Foreign Direct Investment in West Africa: Sectoral Evidence on Pollution Haven and Resource Haven Hypotheses

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Abstract

Through a sectoral analysis of foreign direct investment (FDI) in relation to environmental regulation stringency (ERS) and natural resource endowment (NRE), this study investigates the validity of the pollution haven hypothesis (PHH) and resource haven hypothesis (RHH) for West Africa. Drawing on panel data for sixteen West African countries from 2014 to 2024, the study applies a fixed-effects model with Driscoll–Kraay standard errors to evaluate the two hypotheses simultaneously. The results indicated that ERS did not significantly influence aggregate FDI inflows. In contrast, NRE and labour endowment emerged as key drivers of FDI, providing strong support for the RHH. Crucially, the sectoral analysis revealed substantial heterogeneity across industries: FDI in the mining, manufacturing, and petroleum sectors was predominantly resource-seeking, consistent with both the RHH and the PHH, whereas tourism-related FDI declined with greater resource abundance. Furthermore, the positive interaction between ERS and NRE suggests that stricter environmental regulations complement rather than deter resource-driven investment. The study therefore advocates strengthening environmental institutions, enhancing resource governance frameworks, and promoting green investment strategies to foster sustainable development in West Africa.

Introduction

Globalisation has accelerated the movement of capital, technology, and production across borders. Among the many drivers of foreign direct investment (FDI), environmental regulation and natural resource endowments have attracted attention in both academic and policy circles. As developing regions open up their economies to attract FDI, there are concerns that this may come at the cost of environmental degradation or exploitative resource extraction. The West African region, characterised by vast natural resources, developing institutions, and varied environmental regulation frameworks, has become an increasingly attractive destination for FDI.

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Consequently, three competing hypotheses have emerged to explain this phenomenon: pollution haven hypothesis, pollution halo hypothesis, and resource haven hypothesis. The *pollution haven hypothesis* (PHH) posits that firms from countries with stringent environmental regulations relocate to countries with lax standards to reduce compliance costs (Copeland & Taylor, 2004). Conversely, the *pollution halo hypothesis* (PHaH) argues that FDI brings cleaner technologies and better environmental practices (Prakash & Potoski 2006; Wheeler, 2001). The *resource haven hypothesis* (RHH) suggests that FDI in developing countries is primarily driven by access to natural resources, often independent of environmental concerns (Adams & Klobodu, 2018; Collier & Venables, 2011).

The PHH phenomenon presents significant challenges for sustainable development in West Africa, given the region's vulnerability to climate change and ecological degradation (United Nations Environment Programme [UNEP], 2019). Between 2000 and 2022, FDI inflows to West Africa increased in pollution-intensive sectors, particularly in mining, petroleum refining, and cement manufacturing (UNCTAD, 2022). Countries such as Nigeria, Ghana, and Côte d'Ivoire have experienced growing FDI in manufacturing and extractive sectors over the past two decades, raising concerns about whether weak environmental standards or resource wealth attract polluting industries (Adenle et al., 2017). Many of these investments are in environmentally sensitive industries, including cement, textiles, and petrochemicals. Simultaneously, environmental regulation in the region remains weak or poorly enforced (Adeleke et al., 2021; Biala, 2024; Biala et al., 2024; Biala & Ibrahim, 2025). This raises concerns that West African countries may be inadvertently serving as pollution havens. Yet many West African countries continue to attract foreign direct investment (FDI) by adopting pro-investment policies that emphasize ease of doing business and tax incentives while downplaying environmental considerations, leading to a *race to the bottom*, where countries competitively lower environmental standards to attract FDI. Consequently, the region risks long-term ecological damage that could undermine sustainable development and worsen the impacts of climate change (Copeland & Taylor, 2004). On the other hand, the possibility that FDI is primarily driven by resource exploitation raises the issue of a resource haven (or seeking) hypothesis.

Although a large body of literature has examined the FDI–environment nexus, recent evidence remains inconclusive regarding whether FDI contributes to pollution haven or resource-driven outcomes in developing regions. For West Africa specifically, there is limited empirical evidence assessing whether FDI is driven by regulatory arbitrage, environmental upgrading, or resource extraction—a gap that obscures whether investment is pulled by lax regulations, green incentives, or resource wealth. Recent global studies have reported conflicting results: some support the pollution haven hypothesis (Naqvi et al., 2023; Özsalman et al., 2025), while others document pollution halo effects (Liu et al., 2024; Benzerrouk et al., 2021). In the African context, emerging evidence suggests that natural resource abundance may be a stronger determinant of FDI location than environmental regulatory differences (Afolabi, 2023; Bouzahzah, 2022). Despite these developments, little evidence exists on whether pollution haven, pollution halo, and resource haven mechanisms operate simultaneously within West Africa. Consequently, the relative importance of environmental regulations versus resource endowments in shaping FDI inflows and environmental outcomes remains unresolved in the region.

Moreover, sectoral FDI patterns remain underexplored in the West African context. Most existing studies rely on aggregate FDI inflows, implicitly assuming that investment in mining, manufacturing, petroleum, and tourism responds uniformly to environmental regulations and resource endowments. This aggregation masks critical heterogeneity: polluting sectors may be attracted by lax standards (PHH), while clean sectors such as tourism may respond to different incentives altogether. Without disaggregating FDI by sector, it is impossible to determine whether West Africa is primarily a destination for resource-extractive, pollution-intensive, or environmentally responsible investment. The present study addresses this gap by separately analysing FDI inflows to mining, manufacturing, petroleum, and tourism sectors, thereby providing a more distinct understanding of the FDI–environment nexus in the region.

This study extends the literature by directly linking environmental regulation stringency and natural resource endowment to FDI and providing for West Africa sectoral evidence on the two hypotheses within a single unified framework of the OLI paradigm using panel Driscoll-Kray estimation. By explicitly testing these hypotheses within the OLI paradigm, it resolves the fragmentation in existing literature where studies typically examine only one of the hypotheses. The sectoral analysis provides an insight into the need for sector-specific theoretical extensions. These were accomplished by investigating the influence of

environmental regulation stringency and resource endowment on total and sectoral FDI inflows to West African countries, and determining whether resource endowment drives FDI more than regulatory arbitrage.
The remainder of this study is structured as follows. Section 2 reviews the pre-existing relevant literature; Section 3 details the methodology employed; Section 4 presents and discusses the results; and Section 5 concludes the study with policy implications, limitations of the study, and suggestions for future research.

Prior Studies

The relationship between foreign direct investment (FDI) and environmental quality has generated extensive theoretical and empirical debate, particularly in developing regions where efforts to attract foreign capital often coexist with concerns about environmental sustainability. While some studies argue that FDI contributes to environmental degradation by relocating pollution-intensive activities to countries with weaker environmental regulations, others contend that it promotes environmental improvement through technology transfer, managerial innovation, and the diffusion of cleaner production techniques. A growing strand of literature posits that FDI is driven by natural resource availability in the host countries. Another strand of literature further suggests that the environmental effects of FDI may vary across sectors, reflecting differences in resource dependence, production processes, and regulatory exposure. Consequently, the empirical evidence remains inconclusive, necessitating further investigation, especially within the context of West Africa.

The PHH posits that firms, particularly in pollution-intensive industries, tend to relocate production to countries with laxer environmental regulations in order to minimize operational and compliance costs (Copeland & Taylor, 2004). This hypothesis is grounded in the idea that multinational corporations (MNCs) seek to reduce costs associated with strict environmental standards in their home countries by shifting their activities to developing countries, which often prioritize economic development over environmental protection. In countries with stringent environmental laws, firms incur high costs related to waste management, emissions reduction, and compliance with eco-friendly regulations. Conversely, developing countries, which may have weak enforcement mechanisms or deliberately maintain lenient environmental policies, offer an attractive alternative for production due to lower regulatory costs (Eskeland & Harrison, 2003). As a result, these developing countries become "pollution havens," drawing in foreign direct investment (FDI) from industries seeking to lower production costs. This contributes to environmental degradation in the host countries (Dean et al., 2009).

On the other hand, the RHH, also referred to as *Factor endowment theory* or *Heckscher-Ohlin Model*, posits that trade patterns are determined by resource availability, not just regulation. Firms relocate to countries with abundant resources to minimise costs. It explains international trade patterns based on differences in countries' relative factor endowments—such as labour, capital, natural resources, and land. It suggests that a country will export goods that use its abundant and cheap factors of production, and import goods that use its scarce factors (Heckscher, 1919; Ohlin, 1933). In more recent literature, the factor endowment theory has been extended to explain FDI and industrial relocation. In this context, the theory suggests that firms relocate in search of abundant and cheap resources to minimize costs. They relocate to countries with abundant and cheap resources and then export from there export goods that intensively use the abundant resources. Firms from capital-abundant, high-wage countries invest in labour- or resource-abundant, low-cost countries to exploit cheaper production inputs (Iraldo, et al., 2011). For example, West African countries with abundant natural resources and relatively low capital may attract FDI in resource-extractive or pollution-intensive industries. The theory helps explain why firms may relocate—not just due to regulation, but also because of relative cost advantages derived from endowments.

Recent empirical studies continue to provide conflicting evidence regarding the drivers of FDI and FDI-environment nexus. Imran et al. (2025) applied a NARDL model to the world's top five emitters and found that Japanese and Chinese FDI outflows increase short-term global carbon emissions, while negative shocks from Japan and Russia support PHH. Afolabi (2023), using system GMM on 16 resource-rich Sub-Saharan African countries, concluded that higher resource rents significantly increase CO_2 emissions, but enhanced regulatory quality reverses this effect. Bouzahzah (2022) examined 40 African countries and found that institutional quality critically moderated the FDI-emissions nexus. Nevertheless, a region-specific study for West Africa that simultaneously tests the two hypotheses remains absent.

Revisiting the PHH in the context of BRICS economies, Apergis et al. (2023) employed bilateral FDI flows from

OECD countries and found that foreign investment contributed to increased carbon emissions in host economies, particularly where environmental standards were relatively weak. Similarly, Kılavuz et al. (2024), examining seven major emerging economies under the framework of recent global climate agreements, reported evidence consistent with the PHH, suggesting that differences in environmental regulation continue to influence investment location decisions. Using a gravity-model approach to analyse trade and investment relations between China and the European Union, Avazdahandeh (2024) also found support for the CO_2 haven hypothesis, indicating that pollution-intensive activities may relocate across jurisdictions with differing environmental standards. Furthermore, Naqvi et al. (2023) demonstrated that environmental sustainability outcomes remain strongly influenced by pollution haven mechanisms, although the magnitude of these effects depends on renewable energy adoption and biomass energy utilisation. Collectively, these studies suggest that environmental regulation remains a significant determinant of the environmental effects of international investment, lending support to the pollution haven perspective.

In contrast, a growing body of literature provides evidence in against the PHH. Using data from the Sichuan–Chongqing urban agglomeration in China, Gao et al. (2022) found that foreign direct investment improved environmental quality through technology spillovers and enhanced production efficiency. Similarly, Liu et al. (2024), analysing Chinese outward FDI in Belt and Road Initiative countries, concluded that foreign investment can generate environmental improvements when accompanied by technological advancement and appropriate institutional frameworks. Opoku et al. (2022) further demonstrated that environmental sustainability itself served as an important determinant of foreign investment inflows in developing countries, suggesting that multinational enterprises may increasingly favour environmentally responsible destinations. These findings challenge the traditional pollution haven argument and provide support for the view that FDI can contribute positively to environmental outcomes through knowledge transfer, cleaner technologies, and improved environmental management practices.

Recent studies have also highlighted the importance of globalization, natural resource endowments, and institutional quality in shaping the FDI–environment relationship. Acheampong (2022), examining Ghana, found that deeper integration into the global economy exerted significant effects on carbon emissions, underscoring the role of globalization channels in environmental outcomes. Focusing on Sub-Saharan Africa, Afolabi (2023) showed that the environmental effects of natural resource rents depend critically on regulatory quality, with stronger institutions mitigating environmental degradation associated with resource exploitation. Similarly, Bouzahzah (2022) found that institutional quality significantly influenced the validity of the Pollution Haven Hypothesis in African countries, implying that environmental outcomes are shaped not only by investment flows but also by governance structures. These findings suggest that natural resource abundance and institutional effectiveness may jointly determine whether countries experience pollution haven or resource haven outcomes.

Recent contributions by Biala et al. (2026) further illuminate the FDI-environment relationship and the conditioning role of governance and the importance of disaggregated analysis in the African context. Biala et al. (2026) examined the impact of climate finance on environmental sustainability across 40 Sub-Saharan African countries using the load capacity factor and Environmental Performance Index. Employing System GMM and Driscoll–Kraay standard errors, they found that climate finance inflows alone exerted no statistically significant independent effect on environmental sustainability. However, the interaction between climate finance and governance quality was positive and significant, indicating that the effectiveness of climate finance is conditional upon institutional strength. Foreign direct investment was associated with environmental deterioration, supporting the PHH.

Similarly, Ibrahim and Biala (2026) investigated whether renewable and non-renewable energy consumption exert asymmetric effects on environmental sustainability in Nigeria using the Nonlinear Autoregressive Distributed Lag (NARDL) model. Their results revealed significant asymmetric effects that varied by energy type, time horizon, and environmental indicator. Positive shocks to non-renewable energy significantly reduced environmental sustainability in the long run, while negative shocks to renewable energy also unexpectedly degraded LCF. This study is relevant to the present paper because it demonstrates that aggregate energy consumption data mask important asymmetric relationships—a finding that parallels our argument that aggregate FDI data mask sectoral heterogeneity.

Despite these advances, the literature remains fragmented. Existing studies typically focus on either the

pollution haven or pollution halo hypothesis, while relatively few simultaneously examine the role of environmental regulation, foreign direct investment, and natural resource endowments within a unified analytical framework. Moreover, empirical evidence for West Africa remains limited, despite the region's increasing dependence on foreign investment, abundant natural resources, and evolving environmental governance systems. Consequently, the extent to which West African countries function as pollution havens, pollution halos, or resource havens remains unresolved, providing the motivation for the present study.

The literature shows that substantial research has been conducted on PHH PHaH, and RHH, but studies on West Africa as a whole are limited, and that the existing studies have produced mixed and inconclusive results. While some studies find firms relocate to avoid regulations (Cole et al., 2005), others show FDI is resource-seeking firms targeting oil, minerals, etc. (Wagner & Timmins, 2008) or market-seeking (Alfaro et al., 2008). This theoretical gap underscores the need for further studies.

Methodologically, while some previous studies have used aggregate FDI data without distinguishing between pollution-intensive and non-pollution-intensive sectors, others are plagued by data constraints, omission of key variables in the model, and variations in the contexts studied. Limited attention has been given to the role of trade openness, globalization, pollution-intensive industry, green technology, and sustainable development, which could potentially explain the relationship between environmental regulation and industrial relocation in West African nations.

On theoretical gaps, no study explicitly tests which driver (PHH vs. RHH) dominates in West Africa. Besides, majority of the studies on environmental regulation and FDI have focused on developed countries (Apergis et al., 2018; Lahiri & Ono, 2015; Levinson & Taylor, 2008). Despite the increasing integration of West African countries into the global economy and their rising industrial ambitions, there is limited empirical evidence testing the three hypotheses in this specific regional context. While they have received considerable theoretical and empirical attention globally, its application in West Africa is still underexplored. Most existing studies focus on global or bilateral trade patterns involving developed and large emerging economies (e.g., China, India), often overlooking regional dynamics, intra-Africa industrial movement, and the heterogeneity in environmental policy implementation across West Africa countries.

Overall, the empirical literature reveals that (1) PHH validity depends strongly on institutional quality, sector, and source country, (2) natural resource endowments often drive FDI more than regulatory differences in Africa, (3) sectoral analyses (extractive industries) show stronger PHH patterns, (4) some studies find FDI improves environmental quality (halo effect), particularly in developed countries and specific sectors, (5) methodological choices (aggregate vs. sectoral data, country-level vs. firm-level, econometric techniques) significantly influence results, and (6) West Africa remains understudied relative to other regions, with limited region-specific empirical research that simultaneously considers all three hypotheses. The resource-seeking hypothesis posits that FDI is primarily attracted to countries with abundant natural resources, often independent of environmental regulations. Empirical evidence consistently supports this hypothesis, particularly in developing and resource-rich economies.

This study, therefore, aimed to fill these gaps by (1) by directly linking environmental regulation stringency and natural resource endowment to FDI, (2) applying panel data analysis over a decades (2014–2024), (3) applying discroll-kraay standard error to account for heteroskedasticity and autocorrelation, (4) distinguishing between sectors based on pollution intensity, and (5) incorporating trade openness as a moderator.

Methodology

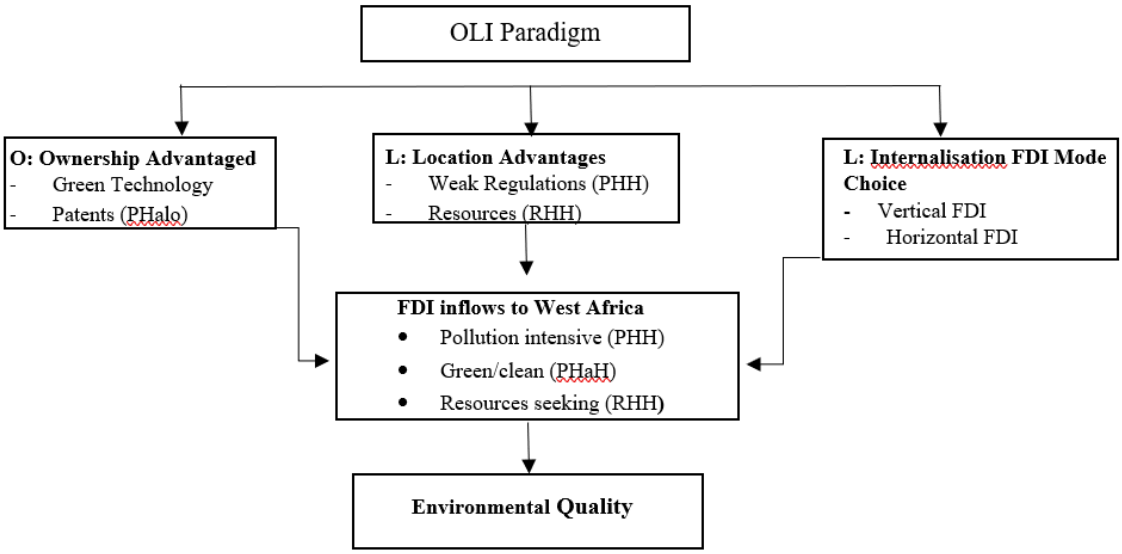
Theoretical Framework

This study adopts the OLI paradigm (Dunning, 1979; 2001), an integrated framework to explore the connections between FDI and environmental regulation and resource endowment in West Africa. The OLI paradigm, also known as the *Eclectic Paradigm*, is adopted because it integrates the two hypotheses (PHH and RHH) upon which this study rests. The *OLI paradigm* explains why multinational enterprises engage in FDI rather than licensing or exporting. Its three key components—ownership advantages (O), location advantages (L), and internalisation advantages (I) represent the two hypotheses under investigation.

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 RHH. Location advantages (host-country attributes such as natural resources and environmental regulations) explain why West Africa may attract resource-seeking or pollutig FDI. Internalisation 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 and RHH



Source: Authors

Model Specification

A mathematical model of the OLI paradigm can be formulated to describe the relationship between environmental regulations, resource endowment and FDI:

$$EQ_i = f(FDI) = f(ERS, NRE, X) \quad (1)$$

where EQ = environmental quality, *ERS* = environmental regulatory stringency in the jurisdiction where FDI is located, *NRE* = natural resource endowment, and X = other factors that may affect *EQ*, and ε = an error term. To achieve the objectives of this study, this theoretical model is elaborately specified to accommodate other explanatory variables during estimation.

Since PHH posits that environmental regulation stringency drives FDI, an approach to testing PHH is to examine the effect of environmental regulations (ERS) on the inflow of FDI into West African countries. Hence, the model for pollution haven hypothesis is specified as

$$FDI_{it} = \alpha_0 + \alpha_1 ERS_{it} + \alpha_2 Z_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (2)$$

where FDI= foreign direct investment inflow to country i in year t, ERS is environmental regulation stringency index,. Z = Vector of control variables; *i, t* = Country and year; μ_i = Country fixed effects; λ_t = Time fixed effects; ε_{it} = Error term, which accounts for unobserved factors.

To test for the resource-seeking hypothesis, natural resources endowment (NRE) and human resource endowment/labour (LAB) were introduced into Equation 2 to have Equation 3;

$$FDI_{it} = \alpha_0 + \alpha_1 ERS_{it} + \alpha_2 NRE_{it} + \alpha_3 LAB_{it} + \alpha_4 Z_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (3)$$

To examine whether the effects of environmental regulations (ERS) on FDI inflows differ across sectors (pollution-intensive vs. clean sectors), Equation 3 was estimated for each sector to test the PHH with sectoral FDI inflow as the dependent variable rather than total FDI inflow. The sectors considered were mining, petroleum, manufacturing, and tourism sectors.

From Equation 3, it was expected that PHH would hold for mining, petroleum, and manufacturing industries ($\alpha_1 < 0$) but not for tourism industry ($\alpha_1 \approx 0$). The PHH holds

if $\alpha_1 < 0$, suggesting stricter regulations deter FDI in pollution-intensive sectors; the PHH is rejected, if $\alpha_1 \geqslant 0$, implying that regulations do not significantly deter FDI (or may even attract cleaner FDI due to institutional quality).

Following the existing literature, such as Benzerrouk et al. (2021) and Liu et al. (2024), Equation 3 was expanded by introducing the control and moderating variables to have Equations 4 and 5a through 5d as follows:

Total FDI inflows model:

$$FDI_{it} = \alpha_0 + \alpha_1 ERS_{it} + \alpha_2 GDP_{it} + \alpha_3 NRE_{it} + \alpha_4 LAB_{it} + \alpha_5 INFR_{it} + \alpha_6 TOP_{it} + \alpha_7 \mathrm{EXC_{it}} + \alpha_8 \mathrm{ENER_{it}} + \alpha_9 (ERS_{it} * NRE_{it}) + \mu_i + \lambda_t + \varepsilon_{it} \quad (4)$$

FDI inflows to mining sector model:

$$FDIMIN_{it} = \alpha_0 + \alpha_1 ERS_{it} + \alpha_2 GDP_{it} + \alpha_3 NRE_{it} + \alpha_4 LAB_{it} + \alpha_5 INFR_{it} + \alpha_6 TOP_{it} + \alpha_7 \mathrm{EXC_{it}} + \alpha_8 \mathrm{ENER_{it}} + \alpha_9 (ERS_{it} * TOP_{it}) + \alpha_{10} (ERS_{it} * NRE_{it}) + \mu_i + \lambda_t + \varepsilon_{it} \quad (5a)$$

FDI inflows to manufacturing sector model:

$$FDIMAN_{it} = \alpha_0 + \alpha_1 ERS_{it} + \alpha_2 GDP_{it} + \alpha_3 NRE_{it} + \alpha_4 LAB_{it} + \alpha_5 INFR_{it} + \alpha_6 TOP_{it} + \alpha_7 \mathrm{EXC_{it}} + \alpha_8 \mathrm{ENER_{it}} + \alpha_9 (ERS_{it} * TOP_{it}) + \alpha_{10} (ERS_{it} * NRE_{it}) + \mu_i + \lambda_t + \varepsilon_{it} \quad (5b)$$

FDI inflows to petroleum sector Model

$$FDIOP_{it} = \alpha_0 + \alpha_1 ERS_{it} + \alpha_2 GDP_{it} + \alpha_3 NRE_{it} + \alpha_4 LAB_{it} + \alpha_5 INFR_{it} + \alpha_6 TOP_{it} + \alpha_7 \mathrm{EXC_{it}} + \alpha_8 \mathrm{ENER_{it}} + \alpha_9 (ERS_{it} * TOP_{it}) + \alpha_{10} (ERS_{it} * NRE_{it}) + \mu_i + \lambda_t + \varepsilon_{it} \quad (5c)$$

FDI inflows to tourism sector (FDIITE) model:

$$FDIITE_{it} = \alpha_0 + \alpha_1 ERS_{it} + \alpha_2 GDP_{it} + \alpha_3 NRE_{it} + \alpha_4 LAB_{it} + \alpha_5 INFR_{it} + \alpha_6 TOP_{it} + \alpha_7 \mathrm{EXC_{it}} + \alpha_8 \mathrm{ENER_{it}} + \alpha_9 (ERS_{it} * TOP_{it}) + \alpha_{10} (ERS_{it} * NRE_{it}) + \mu_i + \lambda_t + \varepsilon_{it} \quad (5d)$$

FDI = Foreign direct investment, NRE = Natural resources endowment, LAB = Labour or human resources endowment (labour cost or wage rates), ERS = Environmental regulation stringency, GDP = Gross domestic product per capita EXC = Exchange rate, TOP = Trade openness, POP = Population, URB = urbanization, INFR = Infrastructure quality and ENER = Energy intensity.

The control variables for the models specified reflect major economic, institutional and geographical determinants of FDI. In the vector of control variables, GDP Growth captures market size and economic stability ($\propto_2 > 0$, implying FDI flows to faster-growing economies or wealthier countries may have stronger environmental performance); trade openness (TOP) measures integration into global markets (with associated $\propto_6 > 0$ suggesting FDI favours countries with fewer trade barriers); and natural resource (NRE and LAB) represents the RHH (with $\propto_3, \propto_4 > 0$ indicating resource-seeking FDI). Interaction terms were used to reconcile RHH and PHH (e.g., ERS*NRE). While models 5a to 5c test for FDI in pollution-intensive sector and model 5d tests for FDI in clean or zero pollution sector.

Definition and Measurement of the Variables

The summary of the variables used in the models, including their definitions, measurements, a priori expectations, and sources are contained in Table 1.

Table 1
Details of the Variables

Variable	Definition	Measurement	Data Source
FDI	Foreign direct investment	Total FDI Inflows as % of gross domestic product	World Development Indicators
Sectoral FDI	Pollution- intensive sectors and clean sectors	FDI inflows as % of GDP to pollution- intensive sectors (FDIMIN, FDIMAN and FDIOP) and clean sectors (FDIITE)	World Development Indicators
ERS	Environmental regulation stringency	Enforcement of environmental regulations (EER) score	Mo Ibrahim Foundation
NRE	Natural resource endowment	Total natural resource rents (% of GDP)	World Development Indicators
LAB	Labour endowment	Labor force participation rate, total (% of total population ages 15-64).	World Development Indicators
TOP	Trade openness	This is measured by trade (exports + imports) as % of GDP	World Development Indicators
GDP	GDP per capita	GDP per capita in constant 2015 US dollars	World Development Indicators
ENER	Energy intensity	Energy use (kg of oil equivalent) per $1,000 GDP (constant 2021 PPP)	World Development Indicators
INFR	Infrastructural quality	Access to electricity as % of population	World Development Indicators
EXC	Exchange rate volatility	Real effective exchange rate index (2010 = 100)	World Development Indicators

Source: Authors

Estimation Techniques

This study employs fixed effects model (to control for unobserved heterogeneity or time-invariant country-specific factors such as geography, colonial history). Driscoll–Kraay standard errors (Driscoll & Kraay, 1998) was adopted to correct for potential econometric issues commonly found in panel data (especially when panel data is with large cross-sectional dimension (N) and small time series dimension (T)), particularly cross-sectional dependence, heteroskedasticity and autocorrelation. These issues can lead to inefficient and biased inference if not properly addressed, especially in macro-panel datasets where units (such as countries) are likely interrelated. It is also used for improvement of the quality and reliability of empirical analysis, especially when

dealing with panel data that exhibits unobserved heterogeneity, autocorrelation, heteroscedasticity and cross-sectional dependence.

Driscoll-Kraay (D–K) standard errors also permit the performance of fixed effects in the estimation, when heteroscedasticity and serial and spatial dependency are possible, D–K is regarded as one of the best methods. Moreover, D–K covariance estimator can handle missing values and is applicable to the data both unbalanced and balanced. Driscoll-Kraay Standard Errors also adopt the newey-west standard error technique to address problems of heteroskedasticity and autocorrelation of errors. Correction for cross-sectional dependence is best addressed by the Driscoll-Kraay technique (Nchofoung & Asongu, 2022, Saadi 2020).

Data

This study employed annual panel data spanning from 2014 to 2024, collected for sixteen West African countries (Benin, Burkina Faso, Cape Verde, Gambia, Ghana, Guinea, Guinea-Bissau, Ivory Coast, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone and Togo). The data were sourced from World Bank World Development Indicator (WDI) and Worldwide Governance Indicators (WGI). The data for resource rents expressed as percentage share of GDP derived from natural resources (e.g., oil rents, mineral rents, forest rents). The WDI provides country-level data on total and disaggregated natural resource rents (% of GDP).

Results and Discussion

Preliminary Analysis of Results

Descriptive Statistics

Descriptive analysis of all the variables employed in this study over the 2014–2024 period across 16 West African countries were carried out. The mean value of environmental quality (EQ) was 0.616 tonnes CO_2 emissions per capita, with substantial variation across countries (standard deviation = 0.78, range: 0.092 to 3.341). This indicates significant heterogeneity in emission levels within the region, with some countries emitting nearly 36 times more than others. The mean FDI inflow as a percentage of GDP was 3.789%, though the wide range (-2.575% to 23.999%) reflects the volatile nature of investment flows and the presence of both divestment and significant inflows across the sample period.

Natural resource endowments (NRE) averaged 8.5% of GDP, ranging from near-zero (0.002%) to 26.181%, confirming the resource-rich but unevenly distributed nature of West African economies. Trade openness (TOP) averaged 62.683% of GDP, indicating moderate integration into global markets, while labour force participation (LAB) is high at 64.308%, consistent with the region's youthful demographic structure.

Notably, sectoral FDI showed enormous variation. Manufacturing FDI (FDIMAN) exhibited the highest mean value (5,422.68) and standard deviation (11,143.80), reflecting the dominance of manufacturing investments in some countries alongside their complete absence in others. Petroleum sector FDI (FDIOP) averaged 237.09, while mining FDI (FDIMIN) averaged 13.79. Tourism FDI (FDIITE) showed the smallest mean (5.566) and relatively lower variation, suggesting more consistent but smaller-scale investments in the service sector.

Correlation Analysis

The correlation analysis revealed several theoretically anticipated relationships worthy of note. FDI inflows showed positive correlations with NRE (0.309, $p < 0.01$), TOP (0.258, $p < 0.01$), and urbanization (URB = 0.208, $p < 0.01$), but a negligible correlation with EQ (0.002, $p = 0.974$). This preliminary evidence suggests that FDI is attracted to resource-rich, open, and urbanized economies rather than to countries with higher emissions.

Environmental regulation stringency (ERS) exhibited weak and mostly insignificant correlations with most variables, including negative but non-significant associations with FDI (-0.079, $p = 0.300$) and sectoral FDIs. This preliminary finding suggests that regulatory stringency alone does not strongly determine investment patterns—a result that anticipates the regression findings. Importantly, the correlation between ERS and NRE is negative but weak (-0.139, $p = 0.066$), indicating no systematic relationship between resource wealth and regulatory stringency. The interaction terms (ERS×NRE, ERS×TOP) show expected patterns but will be interpreted within the multivariate framework.

The diagnostic test results for all estimated models are as follows. The Hausman test results (χ^2 ranging from 1.21 to 7.22, all $p > 0.05$) indicated that random effects would be statistically preferred over fixed effects across all specifications. However, given the theoretical justification for controlling for time-invariant country-specific heterogeneity (geography, colonial history, legal system origins) and the presence of cross-sectional dependence, the fixed effects estimator with Driscoll–Kraay standard errors remained appropriate.

The heteroskedasticity tests revealed significant presence of heteroskedasticity in Equations 4, 5, 5a, 5b, and 5c (all $p < 0.01$), justifying the use of robust standard errors. Only Equation 5d (tourism) showed no evidence of heteroskedasticity ($p = 0.813$). Cross-sectional dependence tests indicated significant dependence in Equation 4 ($Z = 3.815$, $p = 0.0001$) and Equation 5b ($Z = 3.724$, $p = 0.0002$), confirming the need for the Driscoll–Kraay correction which explicitly addresses cross-sectional dependence. Serial correlation was detected in equation 5d ($F = 32.548$, $p = 0.000$), further validating the chosen estimation approach. Normality tests showed that residuals were normally distributed across all specifications (all $p > 0.05$), satisfying this classical assumption. Variance Inflation Factor (VIF) values ranged from 1.27 to 1.47, all substantially below the threshold of 10, confirming the absence of multicollinearity concerns.

Regression Results for Total FDI Inflows

Table 2 presents the results for the total FDI inflows model, which tests whether environmental regulations deter FDI (PHH) and whether natural resource endowments attract FDI (RHH).

The coefficient on ERS was positive but statistically

insignificant (β = 0.00023, p = 0.933). This definitively rejected the pollution haven hypothesis for total FDI inflows into West Africa. There is no evidence that countries with weaker environmental regulations attract more FDI. Conversely, there is no evidence that stricter regulations deter investment. This finding aligns with Adu and Denkyirah (2019), who found no PHH evidence for 10 ECOWAS countries, and with Eskeland and Harrison (2003), who found no robust evidence that multinationals relocate due to environmental costs. It contradicts studies such as Cole and Elliott (2005) and Copeland and Taylor (2004) that found PHH support in broader samples. Several interpretations emerge. First, environmental compliance costs may represent a sufficiently small proportion of total production costs that they do not influence location decisions, especially compared to labour costs, infrastructure quality, and market access. Second, West African environmental regulations may be sufficiently homogeneous or weakly enforced that variation does not create meaningful cost differentials. Third, multinational firms may be subject to home-country regulations or international standards that override host-country regulatory differences.

The coefficient on NRE was positive, large, and highly significant (β = 0.31, p = 0.003). A one percentage point increase in natural resource rents as a share of GDP increased FDI inflows by approximately 0.31 percentage points of GDP. This strongly supports the resource haven hypothesis (RHH) and suggests that resource-seeking motivation dominates FDI location decisions in West Africa. This finding is consistent with a substantial body of literature on African FDI. Adams and Klobodu (2018) found that FDI in Sub-Saharan Africa is driven more by natural resources than environmental leniency. Asiedu (2006) identified natural resources as a primary determinant of FDI in Africa. The finding also aligns with the OLI paradigm's location advantages component, which identifies natural resource endowments as a key factor explaining FDI patterns.

Labour force participation (LAB) exerted a strong positive effect (β = 0.31, p = 0.000), indicating that countries with larger labour forces attract significantly more FDI. This supports the factor endowment theory underlying the RHH, suggesting that labour-abundant countries benefit from FDI seeking lower production costs. Given West Africa's demographic profile, this finding suggests that the region's "demographic dividend" potential extends to FDI attraction.

Infrastructure quality (INFR) showed a strong positive effect (β = 0.11, p = 0.001), confirming that electricity access—as a proxy for infrastructure development—is crucial for FDI attraction. Trade openness (TOP) also positively affected FDI (β = 0.14, p = 0.010), indicating that countries integrated into global markets receive more investment. The exchange rate (EXC) coefficient was positive but insignificant (β = 0.03, p = 0.154), suggesting that while exchange rate stability may matter, it is not a primary determinant in this sample.

Table 2

Driscoll–Kraay Standard Errors Results for Total FDI Inflows

Variable	Coefficient	p-value
ERS	0.00023	0.933
NRE	0.3093	0.003***
LAB	0.3115	0.000***
GDP	-0.0751	0.044**
INFR	0.1097	0.001***
TOP	0.1351	0.010***
EXC	0.0306	0.154
ERS*NRE	0.00122	0.004***
ENER	-0.0846	0.011**

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

Interestingly, GDP per capita had a negative effect (β = -0.08, p = 0.044), indicating that wealthier West African countries attract less FDI as a share of GDP. This may reflect diminishing returns or that poorer countries offer greater growth opportunities and lower labour costs. Energy intensity (ENER) showed a negative effect (β = -0.08, p = 0.011), suggesting that energy-inefficient economies deter investment—consistent with firms seeking operational efficiency.

The ERS×NRE interaction term was positive and significant (β = 0.0012, p = 0.004). This important finding indicates that stronger environmental regulations enhance—rather than diminish—the positive effect of natural resources on FDI attraction. In other words, resource-rich countries with stronger environmental regulations attract even more FDI than resource-rich countries with weak regulations. This suggests that multinational resource extraction firms prefer stable, well-regulated environments that reduce regulatory uncertainty and reputational risks. This finding challenges the conventional PHH logic that environmental regulations deter investment and instead supports a "regulatory quality" hypothesis where good governance complements resource wealth.

Sectoral Regression Results

Mining Sector FDI

The mining sector results in Table 3 provide insights into pollution-intensive FDI determinants. Environmental regulation stringency (ERS) had a negative coefficient (β = -0.0086) but was statistically insignificant (p = 0.668), indicating that regulatory stringency does not significantly deter mining FDI. This weakens the PHH argument for the mining sector specifically. Natural resources (NRE) showed a positive but marginally insignificant effect (β = 1.37, p = 0.114), which may reflect that mining FDI is more sensitive to specific mineral endowments rather than aggregate resource rents. Trade openness (TOP) positively affects mining FDI (β = 0.56, p = 0.048), while exchange rate (EXC) exhibited weakly significant positive effects (β = 0.054, p = 0.083).

The interaction term ERS×NRE was positive and significant (β = 0.0063, p = 0.022), again demonstrating that stronger regulations complement resource endowments in attracting mining investment. This finding aligns with institutional theories suggesting that multinational mining firms prefer countries with predictable regulatory environments that protect their long-term investments.

Table 3
Driscoll–Kraay Standard Errors Results for FDIMIN

Variable	Coefficient	p-value
ERS	-0.0086	0.668
GDP	-0.3130	0.114
NRE	1.3691	0.114
LAB	-0.0014	0.998
INFR	0.1814	0.123
TOP	0.5645	0.048**
EXC	0.0536	0.083*
ERS*TOP	0.0026	0.344
ERS*NRE	0.0063	0.022**
ENER	-0.0345	0.823

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

Manufacturing Sector FDI

Manufacturing FDI results (Table 4) showed several significant determinants. Natural resource endowments (NRE) positively affected manufacturing FDI (β = 637.9, p = 0.056), suggesting that even manufacturing investment is attracted to resource-rich countries—possibly through backward linkages or resource-processing activities. Infrastructure (INFR) strongly attracts manufacturing FDI (β = 153.9, p = 0.044), confirming the importance of electricity access for industrial development. Trade openness (TOP) showed weakly significant positive effects (β = 210.70, p = 0.080), while exchange rate (EXC) positively affects manufacturing FDI (β = 48.067, t = 2.76, p = 0.020). Environmental regulation (ERS) had a negative but insignificant coefficient (β = -1.68, p = 0.831), again rejecting PHH for this pollution-intensive sector. The ERS×NRE interaction was positive and significant (β = 3.25, p = 0.035), reinforcing the pattern that regulatory stringency and resource endowments are complements rather than substitutes.

Table 4
Driscoll–Kraay Standard Errors Results for FDIMAN

Variable	Coefficient	p-value
ERS	-1.680	0.831
GDP	-149.452	0.252
NRE	637.896	0.056*
LAB	-237.437	0.388
INFR	153.899	0.044**
TOP	210.699	0.080*
EXC	48.067	0.020**
ERS*TOP	0.266	0.830
ERS*NRE	3.246	0.035**
ENER	65.653	0.312

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

Petroleum Sector FDI

In Table 5, petroleum sector results most strongly supported the RHH. Natural resource endowments exerted a large positive effect (β = 19.99, p = 0.003), confirming that oil and gas reserves are primary drivers of petroleum FDI. Labour endowment exhibited a negative effect (β = -16.37, p = 0.010)—unlike the aggregate FDI result—suggesting that petroleum investment is capital-intensive rather than labour-seeking. Infrastructure quality strongly attracted petroleum FDI (β = 6.79, p = 0.001), as does trade openness (β = 1.86, p = 0.045). Environmental regulation (ERS) exhibited a negative but insignificant coefficient (β = -0.100, p = 0.576), rejecting PHH. The ERS×NRE interaction is positive and weakly significant (β = 0.0533, t = 2.01, p = 0.072), providing modest evidence that regulatory quality complements resource extraction in the petroleum sector.

Table 5
Driscoll–Kraay Standard Errors Results for FDIOP

Variable	Coefficient	p-value
ERS	-0.1000	0.576
GDP	-2.1304	0.380
NRE	19.9850	0.003***
LAB	-16.3726	0.010***
INFR	6.7932	0.001***
TOP	1.8579	0.045**
EXC	1.1539	0.316
ERS*TOP	-0.0067	0.708
ERS*NRE	0.0533	0.072*
ENER	0.2331	0.812

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

Table 6
Driscoll–Kraay Standard Errors Results for FDIITE

Variable	Coefficient	p-value
ERS	0.0043417	0.232
GDP	0.0464973	0.375
NRE	-0.1467529	0.034**
LAB	-0.0494414	0.167
INFR	-0.0091238	0.621
TOP	0.0174443	0.492
EXC	-0.0561536	0.078*
ENER	0.0601180	0.025**
ERSTOP	0.0004899	0.048**
ERSNRE	-0.0010051	0.004***

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

Tourism Sector FDI

The tourism sector—representing a "clean" sector with minimal direct pollution—provides an important comparison. In Table 6, environmental regulation displayed a positive but insignificant coefficient (β = 0.0043, p = 0.232), suggesting that regulations do not deter tourism FDI—logical since environmental quality is an input to tourism attractions. Natural resource endowments negatively affected tourism FDI (β = -0.15, p = 0.034), indicating that resource-rich countries attract less tourism investment, possibly due to crowding-out effects or the "resource curse" diverting attention from service sector development. Energy intensity positively affects tourism FDI (β = 0.060, p = 0.025), which may reflect that tourism development requires energy infrastructure. Notably, the ERS×TOP interaction was positive and statistically significant (β = 0.0005, p = 0.048), while ERS×NRE was negative and significant (β = -0.001, p = 0.004). This suggests that in the tourism sector, regulatory stringency complements trade openness but works against resource endowments—a pattern distinct from the pollution-intensive sectors.

Overall, the 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. Two overarching patterns emerge. First, natural resources, not regulatory laxity, drive FDI. The consistent positive effects of NRE across models, coupled with insignificant or negative ERS 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. Second, environmental regulation and resource endowments are complements, not substitutes. The consistently positive ERS×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 & van der Linde, 1995) extended to location

decisions—well-designed regulations can enhance competitiveness.

The sectoral results reveal important heterogeneity. While mining, manufacturing, and petroleum sectors all show resource-driven FDI patterns, the tourism sector exhibits a different logic where natural resources actually deter investment. This suggests that policies to attract FDI must be sector-specific, recognizing that "clean" and "pollution-intensive" sectors respond to different incentives. The finding that infrastructure quality (INFR) and trade openness (TOP) consistently attract FDI across sectors underscores that traditional investment climate factors remain crucial. West African countries seeking to attract sustainable FDI should prioritize electricity access, trade facilitation, and regulatory predictability—rather than engaging in a race to the bottom on environmental standards.

Compared with existing literature, these findings converge with studies finding PHH rejection in Africa (Adu & Denkyirah, 2019; Tenaw, 2020) but diverge from those finding PHH support (Okafor, 2018; Özsalman et al., 2025). The divergence likely reflects differences in methodology (sectoral vs. aggregate data), time periods, and the specific countries sampled.

Conclusion

This study set out to test the validity of the PHH and RHH in West Africa. By applying fixed effects estimation with Driscoll–Kraay standard errors to panel data from 16 West African countries (2014–2024), the study simultaneously tested the two hypotheses and arrived at clear, policy-relevant conclusions. The first of these is that the PHH finds no empirical support in West Africa. Environmental regulation stringency does not significantly deter total FDI inflows, nor does it deter FDI in pollution-intensive sectors including mining, manufacturing, and petroleum. There is no evidence that countries with weaker environmental regulations attract more investment, and conversely, no evidence that stricter regulations repel investment.

Second, the RHH finds strong and consistent support. Natural resource endowments are the primary driver of FDI attraction across total FDI and pollution-intensive sectors. Labour endowment, infrastructure quality, and trade openness also significantly attract investment. The region's resource wealth—not regulatory laxity—explains FDI patterns. Third, and most importantly, environmental regulations and natural resource endowments act as complements rather than substitutes. The consistently positive interaction effects (ERS×NRE) across multiple models indicate that resource-rich countries with stronger environmental regulations attract more FDI than resource-rich countries with weak regulations. This finding fundamentally challenges the regulatory arbitrage logic underlying PHH and suggests that institutional quality enhances—not diminishes—investment attractiveness.

This study makes several theoretical contributions. First, by explicitly testing the two hypotheses within a single unified framework using the OLI paradigm, it resolves the fragmentation in existing literature where studies typically examine only one of the hypotheses. Second, the finding that regulations and resources complement each other advances theoretical understanding beyond the simple trade-off model that dominates policy discourse. Third, the sectoral analysis reveals that while resource-seeking dominates pollution-intensive sectors, the tourism sector follows a different logic—suggesting the need for sector-specific theoretical extensions.

The policy implications are clear and actionable. West African governments should resist the temptation to weaken environmental regulations as an investment promotion strategy. Such a race-to-the-bottom approach would be ineffective (since regulations do not deter FDI) and counterproductive (since West Africa already benefits from FDI's halo effects). Instead, policymakers should (1) strengthen environmental regulations and enforcement; this enhances rather than harms investment attractiveness by signalling institutional quality and reducing regulatory uncertainty; (2) invest in infrastructure, particularly electricity access, which consistently attracts FDI across sectors; (3) leverage natural resource endowments while using regulatory frameworks to ensure resource extraction contributes to sustainable development, and (4) promote trade openness while ensuring that environmental standards keep pace with integration into global markets. By strengthening institutions, investing in infrastructure, and maintaining robust environmental standards, West African countries can harness foreign investment for sustainable development without sacrificing either growth or the environment. The resource haven need not become a pollution haven.

This study is subject to certain limitations. First, the study period (2014–2024) is relatively short by panel data standards, though necessary due to data availability for sectoral FDI. While a longer time series would enhance the credibility of the estimates, the current timeframe

still provides meaningful insights into recent trends in West Africa. Second, environmental regulation stringency is measured through policy indices that may not capture enforcement intensity or implementation effectiveness. Third, the study cannot fully account for the heterogeneity of FDI source countries, which may have different environmental standards. Fourth, the study employs a regional panel comprising sixteen West African countries and therefore focuses on average relationships across the region. While this approach is appropriate for identifying broad regional patterns, it may conceal country-specific heterogeneity arising from differences in institutional quality, environmental governance, resource dependence, and economic structure. The results should be interpreted as regional tendencies. Despite these limitations, the study provides important evidence on the interaction between foreign direct investment, environmental regulation, natural resource endowments, and environmental quality in West Africa.

Future research should extend the analysis by (1) examining individual countries or sub-regional clusters to uncover local dynamics and distinguishing FDI by source country (e.g., China vs. OECD countries) to test whether "origin effects" moderate environmental outcomes; (2) incorporating firm-level data to examine the mechanisms through which halo effects operate; (3) employing alternative environmental quality measures beyond CO_2, including water pollution, air quality, and biodiversity impacts; (4) investigating the role of bilateral investment treaties and their environmental provisions; and (5) conducting qualitative case studies to understand how multinational firms navigate regulatory environments in practice.

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Neposredne tuje naložbe v Zahodni Afriki: sektorski dokazi o hipotezah o zatočišču onesnaževanja in zatočišču virov

Izvleček

S pomočjo sektorske analize neposrednih tujih naložb (FDI) v povezavi s strogostjo okoljskih predpisov (ERS) in naravnimi viri (NRE) ta študija preučuje veljavnost hipoteze o zatočišču pred onesnaževanjem (PHH) in hipoteze o zatočišču virov (RHH) za Zahodno Afriko. Na podlagi panelnih podatkov za šestnajst zahodnoafriških držav v obdobju od 2014 do 2024 študija uporablja model s fiksnimi učinki in standardnimi napakami Driscoll–Kraay za hkratno ovrednotenje obeh hipotez. Rezultati so pokazali, da ERS ni bistveno vplival na skupni priliv FDI. Nasprotno pa sta se NRE in razpoložljivost delovne sile izkazala kot ključna gonilna sila FDI, kar močno podpira RHH. Ključno je, da je sektorska analiza razkrila znatno heterogenost med panogami: FDI v rudarskem, proizvodnem in naftnem sektorju so bili pretežno usmerjeni v iskanje virov, kar je v skladu tako z RHH kot s PHH, medtem ko so se FDI, povezani s turizmom, zmanjševali z večjo razpoložljivostjo virov. Poleg tega pozitivna interakcija med ERS in NRE kaže, da strožji okoljski predpisi dopolnjujejo naložbe, usmerjene v pridobivanje virov, namesto da bi jih odvračali. Študija zato zagovarja krepitev okoljskih institucij, izboljšanje upravljanja virov in spodbujanje zelenih naložbenih strategij za pospeševanje trajnostnega razvoja v Zahodni Afriki.

Ključne besede: neposredne tuje naložbe; hipoteza o zatočišču onesnaževanja; neposredne tuje naložbe zaradi iskanja virov; sektorske neposredne tuje naložbe; standardne napake po Driscollu-Kraayu