Environmental Impact of Foreign Direct Investment: The Role of Economic Complexity in Sub-Saharan Africa

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This study investigates the short-run and long-run effects of foreign direct investment (FDI), corruption, and economic complexity on the environment in twenty-five sub-Saharan African (SSA) countries from 1996 to 2018. Using a dynamic panel data model, the results provide broad support for the pollution haven hypothesis and the existence of the environmental Kuznets curve in SSA. Our results indicate that the economic complexity index (ECI) is associated with rising environmental degradation. Low-quality FDI weakens environmental standards, and corruption facilitates the shift of polluting industrial activities from advanced countries to developing countries with less strict environmental rules. The paper finds that corruption, low quality FDI, and higher ECI tend to exacerbate environmental degradation in SSA. By considering the ECI, this studies contributes to the literature, analyzing the relationship between these key variables and the environment for some of the most vulnerable African countries that are said to be greatly impacted by climate change.

Keywords: SSA, economic complexity index, environmental degradation, corruption, foreign direct investment

INTRODUCTION

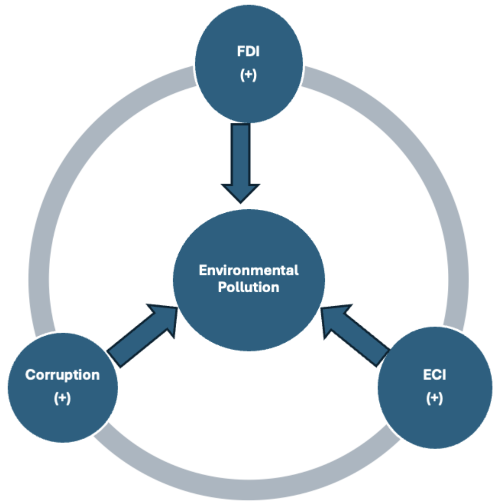
Despite its abundance of diverse natural landscapes (or resources) and unique biodiversity, Sub-Saharan Africa (SSA) faces complex environmental challenges and economic inequalities in the 21st century. As the world becomes increasingly interconnected and interdependent, the environmental challenges the region faces are influenced by several factors, three of which are the focus of this study: foreign direct investment (FDI), economic complexity index (ECI), and corruption. This work examines the complex relationships between these factors and their environmental impacts in SSA. FDI inflows to SSA has become a key element of economic development, and SSA has become an attractive destination for foreign investment because of its rich natural resources and emerging markets. According to Nwaogu and Michael (2015), FDI has been a key driver of economic growth, technological transfer, and newer employment opportunities. Even though African countries have benefited from FDI inflow, particularly from China, it is still unclear if this surge in capital inflows will contribute to sustained long-run growth. Also, the risk of environmental degradation is greater with FDI inflows to SSA, as corporations seek to maximize profits with little regard for environmental consequences. Moreover, corruption is a vital issue in SSA and has far-reaching implications. It can distort economic incentives, weaken environmental regulations, and lead to resource misallocation, fostering unsustainable development practices. Thus, it is critical to understand the connection between corruption and environmental issues while also investigating how FDI inflows and other macroeconomic variables affect environmental degradation in SSA countries.

Our paper aims to integrate these important areas of literature with the Economic Complexity Index (ECI). The ECI, developed by Ricardo Hausmann and Cesar Hidalgo (2011), is a multidimensional metric that reflects a country's economic diversification and sophistication and ranges from about -2.5 to 2.5. A higher ECI is often associated with economic resilience and long-term sustainability with technology-intensive industries. Conversely, countries with lower or negative ECI typically rely on fewer, simpler goods for export, such as agricultural products or raw materials. SSA countries are characterized by low ECI, which can limit the capacity for innovation and lead to a reliance on resource-based industries, and therefore, can have negative environmental repercussions. Therefore, we hypothesize that increased economic complexity in a country correlates with higher environmental pollution due to more industrial activities and complex manufacturing.

As low quality of FDI inflow increases, environmental degradation worsens especially in developing countries due to weak or lenient environmental regulations. This statement has been studied extensively in the literature and has recently received many important contributions. Leal et al. (2021) shows that FDI plays a negative critical role on environmental pollution. Leal and Marques (2021) empirically confirm this relationship as well in some SSA countries. They suggest that strict regulation reduces the level of corruption and thus mitigates environmental pollution. Sarmidu et al. (2015) points this fact in a different direction, suggesting that developing countries either accept FDI without asking the quality for more economic growth, or scrutinize FDI and only accept those with better quality in order to help the environment. Conducting a similar research and analysis in other countries, Wang et. al. (2020) finds that because of corruption, low quality of FDI causes environmental pollution in China. Another line of research in this area focuses on the quality of institutions and corruption and how these affect the quality of FDI in the MENA region (Bardi and Hfaiedh, 2021). Assa (2017) notes that forest area in SSA has been affected negatively from FDI inflows. Conceptually, greater corruption in a country exacerbates environmental pollution by weakening enforcement of environmental regulations. Also, FDI leads to more environmental pollution in developing countries than in developed ones that generally have more stringent environmental policies and strong enforcement.

Our paper tests and supports these hypotheses for SSA countries with scarce empirical literature on determinants of environmental quality. This paper finds that corruption, low quality FDI and higher ECI tend to exacerbate environmental degradation (pollution) in SSA. Moreover, we extend the existing literature by incorporating the ECI into our methodology and analysis in order to examine the short-term and long-term effects of FDI, corruption, and economic diversification on environmental pollution for twenty-five SSA countries between 1996-2018. Our results support the pollution haven hypothesis with the existence of the Environmental Kuznets Curve in SSA. Additionally, we show how ECI, FDI, and the interaction between corruption and FDI play a significant role in environmental degradation.

FIGURE 1
GRAPHICAL REPPRESENTATION OF EXPECTED EMPIRICAL OUTCOMES



Based on the above discussions, Table 1 proposes the following hypotheses to be investigated.

TABLE 1
HYPOTHESES PROPOSED IN THE STUDY

$\boldsymbol{H_1}$	*ECI will positively affect environmental pollution.*
$\boldsymbol{H_2}$	*Greater corruption in a country exacerbates environmental pollution.*
$\boldsymbol{H_3}$	*Foreign direct investment leads to more environmental pollution in developing countries.*

The rest of the paper is organized as follows. We initially discuss a brief literature review in section 2, making connections and identifying gaps we seek to fill. In the methodology section, we outline the test procedures and estimator used to estimate the short-term and long-term effects of the macroeconomic variables on the environment. Section 4 introduces the data and sources of the data, the descriptive statistics, and discusses the empirical outcomes. The paper ends with a summary of the main results and few remarks on future research and policy implications.

LITERATURE REVIEW

The literature on the impact of FDI, Economic Complexity Index (ECI), and corruption on the environment, particularly in Sub-Saharan Africa, reveals a complex interplay of factors influencing environmental quality. Research indicates that while FDI can spur economic growth, its environmental impact is mediated by the quality of governance and regulatory frameworks in the host countries. Bardi and Hfaiedh (2021) study these complex relationships in the MENA region and support the causal correlation between FDI, corruption, and environmental quality, finding evidence that supports the pollution haven hypothesis. It suggests corrupt practices and weak institutional frameworks exacerbate environmental degradation by attracting pollution-intensive industries through FDI (Bardi & Hfaiedh, 2021). Further expanding on this theme, Omri, Daly, Rault, and Chaibi (2015) examine the interconnectedness of carbon dioxide (CO_2) emissions, financial development, trade, and economic growth, revealing a bidirectional causality between CO_2 emissions and economic growth. This work underscores the complexity of the linkage between economic activities, including FDI, and their environmental impacts in the MENA region, which could offer parallel insights for Sub-Saharan Africa (Omri et al., 2015).

Another pertinent study by Lau, Choong, and Eng (2014) investigates the effect of institutional quality and economic growth on CO_2 emissions in Malaysia. Their findings, indicating a positive correlation between institutional quality, economic growth, and environmental quality, emphasize the role of robust governance in mitigating the adverse effects of FDI on the environment (Lau et al., 2014). Moreover, the work of Ali et al. (2019) across 47 developing countries demonstrates that higher institutional quality significantly reduces CO_2 emissions. Additionally, a state-level study in the U.S. shows similar findings, indicating that an increase in the human development index helps to reduce carbon emissions in the short run, consistent with the studies mentioned above (Batmaz et al., 2023). This suggests that improving governance and reducing corruption can be critical in enhancing environmental outcomes in the context of FDI (Ali et al., 2019).

Hfaiedh and Bardi (2021) delve into Tunisia's experience, revealing how FDI linked with corruption can shift pollution-intensive industries to nations with looser environmental regulations, endorsing the pollution haven hypothesis and suggesting a push for energy-efficient and sustainable growth policies. Cole, Elliott, and Fredriksson (2006) introduce a political economy model that articulates how FDI's influence on environmental regulations is significantly swayed by government corruption, positing a dual scenario where corruption levels dictate the stringency of environmental policies. Sarmidi, Shaari, and Ridzuan (2015) further explore this relationship, indicating that while environmental stringency may deter FDI, lower corruption levels can mitigate this effect, underscoring the role of good governance in attracting ethical FDI. Together, these studies highlight the critical balance between attracting FDI and maintaining environmental integrity, especially in regions with loose environmental regulations and poor governance like SSA that are most vulnerable to attracting low quality FDI.

The collective research emphasizes the complex dynamics between FDI, governance, environmental degradation, and policy frameworks across various regions, including SSA and China. Assa (2017) identifies how FDI negatively impacts forest cover in SSA, influenced by governance quality. Leal, Caetano, and Marques (2021) explore the roles of FDI, globalization, and governance in environmental outcomes, advocating for policies that balance economic growth with environmental sustainability. Our analysis also uses control of corruption as a proxy for corruption. This implies that as control of corruption increases, governance performance improves and will attract more FDI and possibly worsen the environment, depending on the type of FDI inflow. However, an increase in corruption control on its own should positively affect environmental pollution. Wang, Wang, and Sun (2020) demonstrate the exacerbating effect of corruption on environmental pollution due to FDI in China, emphasizing the need for strong governance. Bildirici’s (2021) work extends the discussion to the Middle East and SSA, showing a significant relationship between governance, FDI, and CO2 emissions. Kim and Adilov (2012) provide a nuanced view on the FDI-pollution nexus, suggesting FDI's impact varies by region and can potentially lead to cleaner technologies. This body of literature collectively underscores the complex relationship between economic development, environmental sustainability, and the pivotal role of governance, offering insights for navigating the challenges and opportunities of FDI in SSA.

Finally, this paper extends the current literature by highlighting the impact of the ECI on the environment. A high ECI value in developing countries is associated with increased environmental degradation. As countries try to diversify exports and increase manufacturing base, that would worsen environmental quality. Also, developing countries have limited resources to invest in cleaner energy and production methods, especially at the early stages of development. Some studies have theoretically and empirically supported this negative relationship between ECI and environmental degradation. Dogan et al. (2020) identified that economic complexity exacerbated environmental pollution in both lower and higher middle-income countries. Boleti et al. (2021) observed a negative correlation between economic complexity and air quality globally. Similarly, Neagu and Teodoru (2019) noted that a higher ECI is linked to a greater risk of pollution. We test this hypothesis for the SSA countries both in the short- and long-run.

METHODOLOGY

To estimate the short-term and long-term effects of FDI, corruption, and economic complexity on the environment we employ the autoregressive distributed lagged (ARDL) model. The ARDL model has a reparameterization in error correction (EC) form, equivalent to cointegration of non-stationary variables. This model has been widely utilized in the literature to analyze the relationship between economic variables in a time series context (Engle & Granger, 1987; Hassler &Wolters, 2006). We can evaluate the presence of a long-run cointegrating relationship using the Error Correction presentation. This method distinguishes between long-run relationships and short-run dynamics and applies to panel data analysis through the Pooled Mean Group model. The PMG is a single equation estimator introduced by Pesaran, Shin, & Smith (1999) for averaging and pooling samples. This estimator is dynamic, producing steady-state values over time. The African countries we focus on are connected by similar stages of development and equilibrium forces, despite some heterogeneity in the time series of individual countries. The PMG is appropriate because it provides reliable estimation for the average short-run coefficients by taking the straightforward average for each country. In addition, PMG estimators remain consistent and efficient, assuming that slope homogeneity is maintained over time (Azenui, 2023).

A powerful characteristic of the PMG model is its flexibility in handling variations across different panels. Specifically, the model permits short-run coefficients, such as intercepts, error variances, and the speed of adjustment, to differ from one panel to another, reflecting the unique characteristics of each country. In contrast, the long-run slope coefficients, or steady-state values, are assumed to be uniform across countries. This uniformity is particularly advantageous when the long-run equilibrium relationship between variables is anticipated to be consistent across all countries or within a specific group of countries, ensuring that these countries ultimately converge to a common steady state. The model's ability to accommodate country-specific coefficients in the short run is especially valuable given the diverse responses that different countries may exhibit in reaction to economic shocks and policy changes. By allowing for this short-run heterogeneity, the PMG model enables us to accurately estimate the long-run equilibrium relationship without overlooking the distinct short-term dynamics unique to each country. This dual capability makes the PMG model a powerful tool for capturing both the shared long-term trends and the individual short-term adjustments of countries in a given dataset (Azenui, 2023).

Thus, the PMG estimator is the most suitable choice for this analysis, as recommended by the paper's objective, the data from the sample African countries, and the results of the Hausman test. This estimator is particularly effective as it addresses potential endogeneity issues that the data may present. The PMG model is uniquely equipped to accommodate country-specific variations in short-run coefficients, allowing for heterogeneity across the sample. At the same time, it tests for a long-run cointegrating relationship, leveraging the error correction framework discussed earlier. This combination of features makes the PMG estimator the optimal tool for capturing both the common long-term trends and the distinct short-term dynamics within the sample of African countries.

We specify the re-parameterized ARDL (p, q) EC model in equation (1) for analyzing the link between environmental degradation and corruption and other independent variables both in the short-term and over time. Specifically, we explore the strength of the association between the rate of change in environmental pollution and factors that impact the environment.

$$\Delta y_{it} = \theta_i \left[y_{i,t-1} - \lambda_i' X_{i,t}\right] + \sum_{j-1}^{p-1} \xi_{ij} \Delta y_{i,t-1} + \sum_{j=0}^{q-1} \beta_{ij}' \Delta X_{i,t-j} + \varphi_{it} + e_{it} \qquad (1)$$

where y_{it} depicts a change in country *i*'s environmental pollution (which is ecological footprint) across time periods *t* and *t-1*. θ_i is the group-specific speed of adjustment coefficient, also known as the error correction term (ECT). The anticipated value of θ_i is expected to be negative, assuming the variables naturally move back towards a long-term equilibrium (Pesaran, Shin, & Smith, 1999). $y_{i,t-1}$ represents the lag dependent variable, while ***Xi,t*** comprises the vector of long-term associations, with their corresponding result coefficients λ. The β_{ij}' pertains to the short-term coefficients, which may vary by country and be averaged across nations. The unit-specific fixed effects are denoted by φ_{it} and the error term is given as e_{it}. Finally, p and q represent the optimal lag lengths.

DATA, DESCRIPTIVE STATISTICS, AND DIAGNOSTICS

Our analysis uses annual macroeconomic data for SSA countries from 1996 to 2018, collected from secondary sources. The complete dataset contains 575 data points, derived from 25 SSA nations over 23 years. The models incorporate first differences, and we run it with ECI that only has 567 observations, which trims the data points and reduces the data more, giving us the most balanced panel dataset with 542 observations.

The main explanatory variables are economic complexity index (eci), corruption (cor), foreign direct investment (FDI), and gross domestic product per capita (gdp_pc). Gross domestic product (GDP) and FDI data is collected from the World Bank World Development Indicators (WDI) while population is obtained from the United Nations National Accounts. FDI data represent net inflows, and this indicator is calculated as ratios of nominal GDP. ECI is collected from Harvard Growth Lab (Atlas of Economic Complexity), and corruption is collected from the Worldwide Governance Indicators (WGI). We use *control of corruption* as the measure of corruption from the WGI database. Control of corruption is a yearly estimate in standard normal units ranging from approximately -2.5 to 2.5. A value of -2.5 implies weak governance performance while 2.5 indicates strong governance performance. The values for the SSA countries in the dataset range from about -1.8 to 0.75 with most countries and for most years having negative corruption control values, insinuating that most of these countries have weak governance performance. According to the basic indicators on Table 1 below, most observations of our main explanatory variables are close to the mean as indicated by the relatively small standard deviations. The range for some variables particularly population and FDI/GDP ratio are wide, indicating variations and diversity across the countries in the panel.

TABLE 2
DESCRIPTIVE STATISTICS OF MAIN EXPLANATORY VARIABLES

Variables	observations	Average	Standard deviation	Minimum	Maximum
eci	567	-0.923	0.513	-2.337	0.368
cor	575	-0.639	0.592	-1.72	1.22
ecological footprint_pc	575	1.385627	0.7707231	0.010074	4.539
fdi_gdp	575	84899.12	75299.69	28	280368
gdp_pc	575	281.1461	161.1413	1	549
gdp_pcsq	575	104964.5	92062.17	1	301401

Before estimating the PMG model, we run some diagnostic tests that the literature considers important when analyzing panel ARDL. These diagnostics include cointegration and panel unit root tests, with results reported in the appendix. Based on our cointegration test results, we reject the null hypothesis of no cointegration because the absolute value of the test statistics is greater than 2. Therefore, our panel exhibits cointegration among the variables. The validity of the statistical estimates depends on the stationarity of the time series and panel data used, which we assess using unit root tests. The results are reported in the appendix. Based on the panel unit root test, we reject the null hypothesis that the variables are non-stationary. So, the variables used in our analysis as well as the panels are considered stationary.

ESTIMATION RESULTS

Table 2 presents the estimates from the PMG model, with a column for results without the FDI and corruption interaction term and the last column showing the model with an interaction term between FDI and corruption. The long-term coefficients of interest are initially reported, then the EC speed of adjustment parameter is presented. The table ends with the average of the short-term coefficients across all countries. The long-term estimates suggest a long-term equilibrium, indicating that all nations will eventually converge. Assuming a consistent steady-state, the long-term equilibrium relationship between the variables remains similar across countries. However, the short-term coefficients differ by country due to the varying responses to shocks and policies. This is why we report the short-term averages, while making the country specific short-term outcomes available upon request. The EC coefficient is negative and statistically significant across models at the five percent level; thus, the variables tend to return the long-term steady-state. This signifies long-run cointegration among the variables in the panels and across the full sample, with a one percent significance level. The ECT is approximately -0.28, which implies that the variable in our model converges 28% per year towards the long-term equilibrium if there is an exogenous shock or policy in the short-run. Thus, it takes about 3.5 years to eliminate any disequilibrium created at the beginning.

The PMG results suggest that only GDP per capita significantly affects environmental pollution in the short run for the SSA countries. As production and therefore output per person increases in the SSA countries, more pollutants are emitted into the atmosphere and waste dumped into the rivers and oceans, which worsens environmental quality. Though the long-run coefficient for per capita GDP is statistically insignificant for the SSA countries, it is substantially small and even negative in the model without the interaction between corruption and FDI. This supports the environmental Kuznet curve, which hypothesizes that environmental impacts or carbon emissions per person follow an inverted U-shaped pattern in relation to income per capita. (Kwabena et. al., 2017; Dinda, 2004).

We also ran a fixed effect model with level and squared terms for GDP per capita to test the Kuznet's hypothesis (results from the fixed effect model are presented on appendix 2). The results show that both coefficients were statistically significant, with the level term having a positive sign and a negative coefficient for the GDP per capita squared term. This conforms with our PMG results and expectation that environmental degradation will increase with rising GDP per capita, especially in the short run, but not necessarily linearly forever. As the results indicate, degradation of the environment would peak at some point, and then decline as rising per capita income leads to more awareness and stringent environmental regulations. Thus, the relationship between environmental degradation and GDP per capita initially rises (at a decreasing rate) up to a certain point and then levels off and falls after a certain level of GDP per capita. This relationship holds for the SSA countries under analysis.

The results show that our main variable of interest, the ECI, converges to a positive and significant long-run steady state. In other words, an increase in the ECI is associated with rising environmental degradation. As noted earlier, SSA countries are characterized by low ECI, which can limit the capacity for innovation and lead to a reliance on resource-based industries. As these SSA countries increase industrial production and diversify their exports, environmental pollution worsens in the long run.

TABLE 3
PMG MODEL

LR	ef_pc (D1)	Without interaction between FDI and corruption	With interaction between FDI and corruption
	cor	0.136*** (0.0295)	-0.206*** (0.042)
	gdp_pc	-0.0001 (0.0001)	0.00004 (0.00006)
	fdi_share	-0.0000003** (0.0000001)	0.000002*** (0.0000003)
	eci	0.133*** (0.0328)	0.084*** (0.022)
SR	cor*fdi		0.000003*** (0.0000005)
	ECT	-0.2738*** (0.046)	-0.289*** (0.063)
	cor (D1)	-0.006 (0.037)	0.0804 (0.132)
	gdp_pc (D1)	0.002*** (0.0005)	0.002*** (0.0006)
	FDI_share(D1)	-0.00000007 (0.0000001)	0.00000006 (0.0000009)
	eci (D1)	0.011 (0.034)	0.0298 (0.049)
	cor*fdi (D1)		-0.000007 (0.00000098)
	constant	0.491*** (0.000)	0.383 (0.085)
	Number of observations	542	542

Statistical significance for all tables: ***p<0.01, **p<0.05, *p<0.1

The risk of environmental degradation is greater with FDI inflows to SSA, as corporations seek to maximize profits with little regard for environmental consequences. Also, environmental standards and regulations in African countries are much lower and less stringent than developed or more advanced developing countries. A similar outcome has been proven in G-20 economies: FDI inflows and environmental degradation are positively related. (Huang et. al., 2022) Furthermore, corruption is an important issue in SSA and has far-reaching implications. It can distort economic incentives, weaken environmental regulations, and lead to resource misallocation, fostering unsustainable practices by foreign industries. As expected, the steady state coefficient for FDI is significantly positive, confirming the conceptual framework and our initial hypothesis. FDI has a significant positive long-run effect on environmental degradation for the SSA countries. In addition, our results indicate a statistically significant interaction between corruption and FDI. When the level of corruption is interacted with FDI, the influence of FDI on environmental degradation is positive. In other words, a country with better governance performance attracts more FDI inflows and is more likely to have an increase in environmental pollution in the short run. As corruption control improves, it attracts more FDI since foreign companies find it easier to start business and establish in the country with better control of corruption and effective laws. However, the effect of FDI share on environmental pollution will be negative in the long run.[1] With strong governance and better rule of law, FDI companies in host countries will eventually be held accountable for pollution emissions and would find cleaner ways of production. Otherwise, as stated in Huang et al. (2022) and Javorcik and Wei (2003), polluted FDI is more likely to be attracted to countries with high levels of corruption.

Finally, our results postulate that the relationship between corruption and environmental degradation is positive in the model without the interaction between FDI and corruption. Still, corruption has a negative effect on the environment when we control for the interaction between FDI and corruption in the model. As explained in section 4 under data sources, an increase in the corruption coefficient is good since higher values mean better control of corruption or strong governance performance. So, if corruption control increases, then environmental pollution will most likely decrease in the long-run and the rule of law will effectively make polluters accountable (Wang et. al., 2020). Our finding aligns with the literature and supports the environmental Kuznet hypothesis. As countries develop, they become cautious and protective of the environment.

CONCLUSION

Rapid expansion of economic globalization and efforts towards economic growth create a plethora of environmental problems in Sub-Saharan Africa (SSA). The linkage between Foreign Direct Investment (FDI), Economic Complexity Index (ECI), corruption, and environmental degradation has become important in SSA. This paper contributes to scientific research on environmental pollution by investigating the complex relationship between FDI, ECI, corruption, and pollution in some SSA countries. Although there is existing literature on environmental pollution in African countries, research on ECI and environmental pollution via FDI inflows is sparse. Hence, we seek to enhance the existing literature by analyzing the effects of the ECI in the short and long run.

We apply the Pooled Mean Group method to examine how FDI, ECI, and corruption play a critical role in environmental pollution in SSA between 1996-2018. The collection of African countries we analyze are linked by comparable stages of developmental equilibrium, despite the heterogeneity in their individual time series data. Therefore, the PMG method is convenient for this analysis as it provides unchanging estimates of the average short-term coefficients by averaging them across countries individually. According to our PMG results, ECI is significantly and positively related to environmental pollution, which means that more complex production leads to more carbon emissions in SSA, which is in line with the initial hypothesis. Furthermore, FDI and corruption create more environmental issues separately, especially with high levels of corruption. However, when we control for the interaction between FDI and corruption in the model, we conclude that a cleaner environment is associated with better governance. Our results align with the inverted environmental U-shape curve and the pollution haven hypothesis in the literature.

Knowledge of both the theory and evidence reviewed by this paper will enlighten policymakers to pursue greener economic growth efforts and a cleaner environment in SSA. First, the quality of FDI plays a key role in environmental degradation, so countries should not validate the Pollution Haven Hypothesis. As a result of FDI inflows, some African countries may start to produce more complex and diverse products, so it will be necessary to understand the positive relationship between ECI and environmental pollution. Hence, policymakers should consider this. In addition, efficient control of corruption through better law enforcement is indispensable while aiming for a cleaner environment. A better rule of law index will control corruption, reducing environmental pollution. Our study can be extended in a few ways. Since ECI is positively related to environmental degradation, one could explore this relationship further to offer some policies for a cleaner environment. Moreover, human development index variables could be added to the analysis to investigate the importance of human actions and environmental awareness.

ENDNOTE

1. Note that the effect of FDI on ef_pc is the fdi_share coefficient and the cor*fdi coefficient times cor. Since most of the corruption values are negative for the SSA countries, we would be multiplying the coefficient of the interaction term by a negative number.

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APPENDIX: DIAGNOSTIC TESTS RESULTS

Unit Root Test Results for Panel Data

	Levin-Lin-Chu test (6 lags)		Im-Pesaran-Shin test		Harris-Tzavalis test	
Variables	Adjusted t*	p-value	W-t-bar stat	p-value	z-score	p-value
ef_pc	-0.9534	0.1702	-2.7686	0.0028	-10.7357	0.000
FDI	-5.7806	0.000	-7.5395	0.000	-17.1063	0.000
GDP_pc	-4.2426	0.000	-2.5084	0.0061	-7.8564	0.000
eci			-6.6185	0.0061		
cor	-2.803	0.0025	-1.9933	0.0231	-3.1422	0.0008

H0: Panels contain unit roots; H1: Panels are Stationary.

FDI, GDP per capita (GDP_pc), and Economic Complexity Index (ECI) show stationarity across all three tests with very low p-values (significantly less than 0.05). This indicates that these variables do not have a unit root, affirming their stability over time, which makes them suitable for further analysis in time series models without the need for differencing. Conversely, the Ecological Footprint per capita (ef_pc) and corruption (cor) variables demonstrate inconsistent results. The Levin-Lin-Chu test fails to reject the null hypothesis for ef_pc, suggesting it may not be stationary with a p-value of 0.1702. Yet, the Im-Pesaran-Shin and Harris-Tzavalis tests indicate it is stationary, with p-values of 0.0028 and 0.000, accordingly. For the corruption variable, while the Levin-Lin-Chu and Harris-Tzavalis tests suggest stationarity (p-values of 0.0025 and 0.0008), the Im-Pesaran-Shin test points to potential non-stationarity (p-value = 0.0231).

These findings are important for assessing the characteristics of the time series data and selecting suitable econometric models for the analysis.

Fixed Effects Model

ef_pc	without fdi*cor interaction	with fdi*cor interaction
fdi_share	0.00000006 (0.000002)	0.0000001 (0.0000002)
cor	0.002 (0.037)	-0.003 (0.0402)
gdp_pc	0.0012*** (0.0004)	0.0012*** (0.0004)
gdp_pcsq	-0.0000024*** (0.0000006)	-0.000002*** (0.0000006)
eci	0.0401 (0.0298)	0.0406 (0.0299)
cor*fdi		0.00000007 (0.0000002)