r = 0.638$, $p < 0.01$), indicating that countries with more developed infrastructure and greater integration into international trade generally recorded higher CO₂ emissions per capita. This finding is consistent with the scale effect of economic activity, whereby increased economic development and trade expansion were associated with higher emission levels.

FDI inflows were positively and significantly associated with NRE ($r = 0.309$, $p < 0.01$), TOP ($r = 0.258$, $p < 0.01$), and urbanization (URB; $r = 0.208$, $p < 0.01$), whereas their correlation with EQ was negligible and statistically insignificant ($r = 0.002$, $p = 0.974$). This indicates that FDI tends to be concentrated in resource-abundant, more open, and more urbanized economies rather than in countries with relatively higher emission levels.

Environmental regulation enforcement (ERE) exhibited generally weak correlations with the explanatory variables. In particular, its association with FDI was negative but statistically insignificant ($r = -0.079$, $p = 0.300$), providing preliminary evidence that the strength of environmental regulation is not a major determinant of FDI inflows. Similarly, the correlation between ERE and NRE was weak and statistically insignificant ($r = -0.139$, $p = 0.066$), indicating no systematic relationship between resource endowments and environmental regulatory enforcement across the sampled countries.

Overall, the correlation coefficients were moderate in magnitude, with the highest pairwise correlation (0.748) remaining well below the commonly accepted threshold of 0.80. This suggested that multicollinearity was unlikely to pose a serious concern, a conclusion that was subsequently verified using the variance inflation factor (VIF) analysis.

4.1.3. Diagnostic Results

Table 3 presents the results of the diagnostic tests for the estimated models. Although the Hausman test statistics (χ^2 ranging from 1.21 to 7.22; both $p > 0.05$) suggested that the random-effects estimator was statistically acceptable across all specifications, the fixed-effects model was retained because it more appropriately controlled for unobserved, time-invariant country-specific characteristics such as geography, colonial history, and institutional factors. These country-specific effects were likely to be correlated with FDI, environmental regulation, and environmental quality, thereby violating the random-effects assumption of no correlation between the unobserved effects and the regressors. Moreover, the presence of heteroskedasticity, serial correlation, and cross-sectional dependence further justified the use of the FE estimator with Driscoll–Kraay standard errors, which provided robust inference under these conditions. The random-effects estimates were not reported because they yielded qualitatively similar results.

The heteroskedasticity tests indicated significant heteroskedasticity in the two models (both $p < 0.01$). The tests for cross-sectional dependence revealed significant dependence in Model 5 ($z = 3.815$, $p = 0.000$), supporting the application of Driscoll–Kraay standard errors, which explicitly account for cross-sectional dependence. In addition, serial correlation was detected in Model 5 ($F = 6.298$, $p = 0.024$), providing further support for the chosen estimation approach.

The residual normality tests indicated that the residuals were normally distributed across both model specifications (all $p > 0.05$), thereby satisfying the normality assumption. Furthermore, the variance inflation factor (VIF) values ranged from 1.27 to 1.47, well below the conventional threshold of 10, confirming that multicollinearity was not a concern in the estimated models.

Table 3. *Results of diagnostic tests for estimation*

Test/Statistic	Model 5	Model 6
Hausman Test	$\chi^2(10) = 2.67$ (0.976)	$\chi^2(10) = 3.45$ (0.636)
Heteroskedasticity	$\chi^2(16) = 1799.06$ (0.000)	$\chi^2(16) = 3306.94$ (0.000)
Cross-sectional Dependence	$z = 3.815$ (0.000)	$z = 0.647$ (0.518)
Serial Correlation	$F(1,15) = 6.298$ (0.024)	$F(1,15) = 0.487$ (0.496)
Normality	$\chi^2(2) = 3.72$ (0.156)	$\chi^2(2) = 3.55$ (0.173)
VIF	1.27	1.43

Note: p-values are in parentheses.

4.2. Regression Results for the Environmental Quality Model

Table 4 presents the Driscoll–Kraay robust fixed-effects results for the environmental quality model, which directly tests the PHH and PHoH by examining the impact of FDI on CO₂ emissions.

The coefficient on FDI was negative and statistically significant ($\beta \approx -0.003$, $t = -2.58$, $p = 0.028$). This indicates that an increase in FDI inflows as a share of GDP is associated with a decline in CO₂ emissions, supporting the PHoH rather than the PHH for West Africa as a whole. The result suggests that multinational corporations operating in the region might bring cleaner technologies, more efficient production processes, and better environmental management practices that improve local environmental quality. This finding aligns with studies that have found similar halo effects in developing-country contexts. Eskeland and Harrison (2003) found that foreign-owned plants in developing countries were more energy-efficient and used cleaner energy than domestic counterparts. Similarly, Zeng and Eastin (2012) documented that FDI reduced emissions in China’s manufacturing sector, particularly in labour-intensive industries. Pao et al. (2011) found FDI associated with reduced emissions in BRIC countries. However, this result contradicts studies that found PHH support in African contexts, such as Okafor (2018) for sub-Saharan Africa and Özs Salman et al. (2025) for the Fragile Five countries. Several explanations may account for this finding. First, West African countries may be attracting FDI in sectors that are not uniformly pollution-intensive, or multinational firms may be adopting newer, cleaner technologies to maintain social licence to operate and access international markets. Second, the finding may reflect that FDI in the region

is predominantly resource-seeking rather than efficiency-seeking, with resource extraction activities increasingly subject to international environmental standards imposed by parent companies or home-country regulations. Third, the halo effect may operate through demonstration and spillover channels, where local firms adopt cleaner practices to remain competitive.

Table 4. *Driscoll–Kraay standard errors results for environmental quality (CO_2) model*

Variable	Coefficient	Std. Error	t-value	p-value
FDI	-2.800	1.100	-2.58	0.028**
GDP	1.700	2.400	0.69	0.504
ERE	0.300	0.200	1.54	0.154
NRE	3.200	2.200	1.45	0.179
POP	-5.480	1.190	-4.61	0.001***
TOP	0.610	0.350	1.77	0.107
URB	0.021	0.005	4.14	0.002***
ERE*NRE	-0.040	0.020	-2.55	0.029**
ENER	1.570	0.530	2.94	0.015**

Notes: Coefficients of FDI, GDP, ERE, NRE, TOP, ERE×NRE, and ENER were rescaled by 1,000, while POP is rescaled by 10^9 for estimation; *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels respectively.

Urbanization (URB) showed a strong positive association with CO_2 emissions ($\beta = 0.021$, $t = 4.14$, $p = 0.002$). This is consistent with theoretical expectations that urban concentration increases energy demand, transportation emissions, and industrial activity. A one percentage point increase in urban population share was associated with approximately 2% increase in per capita emissions. This finding corroborates Kasman and Duman (2015) for EU countries and Al-Mulali et al. (2015) for Europe, while contrasting with studies that found urbanization associated with efficiency gains and emissions reductions in some contexts. For West Africa, where urban infrastructure often lags behind population growth, the result suggests urgent need for sustainable urban planning.

Energy intensity (ENER) also positively affected emissions ($\beta \approx 0.002$, $t = 2.94$, $p = 0.015$). Given that ENER measures energy use per unit of GDP, this coefficient indicates that economies with higher energy intensity – reflecting less efficient energy use – produce more CO_2 per capita. This finding aligns with the energy-environment literature (Zhang and Cheng, 2009; Nathaniel and Iheonu, 2019) and suggests that energy efficiency improvements offer significant emission reduction potential in the region.

Population growth (POP) exhibited a negative and highly significant coefficient ($\beta = -5.48E-09$, $t = -4.61$, $p = 0.001$). While this coefficient is economically very

small due to the large population magnitudes (millions), the statistical significance indicates that faster-growing populations have lower per capita emissions. This counterintuitive finding may reflect that population growth in West Africa occurs primarily in rural areas with low per capita energy consumption or that high population growth correlates with lower income levels and thus lower consumption-based emissions. This finding is consistent with Shi (2003), who found that population effects on emissions vary significantly by income level, and with Dietz and Rosa (1997), who demonstrated that population elasticity of emissions is less than unity in developing countries.

The interaction term $ERE \times NRE$ was negative and significant ($\beta \approx -0.00004$, $t = -2.55$, $p = 0.029$). This important finding indicates that the relationship between natural resource endowments and emissions is moderated by ERE. In countries with stronger environmental regulations, the emission-increasing effect of natural resource extraction is attenuated. This suggests that regulatory frameworks can effectively mitigate the environmental damage associated with resource exploitation – a finding with significant policy implications for resource-rich West African economies.

GDP per capita, ERE, NRE, and TOP showed a positive but statistically insignificant coefficients. The statistically insignificant coefficient of GDP per capita suggests that the scale effect of economic growth on emissions is not robustly detected in this sample, possibly due to the relatively short time period or the countervailing composition and technique effects.

4.3. Regression Results for the Total FDI Inflows Model

Table 5 reports the estimation results for the FDI inflows model, which jointly tested the PHH and the RHH. The findings provided no empirical support for the PHH but offered strong evidence in favour of the RHH.

Environmental regulation enforcement (ERE) exerted a positive but statistically insignificant effect on FDI inflows ($\beta = 0.0002$, $p = 0.933$), indicating that the ERE neither discourages nor attracts foreign investment into West Africa. This result fails to support the PHH, suggesting that multinational enterprises do not base their investment decisions on differences in environmental regulatory enforcement across the region. The finding is consistent with the evidence reported by Adu and Denkyirah (2019) for ECOWAS countries and by Eskeland and Harrison (2003), both of whom found that environmental compliance costs did not significantly influence multinational firms' location decisions. However, it differs from the findings of Copeland and Taylor (2004) and Cole and Elliott (2005), who reported evidence supporting the PHH. These differences may have reflected variations in institutional quality, the effectiveness of environmental enforcement, and the relatively small contribution of environmental compliance costs to firms' total production costs across regions.

In contrast, natural resource endowments (NRE) exerted a positive and highly significant effect on FDI inflows ($\beta = 0.309$, $p = 0.003$). Specifically, a one-percentage-point increase in natural resource rents was associated with an approximately 0.31-percentage-point increase in FDI inflows as a share of GDP. This finding provides strong empirical support for the RHH, indicating that resource abundance is a more important determinant of foreign investment than environmental regulation in West Africa. The result is consistent with the findings of Asiedu (2006) and Adams and Klobodu (2018) and further supports Dunning's OLI paradigm, which identifies natural resource endowments as a key location-specific advantage influencing multinational investment decisions.

Table 5. *Driscoll–Kraay standard errors results for the FDI inflows model*

Variable	Coefficient	Std. Error	t-value	p-value
ERE	0.0002	0.003	0.09	0.933
NRE	0.309	0.077	4.00	0.003***
LAB	0.312	0.038	8.20	0.000***
GDP	-0.075	0.033	-2.30	0.044**
INFR	0.110	0.022	5.00	0.001***
TOP	0.135	0.043	3.17	0.010***
EXC	0.031	0.020	1.54	0.154
ERE*NRE	0.001	0.0003	3.70	0.004***
ENER	-0.085	0.027	-3.12	0.011**

Notes: *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels respectively.

Among the control variables, labour endowment (LAB), infrastructure quality (INFR), and trade openness (TOP) exerted positive and statistically significant effects on FDI inflows, indicating that countries with larger labour forces, better infrastructure, and greater integration into international markets attract higher levels of foreign investment. By contrast, GDP per capita had a negative and statistically significant coefficient ($\beta = -0.075$, $p = 0.044$), suggesting that FDI is concentrated in relatively lower-income economies within the region. This pattern is likely attributable to lower production costs, untapped investment opportunities, and the predominance of resource-seeking investment, which depends more on natural resource availability than on market size. Energy intensity (ENER) also exerted a negative and statistically significant effect, implying that relatively more

energy-efficient economies attract greater FDI inflows, whereas the exchange rate (EXC) had no statistically significant influence on foreign investment.

The interaction term between environmental regulation enforcement and natural resource endowment ($ERE \times NRE$) was positive and statistically significant ($\beta = 0.001$, $t = 3.70$, $p = 0.004$). This result indicates that stronger environmental regulation strengthens, rather than diminishes, the positive effect of natural resource endowments on FDI inflows. Put differently, resource-rich countries with more effective environmental governance attract more foreign investment than similarly resource-abundant countries with weaker regulatory enforcement. This finding contradicts the conventional PHH, which posits that multinational firms prefer countries with weaker environmental regulations. Instead, it suggests that stronger environmental governance complements natural resource wealth by reducing regulatory uncertainty, enhancing institutional credibility, and mitigating reputational risks faced by multinational enterprises.

Overall, these empirical results paint a clear picture: West Africa functions predominantly as a resource haven rather than a pollution haven, while simultaneously experiencing pollution halo effects from FDI. Three overarching patterns emerge. First, FDI is negatively associated with CO₂ emissions, a finding that is consistent with the PHoH. This finding aligns with the OLI paradigm's ownership advantages component: multinational firms bring cleaner technologies and management practices that benefit host countries. It also supports the ecological modernization theory (Mol, 1995; Jänicke, 2008), which suggests that foreign investment can facilitate environmental upgrading rather than degradation. Secondly, natural resource endowments are positively associated with FDI inflows, consistent with the RHH. The consistent positive effects of NRE across the models, coupled with insignificant ERE coefficients, indicate that resource-seeking motivation dominates. This supports the Heckscher–Ohlin factor endowment theory extended to FDI (Iraldo et al., 2011) and aligns with empirical evidence from Adams and Klobodu (2018) for African economies. Thirdly, environmental regulation and resource endowments are complements, not substitutes. The consistently positive $ERE \times NRE$ interaction coefficients across multiple models constitute one of the most important findings. This challenges the traditional PHH framing that pits environmental protection against investment attraction. Instead, it suggests that stronger regulations signal institutional quality, reduce political risk, and enhance the attractiveness of resource-rich locations. This finding aligns with the Porter hypothesis (Porter and van der Linde, 1995) extended to location decisions: well-designed regulations can enhance competitiveness.

Compared with existing literature, these findings converge with studies finding PHH rejection in Africa (Adu and Denkyirah, 2019; Tenaw, 2020) but diverge from those finding PHH support (Okafor, 2018; Özsalman et al., 2025). This divergence

might be due to differences in methodology (sectoral vs aggregate data), time periods, and the specific countries sampled.

5. Conclusions

This study examined whether West Africa functions as a pollution haven, pollution halo, or resource haven by jointly testing the three competing hypotheses using panel data from 16 West African countries for 2014–2024. The findings provided no support for the PHH, as environmental regulation enforcement did not significantly influence total or sectoral FDI inflows. In contrast, the PHoH was supported, with FDI found to be associated with lower CO₂ emissions per capita, suggesting that multinational enterprises contribute to improved environmental performance probably through cleaner technologies and practices. Strong evidence also supported the RHH, indicating that natural resource endowments, together with labour availability, infrastructure quality, and trade openness, are the principal determinants of FDI inflows. Moreover, environmental regulations and natural resource endowments acted as complements rather than substitutes, implying that resource-rich countries with stronger environmental governance attract more FDI than those with weaker regulatory frameworks.

The study contributes to the literature by jointly evaluating the three competing hypotheses within a unified OLI framework and demonstrating that environmental regulation and resource abundance reinforce, rather than offset, each other in attracting foreign investment. The findings suggest that West African governments should avoid weakening environmental regulations to attract FDI. Instead, strengthening environmental governance, improving infrastructure, leveraging natural resource wealth sustainably, and maintaining openness to international trade are likely to enhance investment attractiveness while supporting sustainable development. Overall, the evidence indicates that West Africa is better characterized as a resource haven with pollution halo effects, rather than a pollution haven.

Limitations of this study should be acknowledged. First, the analysis covered a relatively short period (2014–2024) due to data availability constraints. Second, it did not account for differences in the environmental standards and practices of FDI source countries. Third, potential endogeneity arising from the simultaneous relationships among FDI, environmental regulation, and environmental quality was not explicitly addressed; therefore, the results should be interpreted as conditional associations rather than causal effects. Finally, environmental quality was measured solely by CO₂ emissions, which, although widely used, do not capture other dimensions of environmental degradation such as biodiversity loss, water pollution, land degradation, and ecosystem deterioration.

Future research should address these limitations by applying causal estimation techniques, employing broader measures of environmental quality, distinguishing FDI by source country, incorporating firm-level data to examine the mechanisms underlying pollution halo effects, and exploring the role of bilateral investment treaties and environmental governance through qualitative case studies.

References

- Adams, S.; Klobodu, E. K. M. (2018). Financial development and environmental degradation: Does political regime matter? *Journal of Cleaner Production* 197: 1472–1479. <https://doi.org/10.1016/j.jclepro.2018.06.252>.
- Adeleke, B.; Robertson-Andersson, D.; Moodley, G.; Taylor, S. (2021). Aquaculture in Africa: A comparative review of Egypt, Nigeria, and Uganda vis-a-vis South Africa. *Reviews in Fisheries Science and Aquaculture* 29(2): 167–197. <https://doi.org/10.1080/23308249.2020.1795615>.
- Adenle, A. A.; Ford, J. D.; Morton, J.; Twomlow, S.; Alverson, K.; Cattaneo, A.; Ebinger, J. O. (2017). Managing climate change risks in Africa—A global perspective. *Ecological Economics* 141: 190–201. <https://doi.org/10.1016/j.ecolecon.2017.06.004>.
- Adu, D. T.; Denkyirah, E. K. (2019). Economic growth and environmental pollution in West Africa: Testing the environmental Kuznets curve hypothesis. *Kasetsart Journal of Social Sciences* 40(2): 281–288. <https://so04.tci-thaijo.org/index.php/kjss/article/view/242142>.
- Afolabi, J. A. (2023). Natural resource rent and environmental quality nexus in sub-Saharan Africa: Assessing the role of regulatory quality. *Resources Policy* 82: 103488. <https://doi.org/10.1016/j.resourpol.2023.103488>.
- African Development Bank (AfDB). (2021). *African Economic Outlook 2021: From debt resolution to growth—The road ahead for Africa*. Abidjan: AfDB. <https://afdb-org.cn/wp-content/uploads/2021/05/AfDB21-01-AEO-main-English-highlights-1.pdf>.
- Aigbovo, O.; Idehen, F. E. (2024). Foreign direct investment and carbon emission in Nigeria: A test of pollution haven and pollution halo hypothesis. *POLAC Management Review* 4(2): 218–232. https://pemsj.com/papers/PEMSJ-Vol-4Issue-2_589.pdf.
- Alfaro, L.; Kalemli-Ozcan, S.; Volosovych, V. (2008). Why doesn't capital flow from rich to poor countries? An empirical investigation. *Review of Economics and Statistics* 90(2): 347–368. <https://doi.org/10.1162/rest.90.2.347>.
- Al-Mulali, U.; Ozturk, I.; Lean, H. H. (2015). The influence of economic growth, urbanization, trade openness, financial development, and renewable energy on

- pollution in Europe. *Natural Hazards* 79(1): 621–644. <https://doi.org/10.1007/s11069-015-1865-9>.
- Apergis, N.; Gupta, R.; Lau, C. K. M.; Mukherjee, Z. (2018). U.S. state-level carbon dioxide emissions: Does it affect health care expenditure? *Renewable and Sustainable Energy Review* 91: 521–530. <https://doi.org/10.1016/j.rser.2018.03.035>.
- Asiedu, E. (2006). Foreign direct investment in Africa: The role of natural resources, market size, government policy, institutions and political instability. *World Economy* 29(1): 63–77. <https://doi.org/10.1111/j.1467-9701.2006.00758.x>.
- Bahmani-Oskooee, M.; Bolhassani, M. (2014). Exchange rate uncertainty and trade between US and Canada: Is there evidence of third-country effect. *The International Trade Journal* 28(1): 23–44. <https://doi.org/10.1080/08853908.2014.853589>.
- Benzerrouk, Z.; Abid, M.; Sekrafi, H. (2021). Pollution haven or pollution halo effect? A comparative analysis of developing and developed countries. *Energy Reports* 7: 4862–4871. <https://doi.org/10.1016/j.egyr.2021.07.076>.
- Biala, M. I.; Adeniyi, T. A. (2024). Economic growth and environmental sustainability: Assessing the validity of the environmental Kuznets curve in Nigeria. *Journal of Economics and Allied Research* 9(4): 323–338. <https://jearecons.com/index.php/jearecons/article/view/480>.
- Biala, M. I.; Adeniyi, T. A.; Yusuf, Y. T. (2024). Revisiting the environmental Kuznets relation in Nigeria: An empirical study of economic and environmental trends. *Journal of Economics and Allied Research* 339.
- Biala, M. I.; Ibrahim, A. Q. (2025). The role of trade openness, financial development and institutional quality in the environmental performance of a developing country: Evidence from Nigeria. *Al-Basaer Journal of Economics, Commercial and Management Sciences Research* 4(1): 7–18. <https://asjp.cerist.dz/en/article/272532>.
- Biala, M. I.; Ibrahim, A. Q.; Ibrahim, W. O. (2026). Governance-conditioned effects of climate finance on environmental sustainability in sub-Saharan Africa. *Academia Green Energy* 3(2): 1–13. <https://doi.org/10.20935/AcadEnergy8299>.
- Biala, M. I.; Sanusi, A. Y.; Akosile, F. (2026). Foreign direct investment in West Africa: Sectoral evidence on pollution haven and resource haven hypotheses. *Naše gospodarstvo / Our Economy* 72(2): 10–26. <https://journals.um.si/index.php/oe/article/view/6209>.
- Bouzahzah, M. (2022). Pollution haven hypothesis in Africa: Does the quality of institutions matter? *International Journal of Energy Economics and Policy* 12(1): 101–109. <https://doi.org/10.32479/ijee.11856>.
- Cole, M. A.; Elliott, R. J. (2005). FDI and the capital intensity of “dirty” sectors: A missing piece of the pollution haven puzzle. *Review of Development Economics* 9(4): 530–548. <https://doi.org/10.1111/j.1467-9361.2005.00292.x>.

- Cole, M. A.; Elliott, R. J. R.; Shimamoto, K. (2005). Why the grass is not always greener: The competing effects of environmental regulations and factor intensities on US specialization. *Ecological Economics* 54(1): 95–109. <https://doi.org/10.1016/j.ecolecon.2004.11.014>.
- Collier, P.; Venables, A. J. (2011). *Plundered nations? Successes and failures in natural resource extraction*. Palgrave Macmillan. <https://doi.org/10.5860/choice.49-3978>.
- Copeland, B. R.; Taylor, M. S. (2004). Trade, growth, and the environment. *Journal of Economic Literature* 42(1): 7–71. <https://doi.org/10.1257/002205104773558047>.
- Dietz, T.; Rosa, E. A. (1997). Effects of population and affluence on CO₂ emissions. *Proceedings of the National Academy of Sciences* 94(1): 175–179. <https://doi.org/10.1073/pnas.94.1.175>.
- Driscoll, J. C.; Kraay, A. C. (1998). Consistent covariance matrix estimation with spatially dependent panel data. *Review of Economics and Statistics* 80(4): 549–560. <https://doi.org/10.1162/003465398557825>.
- Dunning, J. H. (1979). Explaining changing patterns of international production: In defence of the eclectic theory. *Oxford Bulletin of Economics and Statistics* 41(4): 269–295. <https://doi.org/10.1111/j.1468-0084.1979.mp41004003.x>.
- (2001). The eclectic (OLI) paradigm of international production: Past, present and future. *International Journal of the Economics of Business* 8(2): 173–190. <https://doi.org/10.1080/13571510110051441>.
- Dunning, J. H.; Lundan, S. M. (2008). *Multinational enterprises and the global economy*. 2nd ed. Edward Elgar.
- Eskeland, G. S.; Harrison, A. E. (2003). Moving to greener pastures? Multinationals and the pollution haven hypothesis. *Journal of Development Economics* 70(1): 1–23. [https://doi.org/10.1016/S0304-3878\(02\)00084-6](https://doi.org/10.1016/S0304-3878(02)00084-6).
- Heckscher, E. F. (1919). The Effect of Foreign Trade on the Distribution of Income. *Ekonomisk Tidskrift* 21: 497–512.
- Iraldo, F.; Testa, F.; Melis, M.; Frey, M. (2011). A literature review on the links between environmental regulation and competitiveness. *Environmental Policy and Governance* 21(3): 210–222. <https://doi.org/10.1002/eet.568>.
- Jänicke, M. (2008). Ecological modernisation: New perspectives. *Journal of Cleaner Production* 16(5): 557–565. <https://doi.org/10.1016/j.jclepro.2007.02.011>.
- Kasman, A.; Duman, Y. S. (2015). CO₂ emissions, economic growth, energy consumption, trade and urbanization in new EU member and candidate countries: A panel data analysis. *Economic Modelling* 44: 97–103. <https://doi.org/10.1016/j.econmod.2014.10.022>.
- Kellenberg, D. K. (2009). An empirical investigation of the pollution haven effect with strategic environment and trade policy. *Journal of International Economics* 78(2): 242–255. <https://doi.org/10.1016/j.jinteco.2009.04.004>.

- Kinda, T. (2010). Investment climate and FDI in developing countries: Firm-level evidence. *World development* 38(4): 498–513. <https://doi.org/10.1016/j.worlddev.2009.12.001>.
- Lahiri, S.; Ono, Y. (2015). Pollution, foreign direct investment, and welfare. *Research in Economics* 69(2): 238–247. <https://doi.org/10.1016/j.rie.2015.03.002>.
- Levinson, A.; Taylor M. S. (2008). Unmasking the pollution haven effect. *International Economic Review* 49(1): 223–254. <https://doi.org/10.1111/j.1468-2354.2008.00478.x>.
- Liu, P.; Ur Rahman, Z.; Jóźwik, B.; Doğan, M. (2024). Determining the environmental effect of Chinese FDI on the Belt and Road countries CO₂ emissions: An EKC-based assessment in the context of pollution haven and halo hypotheses. *Environmental Sciences Europe* 36(1): 48. <https://doi.org/10.1186/s12302-024-00866-0>.
- Manderson, E.; Kneller, R. (2012). Environmental regulations, outward FDI and heterogeneous firms: Are countries used as pollution havens. *Environmental and Resource Economics* 5(1): 317–352.
- Mert, M.; Bölük, G. (2016). Do foreign direct investment and renewable energy consumption affect the CO₂ emissions? New evidence from a panel ARDL approach to Kyoto Annex countries. *Environmental Science and Pollution Research* 23: 21669–21681. <https://doi.org/10.1007/s11356-016-7413-7>.
- Mol, A. P. J. (1995). *The refinement of production: Ecological modernization theory and the chemical industry*. Utrecht: Van Arkel.
- Naqvi, S. A. A.; Hussain, M.; Hussain, B.; Shah, S. A. R.; Nazir, J.; Usman, M. (2023). Environmental sustainability and biomass energy consumption through the lens of pollution haven hypothesis and renewable energy-environmental Kuznets curve. *Renewable Energy* 212(2): 621–631. <https://doi.org/10.1016/j.renene.2023.04.127>.
- Nathaniel, S. P.; Iheonu, C. O. (2019). Carbon dioxide abatement in Africa: The role of renewable and non-renewable energy consumption. *Science of the Total Environment* 679: 337–345. <https://doi.org/10.1016/j.scitotenv.2019.05.011>.
- Nchofoung, T. N.; Asongu, S. A. (2022). Effects of infrastructures on environmental quality contingent on trade openness and governance dynamics in Africa. *Renewable Energy* 189: 152–163. <https://doi.org/10.1016/j.renene.2022.02.114>.
- Ohlin, B. (1933). *Interregional and international trade*. Harvard University Press.
- Okafor, T. G. (2018). Environmental costs accounting and reporting on firm financial performance: A survey of quoted Nigerian oil companies. *International Journal of Finance and Accounting* 7(1): 1–6. <http://article.sapub.org/10.5923.j.ijfa.20180701.01.html>.
- Özsalman, E.; Derindağ, Ö. F.; Bayat, T. (2025). Pollution haven, pollution halo or pollution hell? The impact of foreign direct investment on CO₂ emission and

- temperature rise in fragile five countries. *Journal of Academic Researches and Studies* 17(32): 134–149. <https://doi.org/10.20990/kilisiibfakademik.1634138>.
- Pao, H. T.; Yu, H. C.; Yang, Y. H. (2011). Modeling the CO₂ emissions, energy use, and economic growth in Russia. *Energy* 36(8): 5094–5100. <https://doi.org/10.1016/j.energy.2011.06.004>.
- Pargal, S.; Wheeler, D. (1996). Informal regulation of industrial pollution in developing countries: Evidence from Indonesia. *Journal of Political Economy* 104(6): 1314–1327. <https://www.journals.uchicago.edu/doi/abs/10.1086/262061>.
- Porter, M. E.; Van der Linde, C. (1995). Toward a new conception of the environment-competitiveness relationship. *Journal of Economic Perspectives* 9(4): 97–118. <https://www.aeaweb.org/articles?id=10.1257/jep.9.4.97>.
- Prakash, A.; Potoski, M. (2006). *The voluntary environmentalists: Green clubs, ISO 14001, and voluntary regulations*. Cambridge University Press. <https://doi.org/10.1017/CBO9780511617683>.
- Saadi, M. (2020). Remittance inflows and export complexity: New evidence from developing and emerging countries. *Journal of Development Studies* 56(12): 2266–2292. <https://doi.org/10.1080/00220388.2020.1755653>.
- Shi, A. (2003). The impact of population pressure on global carbon dioxide emissions, 1975–1996: Evidence from pooled cross-country data. *Ecological Economics* 44(1): 29–42. [https://doi.org/10.1016/S0921-8009\(02\)00223-9](https://doi.org/10.1016/S0921-8009(02)00223-9).
- Tenaw, D. (2020). Is Africa a pollution haven or halo? Evidence from 20 largest FDI recipient countries in Africa. *International Journal of Green Economics* 14(1): 78–93. <https://doi.org/10.1504/IJGE.2020.10030417>.
- United Nations Conference on Trade and Development (UNCTAD). (2022). *World Investment Report 2022: International Tax Reforms and Sustainable Investment*. Geneva: UNCTAD. https://unctad.org/system/files/official-document/wir2022_en.pdf.
- United Nations Environment Programme (UNEP). (2019). *Measuring progress: Towards achieving the environmental dimension of the SDGs*. UNEP. https://www.researchgate.net/publication/336374339_Measuring_Progress_Towards_achieving_the_environmental_dimension_of_the_SDGs.
- Wagner, U. J.; Timmins, C. (2008). Agglomeration effects in foreign direct investment and the pollution haven hypothesis. *Environmental and Resource Economics* 43(2): 231–256. <https://link.springer.com/article/10.1007/s10640-008-9236-6>.
- Wang, H.; Jin, Y. (2007). Industrial ownership and environmental performance: Evidence from China. *Environmental and Resource Economics* 36(3): 255–273. <https://doi.org/10.1007/s10640-006-9027-x>.
- Wheeler, D. (2001). Racing to the bottom? Foreign investment and air pollution in developing countries. *Journal of Environment and Development* 10(3): 225–245. <https://www.jstor.org/stable/44319565>.

- World Bank. (2025). *World Development Indicators*. Washington, DC: The World Bank. <https://databank.worldbank.org/source/world-development-indicators>.
- 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.
- Zeng, K.; Eastin, J. (2012). Do developing countries invest up? The environmental effects of foreign direct investment from less developed countries. *World Development* 40(11): 2221–2233. <https://doi.org/10.1016/j.worlddev.2012.03.008>.
- Zhang, X.-P.; Cheng, X.-M. (2009). Energy consumption, carbon emissions, and economic growth in China. *Ecological Economics* 68(10): 2706–2712. <https://doi.org/10.1016/j.ecolecon.2009.05.011>.