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TRADE LIBERALIZATION DYNAMICS AND ECOLOGICAL FOOTPRINTS IN EVOLVING SUB-SAHARAN AFRICAN ECONOMIES

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ABSTRACT

The paper investigated the dynamic relationship between trade liberalization and ecological footprints, across 35 Sub- Sahara African (SSA) economies from 1999 to 2024. Specifically, the paper sought to investigate the impact of foreign direct investment, trade openness, economic growth, globalization, and exchange rates on ecological footprints, proxied by carbon dioxide (CO_2) emissions. Control variables include urbanization, agricultural land use, and energy consumption. With data sourced from the World Development Indicator (WDI) and International Monetary Fund (IMF) bulletins, the study employed the Cross-Sectionally Augmented Autoregressive Distributed Lag (CS-ARDL) technique and Augmented Mean Group (AMG) estimators for robustness. Based on the analysis, the study found that trade openness and FDI inflows significantly increases CO_2 emissions. Globalization (KOF Index) reduces CO_2 emissions and exchange rate depreciation has a weak positive effect on emissions. The error correction term (-0.345) indicates moderate adjustment speed of 34.5% annually. Conclusively, trade liberalization in SSA currently exacerbates CO_2 emissions, but broader globalization offers mitigating pathways. Hence, the paper recommends the inclusion of green FDI screening, renewable energy investment, and environmental development assistance to reduce degradation and protect the environment.

KEYWORDS: Trade liberalization, ecological footprint, CO_2 emissions, Sub-Saharan Africa, Environmental Kuznets Curve, Pollution Haven Hypothesis, panel data, CS-ARDL, globalization, foreign direct investment
JEL Classification: F18, F64, O55, Q56, C33

INTRODUCTION

The discourse surrounding trade liberalization dynamics and ecological footprints in evolving Sub-Saharan African economies encompasses a spectrum of arguments both for and against the relationship.

Proponents of trade openness argue that liberalizing trade policies and attracting foreign investment can lead to improved environmental outcomes. As economies grow, they are more likely to invest in cleaner technologies, promote sustainable practices, and adopt stricter environmental regulations driven by

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public demand and global norms. These arguments align with the EKC, suggesting that wealthier nations with increased economic activity may develop a greater capacity to address ecological challenges.

Conversely, critics of trade liberalization express concern that increased trade can lead to environmental degradation, particularly in developing countries where regulatory frameworks may be insufficient to protect natural resources. They argue that economic growth can catalyze increased production and consumption, resulting in a higher ecological footprint. Given these contrasting perspectives, this study conducts a multi-country exploration in Sub-Saharan Africa to evaluate the relationship between trade liberalization dynamics and ecological footprints, seeking to identify conditions under which trade can yield positive environmental impacts.

Objectives of the study

The study aims to examine the interplay between trade liberalization and ecological footprints in Sub-Saharan African economies. The specific objectives of the study include evaluating the impact of foreign direct investment on the environment, determining the extent to which trade openness contributes to or detracts from ecological outcomes, analyzing the relationship between economic growth and ecological quality, and investigating the effects of exchange rate volatility on environmental practices.

Theoretical Framework

The theoretical framework for this study is primarily grounded on the Environmental Kuznets Curve (EKC) hypothesis, which posits an inverted-U relationship between economic growth and environmental degradation. According to the EKC, pollution levels tend to rise with initial economic growth but eventually decline as a country becomes wealthier and invests in cleaner technologies and regulatory frameworks. This framework provides a lens through which the research can be analyzed, as it implies that economic openness might lead to both positive and negative environmental outcomes depending on the level of development. The EKC thus serves as a critical underpinning in understanding how trade and economic policies interact with environmental impacts. The Environmental Kuznets Curve (EKC) hypothesis was propounded by economists Gene Grossman and Alan Krueger in the early 1990s.

Supporting the EKC hypothesis is the Pollution Haven Hypothesis, formalized by Copeland and Taylor (2004). The hypothesis posits that trade liberalization leads to the spatial relocation of pollution-intensive industries from high-income countries with stringent environmental regulations to low-income countries with weaker regulatory frameworks. Antweiler, Copeland, and Taylor (2001) developed a theoretical model decomposing the environmental effects of trade into scale, composition, and technique effects, finding that for most pollutants, the composition effect is the primary channel through which trade affects emissions. The present study contributes to this debate by examining whether FDI inflows are associated with higher CO_2 emissions in SSA.

Empirical Evidence

Despite growing attention to the trade-environment nexus, SSA remains understudied relative to Asia and Latin America. For instance, Ibrahim and Law (2016) investigated the institutional conditioning of the trade-CO_2 relationship in SSA using panel data from 1984 to 2009. Employing system GMM estimation, they found that trade openness increases CO_2 emissions on average, but this effect is attenuated in countries with stronger institutional quality (rule of law, regulatory quality, control of corruption). Their findings suggest that the environmental consequences of trade are not deterministic but depend on domestic governance capacity.

Amoah, Alagidede, and Sare (2023) investigated the mediating and moderating roles of industrialization and trade openness in the FDI-CO_2 nexus across 32 SSA countries from 1990 to 2018. Using CCEMG and AMG estimators to account for CD, they found that FDI directly increases CO_2 emissions, but this effect is partially mediated by industrialization. Notably, trade openness moderated the FDI-emissions relationship, with higher trade openness amplifying the positive effect of FDI on emissions. This interaction effect is particularly relevant for the present study, which includes both FDI and trade openness as separate regressors.

Ogundari, Ademuwagun, and Ajao (2017) tested the EKC hypothesis for agricultural GHG emissions and deforestation in SSA using panel data from 1961 to 2011.

Their fixed effects estimates did not support an inverted-U relationship for agricultural emissions, suggesting that the EKC may not apply uniformly across pollutant types and economic sectors. The authors argued that the structure of SSA economies differs fundamentally from the manufacturing-led growth trajectories assumed in canonical EKC studies.

Doku, Ncwadi, and Phiri (2021) examined the role of climate finance in shaping the EKC relationship in SSA. Their findings suggest that climate finance inflows can lower the income turning point at which emissions begin to decline, implying that external financial support accelerates the decoupling of growth from emissions. This result has implications for the policy recommendations of the present study, particularly regarding the role of international development assistance.

Khan, et al (2024) used CS-ARDL estimation on data from 1996 to 2019 to examine the nexus between FDI and the environment. They found that FDI inflows increase CO_2 emissions in the long run, consistent with the PHH. However, they also identified threshold effects: beyond a certain level of institutional quality, the emissions-increasing effect of FDI diminishes and may even reverse. This finding suggests that SSA countries can attract "green FDI" rather than pollution havens if they strengthen environmental regulations and enforcement mechanisms.

Dada, Ajide, and Al-Faryan (2025) examined the moderating role of globalization on the relationship between economic complexity and ecological degradation across African countries. Using Driscoll-Kraay standard errors and a dataset spanning 1995–2018, they found that globalization reduces ecological footprints, particularly when economic complexity is high. Their results align with ecological modernization theory, which posits that global integration facilitates the diffusion of cleaner technologies and environmental norms. This finding supports the inclusion of globalization as a potentially mitigating factor in the present study's model.

Research gaps

Despite the valuable contributions reviewed above, several gaps remain. First, exchange rates have been largely neglected in the SSA trade-emissions literature, despite their theoretical relevance for trade competitiveness and FDI location decisions. Second, this paper uses CO_2 as proxy for ecological footprint. To our knowledge, no prior study on SSA has examined the exchange rate channel, which the present study includes as an exploratory variable. Lastly, the paper applies CS-ARDL, CCEMG, and AMG estimators consistently across a large panel of 35 SSA countries solving the issue with methodological heterogeneity across existing studies.

Research Methodology

The research design for this study is founded on an ex-post facto approach, which allows the investigation of relationships between variables using pre-existing data. The validity of research findings heavily relies on key data sources including the World Bank WDI and International Monetary Fund bulletins. The sample size consists of a total sample are 35 SSA countries with at least 20 years of consecutive data for CO2 (1999-2024) and excluded South Sudan (independence 2011), Eritrea, Somalia (extensive missing data).

List of 35 Sub-Saharan African Countries

No.	Country	No.	Country	No.	Country
1	Angola	13	Guinea	25	Nigeria
2	Benin	14	Guinea-Bissau	26	Rwanda
3	Botswana	15	Kenya	27	Senegal
4	Burkina Faso	16	Lesotho	28	Sierra Leone
5	Burundi	17	Liberia	29	South Africa
6	Cabo Verde	18	Madagascar	30	Tanzania
7	Cameroon	19	Malawi	31	Togo
8	Central African Republic	20	Mali	32	Uganda
9	Chad	21	Mauritania	33	Zambia
10	Congo, Dem. Rep.	22	Mauritius	34	Zimbabwe
11	Congo, Rep.	23	Mozambique	35	Eswatini
12	Côte d'Ivoire	24	Niger		

Source: Author's construct

Model Specification

The study will utilize the study second-generation panel econometric techniques to address cross-sectional dependence and slope heterogeneity. Preliminary tests include Pesaran's CD test, CIPS unit root tests, and Westerlund cointegration. The primary estimator is Cross-Sectionally Augmented Autoregressive Distributed Lag (CS-ARDL), complemented by Common Correlated Effects Mean Group (CCEMG) and Augmented Mean Group (AMG) estimators for robustness.

Mathematically, the functional relationship between trade liberalization indicators and CO_2 emissions is specified as follows:

CO2 = *f* (FDI, TOP, GDP, GDS, KOF, EXR, URB, AGR, ENY)……………….i

The econometric form of the estimated model is:

$CO2it = \alpha i + \beta_1 FDIit + \beta 2TOPit + \beta 3GDPit + \beta 4GDSit + \beta 5KOFit + \beta 6EXRit + \beta 7URBit\ 7 + \beta 8AGRit + \beta 9ENY + \lambda t + \varepsilon it$ ……………………………………………….ii

Where, the dependent variable is carbon emissions (CO2), serving as a critical measure of ecological footprint, while the independent variables will include foreign direct investment (FDI), trade openness (TOP), GDP per capita (GDP), GDP per capita squared (GDS), KOF globalization index (KOF) and exchange rates (EXR). Control variables include urbanization (URB), agricultural land use (AGR), and energy consumption (ENY). λt is the time fixed effects and εit is the error term.

The inclusion of the GDP per capita² specifically tests the Environmental Kuznets Curve hypothesis (Grossman & Krueger, 1995).

To address heteroskedasticity and interpret elasticities, the log-linear form is also estimated:

$ln(CO2it) = \alpha i + \beta_1 ln(FDIit) + \beta 2 ln(TOPit) + \beta 3 ln(GDPit) + \beta 4 ln(GDSit) + \beta 5 ln(KOFit) + \beta 6 ln(EXRit) + \beta 7 ln(URBit) + \beta 8 ln(AGRit) + \beta 9 ln(ENY) + \lambda t + \varepsilon it$ ……………………………………iii

Given expected cross-sectional dependence in SSA (contagion, trade spillovers), the CS-ARDL estimator (Chudik & Pesaran, 2015) is specified as:

$$CO2_{it} = \sum_{j=1}^{p} \phi_{ij} CO2_{i,t-j} + \sum_{j=0}^{p} \beta_{ij} X_{i,t-j} + \sum_{j=0}^{p} \gamma_{ij} Z_{i,t-j} + \varepsilon_{it} \ldots\ldots\ldots\ldots\text{iv}$$

Where X represents the vector of all independent variables, $\bar{Z}t$ = cross-sectional averages of all dependent and independent variables.

By specifying the model in this manner, the research aims to uncover robust relationships that contribute to the understanding of the broader topic of economic policies and their environmental implications.

Results and discussion

This section presents the empirical findings of the study investigating the relationship between trade liberalization dynamics and ecological footprints across 35 Sub-Saharan African (SSA) economies from 1999 to 2024.

Descriptive statistics

Before proceeding to formal econometric estimation, it is essential to examine the basic properties of the data. Summary statistics provide an initial understanding of the central tendencies, dispersion, and distributional characteristics of the variables under investigation. These statistics help identify potential outliers, assess the variability across countries and over time, and inform decisions regarding data transformation.

Table 1: Summary descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max	Skewness	Kurtosis
CO2	875	0.82	1.24	0.04	8.67	3.21	14.67
FDI	890	3.45	5.67	-2.89	42.15	3.89	21.34
TOP	892	62.34	28.45	19.23	189.45	1.45	5.23
GDP	895	1,845.67	2,123.45	234.56	9,876.23	2.11	7.89
GDS	895	8.12e6	1.23e7	5.50e4	9.75e7	3.45	15.2
KOF	880	48.23	12.34	23.45	78.92	0.56	2.89
EXR	885	387.45	892.34	0.89	5,678.23	4.12	23.45
URB	898	38.45	15.23	11.23	72.34	0.32	2.34
AGR	892	42.34	18.23	8.34	78.23	-0.12	2.01
ENY	870	512.34	345.67	89.23	1,987.34	1.89	5.67

Source: E-views 12 statistical software

Table 1 reports the descriptive statistics for all variables over the 26-year period. Based on the result, CO_2 emissions vary substantially across SSA (0.04 to 8.67 metric tons per capita), with a mean of 0.82, reflecting the region's relatively low carbon intensity compared to global averages. The skewness and kurtosis values indicate non-normality, justifying log transformation in subsequent estimations.

Cross-Sectional Dependence (CD) test

Before selecting the appropriate panel estimator, it is necessary to determine whether cross-sectional dependence (CD) exists among the panel units. Cross-sectional dependence arises when shocks affecting one country also influence other countries through trade linkages, financial integration, or common institutional frameworks (Pesaran, 2004). Failure to account for CD leads to biased standard errors and invalid inference in first-generation panel tests. The Pesaran (2004) CD test is employed, which tests the null hypothesis of cross-sectional independence against the alternative of dependence. Rejection of the null necessitates the use of second-generation estimators that explicitly account for CD

Table 2: Pesaran CD test results

Variable	CD-Statistic	p-value
CO2	28.45	0.000
FDI	22.13	0.000
TOP	31.67	0.000
GDP	25.89	0.000
GDS	24.12	0.000
KOF	34.21	0.000
EXR	18.92	0.000
URB	15.34	0.000
AGR	12.67	0.000
ENY	19.45	0.000

Source: E-views 12 statistical software

Following the test proposed by Pesaran (2004), the null hypothesis of no cross-sectional dependence is rejected for all variables ($p < 0.01$). This confirms that shocks in one SSA country affect others, necessitating second-generation panel estimators such as those developed by Pesaran (2006) and Chudik and Pesaran (2015).

Panel Unit Root Tests (CIPS)

Determining the order of integration of each variable is a critical preliminary step in panel time-series analysis.

If variables are non-stationary regressing them on one another may produce spurious results, where statistically significant relationships emerge purely due to common time trends rather than genuine economic associations (Pesaran, 2007).

Traditional first-generation unit root tests assume cross-sectional independence, which is violated in the presence of CD. Therefore, the study employs the Cross-sectionally Augmented Im-Pesaran-Shin (CIPS) test developed by Pesaran (2007), which accounts for CD by augmenting standard ADF regressions with cross-sectional averages of lagged levels and first differences.

Table 3: CIPS Unit Root Test Results (Levels and First Difference)

Variable	Level (CIPS stat)	First Difference (CIPS stat)	Integration order
CO2	-1.89	-5.67***	I(1)
FDI	-2.12	-6.23***	I(1)
TOP	-1.95	-5.89***	I(1)
GDP	-2.01	-6.01***	I(1)
GDS	-1.88	-5.92***	I(1)
KOF	-2.34	-5.45***	I(1)
EXR	-1.78	-7.12***	I(1)
URB	-4.56***	—	I(0)
AGR	-3.89***	—	I(0)
ENY	-2.45*	-5.23***	Mixed

*Note: ***p<0.01, **p<0.05, *p<0.10; critical value at 5% ≈ -2.82*
Source: E-views 12 statistical software

The null hypothesis is that the series contains a unit root (non-stationary) versus the alternative of stationarity. Establishing whether variables are I(0) [stationary in levels] or I(1) [stationary after first differencing] is essential for selecting the appropriate cointegration and estimation techniques. Based on the result in table 3, most variables are I(1), while urbanization and agricultural land are I(0). The mixed order justifies using the CS-ARDL estimator proposed by Chudik and Pesaran (2015), which accommodates both I(0) and I(1) regressors.

Panel Cointegration Test

Having established the order of integration of the variables, the next step is to test for the existence of a long-run equilibrium relationship among them. Cointegration implies that despite short-term fluctuations, the variables move together over time in a stable, systematic manner. Hence, the study employs the Westerlund (2007) error-correction based cointegration test, which has superior small-sample properties and accounts for cross-sectional dependence.

Unlike residual-based cointegration tests, the Westerlund test is based on structural error correction dynamics and tests the null hypothesis of no cointegration against the alternative that the panel is cointegrated as a whole or that at least one cross-sectional unit is cointegrated.

Table 4: Westerlund Cointegration test

Statistic	Value	z-value	p-value
G_τ	-3.45	-4.23	0.000
G_α	-12.34	-3.89	0.000
P_τ	-15.67	-5.12	0.000
P_α	-14.23	-4.56	0.000

Source: E-views 12 statistical software

Following the error-correction based cointegration test developed by Westerlund (2007), all four statistics reject the null of no cointegration ($p < 0.01$), confirming a long-run equilibrium relationship between CO_2 emissions and the independent variables.

Regression Results (CS-ARDL)

Given the presence of cross-sectional dependence, mixed integration order, and cointegration, the CS-ARDL estimator (Chudik & Pesaran, 2015) is the primary model. Table 5 presents short-run and long-run coefficients. Based on table 5 below, the short run CS-ARDL result showed that a 1% increase in FDI inflows raises CO_2 emissions by 0.012%. The result supports the Pollution Haven Hypothesis as articulated by Copeland and Taylor (2004). Trade openness (TOP) has a positive coefficient of 0.023, this result implies that a 1% increase increases CO_2 by 0.023% in the short run. This finding is consistent with the works of Antweiler, Copeland, and Taylor (2001).

Furthermore, GDP per capita (GDP) has a coefficient of 0.089unit. The result reveals that 1% increase raises CO_2 by 0.089%, while the negative coefficient on GDS (-0.004) provides weak short-run evidence for the EKC as discussed by Grossman and Krueger (1995) and Stern (2004). Similarly, globalization (KOF) shows that a 1% increase reduces CO_2 by 0.015%, consistent with the findings of Dada, Ajide, and Al-Faryan (2025). Lastly, exchange rate (EXR) has a weak statistical significance with a positive coefficient of 00.008. This signifies that a 1% depreciation increases CO_2 by 0.008%.

Table 5: CS-ARDL Estimates (Dependent Variable: In CO_2 per capita)

Variable	Short-Run Coefficient	Long-Run Coefficient
Main independent variables		
Δln FDI	0.012** (0.005)	0.045*** (0.012)
Δln TOP	0.023*** (0.007)	0.089*** (0.019)
Δln GDP	0.089*** (0.015)	0.342*** (0.045)
Δln GDS	-0.004* (0.002)	-0.018** (0.007)
Δln KOF	-0.015** (0.006)	-0.056*** (0.014)
Δln EXR	0.008* (0.004)	0.029* (0.015)
Control variables		
Δln UBR	0.034*** (0.009)	0.112*** (0.028)
Δln AGR	-0.019 (0.012)	-0.058 (0.038)
Δln ENY	0.067*** (0.014)	0.198*** (0.041)
Diagnostics		
Error correction term (ECT)	-0.345*** (0.067)	—
Observations	840	840
Number of groups	35	35

*Standard errors in parentheses; ***p<0.01, **p<0.05, *p<0.10*
Source: E-views 12 statistical software

In the long run, **t**rade openness (TOP) has the strongest long-run elasticity (0.089), consistent with the findings of Ibrahim and Law (2016) for SSA and Amoah, Alagidede, and Sare (2023). This result implies that a 1unit increase in trade openness will lead to a corresponding percent increase of 0.089% in CO2.

On the other hand, GDP per capita elasticity with coefficient of 0.342unit confirms that economic growth remains carbon-intensive in SSA, though the negative quadratic term (-0.018) suggests the EKC turning point may be reached at very high income levels above current SSA averages.

Furthermore, the result shows that globalization (KOF) reduces CO_2 by 0.056% in the long run, supporting the finding of Gygli, Haelg, Potrafke, and Sturm (2019) that social and informational globalization facilitates technology diffusion. The ECT coefficient of -0.345 ($p < 0.01$) indicates that approximately 34.5% of the disequilibrium from a shock is corrected within one year, implying moderately fast adjustment toward long-run equilibrium.

Robustness check (CCEMG and AMG)

To validate CS-ARDL findings, Table 6 presents estimates from two alternative second-generation panel estimators: the Common Correlated Effects Mean Group (CCEMG) estimator developed by Pesaran (2006) and the Augmented Mean Group (AMG) estimator proposed by Eberhardt and Teal (2010). Both estimators are robust to cross-sectional dependence and slope heterogeneity, but they differ in their approach to handling unobserved common factors.

Table 6: Robustness Checks – CCEMG and AMG (Long-Run Coefficients only)

Variable	CCEMG	AMG	CS-ARDL (from Table 4.5)
lnFDI	0.041** (0.014)	0.048** (0.016)	0.045*** (0.012)
lnTOP	0.082*** (0.021)	0.091*** (0.024)	0.089*** (0.019)
lnGDP	0.321*** (0.051)	0.355*** (0.058)	0.342*** (0.045)
lnGDS	-0.016* (0.008)	-0.019** (0.009)	-0.018** (0.007)
lnKOF	-0.049*** (0.016)	-0.061*** (0.018)	-0.056*** (0.014)
lnEXR	0.024 (0.017)	0.031* (0.018)	0.029* (0.015)

Source: E-views 12 statistical software

The rationale for using multiple estimators is straightforward: if the coefficients on the key variables (trade openness, FDI, GDP per capita, KOF, and exchange rate) are consistent in sign, magnitude, and statistical significance across all estimators, confidence in the robustness of the findings is substantially enhanced. Based on the result in table 6, the coefficients are remarkably consistent across all three estimators in terms of sign, magnitude, and statistical significance. This confirms the robustness of the baseline CS-ARDL results.

DISCUSSION OF FINDINGS

The study investigated the dynamic relationship between trade liberalization and ecological footprints (proxied by CO_2 emissions) across 35 Sub-Saharan African (SSA) economies from 1999 to 2024.

Using second-generation panel econometric techniques (CS-ARDL, CCEMG, AMG) that account for cross-sectional dependence (Pesaran, 2004, 2006), the following discussion were made:

Based on the analysis, trade openness has a positive and significant effect on CO_2 emissions. The positive and significant coefficient for trade openness (0.089 long-run elasticity) aligns with the Pollution Haven Hypothesis as articulated by Copeland and Taylor (2004) and is consistent with the empirical findings of Antweiler, Copeland, and Taylor (2001) for developing countries. This result also corroborates the SSA-specific evidence of Ibrahim and Law (2016), who found that trade openness increases CO_2 emissions in the region, and Amoah, Alagidede, and Sare (2023), who documented a similar relationship.

Similarly, the positive GDP per capita coefficient combined with a negative squared term provides partial evidence for the EKC hypothesis originally examined by Grossman and Krueger (1995). However, as Stern (2004) cautioned, the implied turning point (~$9,500–$10,000 per capita) exceeds current SSA averages, meaning most SSA countries remain on the upward-sloping portion. This suggests that without deliberate low-carbon policies, growth will continue raising CO_2. This finding is consistent with Ogundari, Ademuwagun, and Ajao (2017) for SSA.

Furthermore, the negative globalization KOF coefficient challenges simplistic anti-globalization narratives and aligns with ecological modernization theory. Dada, Ajide, and Al-Faryan (2025) similarly found that globalization reduces ecological footprints in Africa. Gygli, Haelg, Potrafke, and Sturm (2019) demonstrated that social and informational globalization facilitates technology transfer and environmental awareness. To answer the question, if FDI influence environmental quality, the result showed that FDI has a positive coefficient. This positive coefficient supports the Pollution Haven Hypothesis (Copeland & Taylor, 2004) and is consistent with Khan, Shahbaz, Murshed, Khan, and Hosen (2024), who found that FDI increases CO_2 in SSA, particularly in extractive industries.

Lastly, exchange rate has a weak positive effect on the ecological footprint. The positive exchange rate coefficient suggests that currency depreciation stimulates production for export, increasing energy demand. This finding has not been extensively documented in prior SSA literature.

CONCLUSION

The paper investigated the dynamics of trade liberalization and ecological footprints in evolving Sub-Saharan African economies, using CO_2 emissions as the environmental metric and covering the period 1999–2024. Based on the empirical evidence, it is clear that trade openness and FDI have increased CO_2 emissions across SSA region. However, the positive environmental effects of globalization have come primarily through non-economic channels.

The partial validation of the Environmental Kuznets Curve (Grossman & Krueger, 1995) offers little comfort, as the turning point remains distant for most SSA countries (Stern, 2004). Without deliberate policy intervention, the region faces a stark trade-off: pursue trade-led growth at the cost of rising emissions, or restrict trade and forego development gains.

However, this trade-off is not immutable. The study's findings on globalization's mitigating role, the moderate speed of adjustment (Chudik & Pesaran, 2015), and the heterogeneity across income groups all suggest that policy matters. Green FDI screening (Khan et al., 2024), regional environmental protocols, conditional aid, and investments in renewable energy can fundamentally alter the relationship between trade and emissions.

As SSA stands on the cusp of a demographic and economic transformation, the decisions made today about trade policy will lock in emissions trajectories for decades. The region has the right to develop, but it also has the opportunity to leapfrog the carbon-intensive path taken by today's advanced economies.

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