Journal of Trade Science

Environmental taxation, institutional quality and trade development nexus in sub-Saharan Africa

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Received 10 July 2025
Revised 3 November 2025
2 January 2026
Accepted 7 January 2026

Abstract

Purpose – This study assesses the moderating and threshold impact of environmental tax and institutional quality on enhancing the international trade capabilities of economies in sub-Saharan Africa (SSA).

Design/methodology/approach – The study employed the system generalised method of moments and a dynamic threshold estimation technique on annual panel data from 24 emerging economies in SSA between the period 2010 and 2024.

Findings – The study revealed that environmental taxation has a nonlinear impact on trade in sub-Saharan Africa, turning from negative to positive only when institutional quality surpasses specific thresholds. Political stability, regulatory quality and government effectiveness significantly condition whether environmental taxes hinder or enhance trade.

Research limitations/implications – The study recommends that policymakers in SSA align environmental tax reforms with institutional strengthening. Reforms should be sequenced based on governance capacity, supported by readiness diagnostics and coordinated regionally to avoid emissions leakage and protect trade competitiveness.

Originality/value – This study is the first to apply a threshold framework to environmental taxation and trade in SSA, identifying governance tipping points. It moves beyond conventional models by treating institutional quality not as a control but as a structural determinant of policy success, offering a new lens on sustainable trade transitions in developing economies.

Keywords Environmental tax, Developing economies, Institutional quality, Trade development, Sustainable development, Sub-Saharan Africa

Paper type Research article

1. Introduction

The intensifying global commitment to sustainable development has elevated environmental policy instruments, particularly environmental taxes, to the forefront of public finance and ecological regulation (Shen *et al.*, 2024). These taxes, levied on environmentally harmful activities or products, are designed to internalise negative externalities, aligning private incentives with social costs (Khaddage-Soboh *et al.*, 2023). By raising the cost of pollution-intensive production, they promote greener technologies and sustainable industrial behaviour. However, the promise of environmental taxation remains theoretical when transplanted into structurally distinct contexts, such as sub-Saharan Africa (SSA), where economic realities diverge significantly from the paradigmatic cases of the Global North (Mpofu, 2022).

In SSA, where economies are resource-dependent and trade serves as a critical development engine, environmental taxation presents a policy paradox; while it offers an avenue for ecological correction, it simultaneously threatens to erode the cost competitiveness of export-driven industries. This tension constitutes the core research question:

Journal of Trade Science
Vol. 14 No. 2, 2026
pp. 127-149
Emerald Publishing Limited
e-ISSN: 2755-3957
p-ISSN: 2815-5793
DOI 10.1108/JTS-07-2025-0034

How do environmental taxes affect trade development in SSA, and to what extent does institutional quality condition this relationship?

This question remains both empirically underexplored and theoretically unresolved.

To clarify, environmental taxation affects trade through its influence on production costs and competitiveness. In resource-dependent and export-driven sectors such taxes can raise operating costs and temporarily weaken export competitiveness, especially where firms lack the capacity or technology to adapt (Wang and Yu, 2021). Over time, however, well-calibrated environmental taxes can drive efficiency improvements, encourage cleaner production and support the growth of environmentally sustainable exports (Demiral and Demiral, 2023).

From a wider lens, trade openness encompasses both exports and imports. While exports signal productive strength, imports often represent channels for acquiring cleaner technologies and more efficient inputs (Yu *et al.*, 2022). Consequently, the overall impact of environmental taxation on trade openness is theoretically mixed as it may initially constrain exports but may eventually enhance the structural quality of trade. This study thus treats trade openness as a composite outcome shaped by these countervailing effects, with institutional quality serving as a key moderating factor.

Despite global momentum towards green fiscal policy, SSA has lagged in adopting comprehensive environmental tax frameworks. As of 2023, only 7% of SSA countries have implemented such systems, in stark contrast to over 50% in Europe (OECD, 2023a). Despite this discrepancy, the region's environmental stakes are rising. SSA's carbon dioxide emissions, although historically modest, have grown at an average annual rate of 3% since 2000, surpassing global averages (World Bank, 2024). This surge coincides with rapid urbanisation and population growth, intensifying environmental degradation across sectors.

Simultaneously, trade contributes over 50% of GDP on average in SSA, with exports concentrated on carbon-intensive commodities such as oil, minerals and agriculture (WTO, 2023). For instance, oil and gas alone accounted for more than 40% of SSA exports in 2021 (UNCTAD, 2023) and environmental taxes risk exacerbating cost pressures in these sectors and potentially compromising trade performance and economic growth.

Yet the implementation of environmental taxation in SSA is not merely an economic issue; it is profoundly institutional. Institutional weaknesses, including endemic corruption, fragile regulatory systems and limited administrative capacity, compromise the enforceability and credibility of environmental tax regimes (Bahri *et al.*, 2021; OECD, 2023b). With SSA registering the lowest regional score (32/100) on the 2022 Corruption Perceptions Index (Transparency International, 2023), the question is not only whether these taxes are desirable, but whether they are even feasible. Indeed, institutional deficiencies cost SSA an estimated $50 billion annually in corruption-related losses (AfDB, 2024), undermining policy legitimacy and public trust.

In the context of SSA, considering the interplay between environmental taxation, institutional quality and trade is particularly critical due to the region's resource dependence, weak regulatory enforcement and fiscal vulnerability. Environmental taxes, if implemented without adequate institutional support, may unintentionally suppress export competitiveness or exacerbate informal economic activity (Mao and Wang, 2023). Conversely, in countries with stronger governance and administrative capacity, such taxes can promote cleaner production and enhance participation in sustainable global value chains (Mao and Wang, 2023).

In addition, identifying an institutional quality threshold is therefore essential as it helps determine the point at which institutional strength begins to convert environmental taxation from a fiscal burden into a developmental instrument (Okombi and Ndoum Babouama, 2024). This threshold-based perspective acknowledges that the same policy may yield divergent trade outcomes across SSA depending on governance quality, thereby providing policy-relevant insights for differentiated implementation.

This study contributes to the literature in three important and interrelated ways. First, it addresses a critical empirical gap by systematically examining the trade effects of environmental taxation in SSA, a topic largely neglected in existing studies that focus predominantly on fiscal or environmental outcomes (Noubissi *et al.*, 2021; Tchapchet *et al.*, 2024). Most analyses assume institutional conditions conducive to tax enforcement, an assumption that does not hold in SSA. Second, it makes a theoretical contribution by extending institutional theory into the domain of environmental economics. Specifically, the research tests the proposition that institutional quality moderates the impact of environmental taxation on trade. This approach challenges the environmental tax orthodoxy by arguing that policy effectiveness is conditional, rather than intrinsic, a stance that bridges the gap between regulatory theory and development economics. Third, this study introduces a novel integrative framework that situates environmental taxation within the tripartite interaction of trade development, institutional governance and ecological sustainability. In doing so, it moves beyond the narrow "double-dividend" discourse (Felbermayr *et al.*, 2025) and instead proposes a context-sensitive, policy-relevant model grounded in the developmental realities of SSA.

Methodologically, the research employs a panel data analysis of SSA economies using recent (2010–2024) macroeconomic and institutional indicators. This enables robust cross-country comparisons and enhances the generalisability of the findings. Moreover, by aligning the analysis with the United Nations Sustainable Development Goals (SDGs), particularly SDG 13 (Climate Action) and SDG 8 (Decent Work and Economic Growth), this study integrates indicators of carbon efficiency and institutional capacity to demonstrate how environmental taxation and trade dynamics contribute to sustainable and inclusive growth, offering actionable insights for policymakers navigating green transitions into low- and middle-income economies.

The remaining section of the paper is structured as follows: Section 2 reviews relevant literature, both theoretical and empirical, on environmental tax, institutional quality and international trade. Section 3 details the methodology, including data collection and analytical techniques used. Section 4 presents the findings and discusses their implications. Section 5 concludes the paper and offers policy recommendations based on the results.

2. Literature review

2.1 Theoretical background

The pollution haven hypothesis (PHH), initially posited by Walter and Ugelow (1979), has long framed debates surrounding environmental regulation, trade liberalisation and industrial geography in the context of globalisation. The core premise of PHH is deceptively straightforward: firms in pollution-intensive sectors relocate production to areas with weaker environmental regulations to minimise compliance costs (Fu *et al.*, 2021). In doing so, these firms effectively arbitrage environmental standards across borders, giving rise to what PHH terms "pollution havens," typically, developing countries that maintain low regulatory thresholds to attract foreign direct investment (FDI).

At its core, the PHH situates environmental regulation as a primary determinant of global industrial location decisions, foregrounding a presumed trade-off between environmental protection and economic competitiveness (Bialek and Weichenrieder, 2021). This framework resonates strongly in the contemporary landscape, where environmental taxes represent a direct monetisation of ecological externalities, raising the cost of pollution-intensive production. Under such conditions, the PHH suggests that firms will seek cost advantages by shifting operations to countries with more permissive regimes.

While compelling, the PHH remains theoretically and empirically contested. Its strength lies in providing an intuitive explanation for the observed clustering of pollution-intensive industries in the Global South, a pattern supported by sectoral evidence from mining, manufacturing and chemical industries (Levinson, 2018). However, its limitations are equally

notable. The hypothesis tends to overstate the singular role of environmental policy, neglecting the broader calculus of firm relocation decisions, which include labour costs, infrastructure quality, market access, political risk and critically institutional integrity (Ning and Shen, 2024).

This study intervenes at precisely this juncture of theoretical inadequacy by extending the PHH framework through the lens of institutional theory. Specifically, it challenges the static assumptions of PHH by proposing that institutional quality acts as a critical moderator in the relationship between environmental taxes and trade dynamics. This reconceptualisation adds explanatory depth to PHH by recognising that the presence or absence of credible, well-functioning institutions fundamentally alters how environmental taxation influences trade and investment patterns.

In strong institutional contexts, environmental taxes may not trigger capital flight, but instead induce a "Porter effect," whereby firms respond through innovation, productivity enhancement and green competitiveness (Sheng *et al.*, 2023). Conversely, in weak-institutional settings, such as many parts of SSA, lax enforcement mechanisms, regulatory opacity and corruption may not only fail to discipline pollution-intensive industries but may inadvertently incentivise regulatory arbitrage, affirming the predictions of PHH in these cases (AfDB, 2024; Transparency International, 2023).

Thus, this study's theoretical contribution is twofold: first, it extends the PHH through institutional theory by embedding institutional quality, thus refining its causal mechanisms and improving its explanatory power in non-OECD contexts. This is particularly relevant for SSA, where institutional heterogeneity significantly mediates policy effectiveness.

Also, the research shifts the analytical focus from environmental taxation as a purely fiscal or environmental tool to one with deep trade implications, especially when institutional asymmetries are accounted for. It proposes that environmental taxes, when filtered through institutional capacity, may either deter pollution havens (by raising enforcement credibility) or reinforce them (by signalling regulatory weakness).

In doing so, the study engages constructively with PHH, not by rejecting its premises outright but by repositioning it within a multi-dimensional framework that accommodates institutional variation, policy complexity and economic geography.

2.2 The nexus of environmental taxation, institutional quality and trade development

The intersection of environmental taxation, institutional quality and trade development has become a fertile ground for empirical inquiry, yet one still marked by fragmentation, both in regional focus and theoretical depth.

Over the past 2 decades, a notable body of literature has emerged from studies in developed economies, often anchored in the assumption of mature institutions and functional regulatory architectures. In these contexts, environmental taxes are not merely fiscal tools, but policy instruments embedded in broader green industrial strategies. Studies conducted by Benedetti *et al.* (2023) and Gaigné and Tamini (2021) illustrated how pollution taxes in industrialised settings can catalyse cleaner trade compositions by reshaping production incentives.

Building on the contextual foundation, recent empirical approaches have evolved, shifting away from early cross-sectional analyses towards more sophisticated econometric techniques such as panel threshold models, structural gravity frameworks and dynamic GMM estimations. These advances have enabled a more dynamic treatment of institutional heterogeneity and cross-country dependencies. In particular, the EU's experience with environmental goods trade shows that moderate taxation, aligned with robust institutional frameworks, enhances trade in environmental technologies. Similarly, Khan *et al.* (2022) and Wu and Madni (2021) demonstrated that welfare gains and emissions mitigation are contingent on surpassing certain institutional thresholds, without which environmental taxes may generate economic friction without delivering ecological dividends.

Nevertheless, the empirical salience of these findings becomes tenuous when transposed to developing economies, where institutional fragility, regulatory inconsistency and limited industrial diversification constitute binding constraints. In SSA, for example, trade openness coexists with weak institutional enforcement, making it a region where environmental taxes may unintentionally exacerbate ecological and economic vulnerabilities rather than resolve them. Ibrahim and Law (2016), examining SSA, emphasise this duality, revealed that the environmental benefits of trade liberalisation manifested only in countries with stronger institutional anchors. Recent evidence reinforces this institutional asymmetry. Asongu and Odhiambo (2021), analysing SSA economies, found that environmental taxation improved environmental outcomes only when coupled with effective governance and regulatory stability, while in weakly governed states, it constrained export competitiveness without meaningful ecological gains. Similarly, Agboola *et al.* (2022) showed that trade openness amplifies carbon emissions in resource-exporting SSA countries unless moderated by robust environmental governance mechanisms. Maji *et al.* (2023) extended this insight by demonstrating that institutional quality thresholds, particularly the rule of law and government effectiveness, determined whether environmental taxes stimulate cleaner trade or merely burden producers. Finally, Traoré and Asongu (2024) provided evidence that stronger institutional accountability fosters green technology adoption in SSA's manufacturing exports, thereby transforming environmental taxation from a fiscal burden into a competitiveness-enhancing tool.

Furthermore, country-specific evidence reinforces this causal sequencing. Abreo *et al.* (2021) provided compelling evidence from Colombia that institutional upgrading preceded trade growth, rather than following it. Similarly, Wani and Yasmin (2023) found that governance reforms in India reshaped export performance, particularly in environmentally sensitive sectors. Comparable trends are observed across other regions, for instance, in East Asia, Liu *et al.* (2022) demonstrated that environmental tax reforms in South Korea enhanced export competitiveness in green manufacturing once regulatory quality surpassed a critical governance threshold. In the European Union, Gaigné and Tamini (2021) showed that environmental taxation contributes positively to trade diversification when coupled with strong institutional coordination across member states. Zhang *et al.* (2024) reported similar outcomes in OECD economies where high institutional effectiveness enables firms to offset environmental compliance costs through innovation and cleaner production. Gazzani (2021) found that environmental fiscal instruments in Latin America promoted trade in eco-friendly goods, contingent upon policy credibility and enforcement consistency.

Within Africa, Ibrahim and Ajide (2022) provided new SSA-specific evidence showing that political stability and control of corruption jointly dumped the trade–environment nexus, particularly by improving the competitiveness of low-carbon exports. These insights bridge the empirical divide between developed and developing contexts, reaffirming the centrality of institutional quality.

2.3 Research gaps and contributions

The current study, therefore, steps beyond conventional linear causality models and adopts a moderation–threshold approach, treating institutional quality as both a filter and an amplifier of environmental taxation's impact. This conceptual reconfiguration responds to emerging evidence that the effectiveness of environmental taxes is conditional, not absolute, a view partially echoed in Peiró-Palomino *et al.* (2022), who found that only high-governance nations can leverage such taxes to shift towards cleaner trade patterns. By contrast, in weak institutional environments, environmental taxes may inadvertently trigger capital flight or deepen environmental injustice by encouraging pollution havens.

The empirical record further revealed methodological inconsistencies that cloud comparative insights. While structural gravity models (e.g. Heid *et al.*, 2021; Beverelli *et al.*, 2023) offered robust frameworks for capturing bilateral trade flows and multilateral

resistance effects, many SSA-focused studies relied on less granular datasets, limiting their explanatory precision. Moreover, while threshold regression models and nonlinear estimations have gained traction in advanced economy studies (Khaskheli *et al.*, 2021; Gaigné and Tamini, 2021), such models remain underutilised in SSA. This methodological lag risks obscuring critical inflexion points, such as when institutional reforms begin to significantly moderate the environmental cost–trade nexus.

What distinguishes the current study is not simply its empirical focus on SSA but its analytical repositioning of the debate. While much of the extant literature adopted either a "pollution haven" or "green growth" perspective in isolation, this study synthesised both within a context-sensitive institutional framework. It posits that five discrete dimensions of institutional quality, regulatory quality, rule of law, government effectiveness, control of corruption and political stability, differentially influence the trade outcomes of environmental taxation.

This nuanced approach directly addressed several evident gaps: first, existing studies often fail to account for the structural idiosyncrasies of SSA, its heavy resource dependency, institutional volatility and weak tax administration. Therefore, focusing exclusively on SSA, the study produces context-specific insights that transcend the "one-size-fits-all" paradigm of environmental fiscal policy. Secondly, while prior work hinted at institutional conditioning (e.g. Wu and Madni, 2021), few have modelled institutional quality as a threshold variable, particularly within SSA. This study operationalises that relationship, thus advancing our understanding of when and how institutions amplify or suppress the trade impacts of green taxes. Third, the research adopted a multi-method econometric strategy, combining system GMM and nonlinear threshold regression techniques. This dual approach not only mitigates endogeneity but also enabled the detection of nonlinearities and asymmetries, both of which are indispensable in low-capacity institutional environments. Finally, by integrating empirical analysis with WTO-compliance considerations, the study addresses a key policy dilemma: how to design environmental taxes that are both trade-neutral and environmentally effective, especially in regions vulnerable to emissions leakage and capital reallocation.

In doing so, this research not only contributes to an enriched empirical literature on green taxation and trade but also speaks to a deeper theoretical question:

Can environmental policy be developmental in weak institutional settings?

If the answer hinges on institutional thresholds, as this study suggests, then future policy frameworks must be tailored not only to emissions profiles but also to governance architectures.

3. Methodology

3.1 Model specification

The theoretical foundation of this study is grounded in the PHH and its extensions within the environment–institution–trade nexus. The PHH posits that differences in environmental regulation stringency across countries influence the spatial distribution of pollution-intensive industries and associated trade flows (Fu *et al.*, 2021). Building on this framework, the study integrates the role of institutional quality as a conditioning factor that shapes how environmental taxation affects trade dynamics, especially within resource-dependent economies in SSA.

The model's validity rests on the recognition that environmental taxes, institutional quality and trade are jointly determined by policy design, governance capacity and economic structure. Prior studies (e.g. Gaigné and Tamini, 2021; Borowiec *et al.*, 2024) emphasised that institutional strength determines whether environmental taxation acts as a constraint or a catalyst for trade. Accordingly, this study formalises the relationship as follows:

$$T_i = f(E_i, C_i, Q_i) \tag{1}$$

where T_i represents the flow of trade openness for country *i*. E_i denotes the stringency of environmental regulations or environmental taxes in country *i*, C_i captures comparative advantages such as production costs, factor endowments and trade openness, and Q_i measures institutional quality in country *i* (e.g. governance effectiveness, regulatory quality and rule of law).

While a full bilateral gravity model would incorporate the attributes of both trading partners (*i* and *j*), data limitations and the study's focus on the domestic determinants of trade openness within SSA, justify concentrating on country *i* characteristics over time *t*. In this regional context, cross-country trade is often asymmetric and heavily influenced by domestic institutional and policy conditions rather than reciprocal regulatory effects (Ibrahim and Law, 2016; Ibrahim and Ajide, 2022). Moreover, the available panel data are structured at the country level, precluding full bilateral estimation. Hence, this study adopts an augmented single-country model emphasising internal policy–trade linkages rather than bilateral trade flows.

If the model is expanded by incorporating pollution emissions (P_i) explicitly included with Z_i covering controlled variables included in the model, the equation can expand to:

$$T_{it} = \gamma_0 + \gamma_1 P_{it} + \gamma_2 E_{it} + \gamma_3 Q_{it} + \gamma_4 (E_{it} * Q_{it}) + \gamma_5 Z_{it} + \varepsilon_{it} \tag{2}$$

Where $\gamma 1 > 0$ is pollution-intensive industries contribute to trade. In addition, $\gamma 2 > 0$ is that environmental taxes (E_{it}) reduce pollution and trade flows in pollution-intensive sectors. Furthermore, $\gamma 4$ represents the interaction term capturing how institutional quality (Q_{it}) influences the effect of environmental taxes (E_{it}) on trade.

To find the threshold of institutional quality (Q^*) where environmental taxes (E) have a significant effect on trade (*T*), the study focused on the marginal effect of *E* on *T*:

$$\frac{\partial T_{it}}{\partial E_{it}} = \beta_1 + \beta_3 Q_i \tag{3}$$

The threshold level of institutional quality (Q^*) is derived by setting the marginal effect to a critical value, such as zero or a specified significance level. Assuming the critical value is zero:

$$\beta_1 + \beta_3 Q_{it} = 0 \text{ Solving for } Q^* \tag{4}$$

$$Q^* = \frac{\beta_1}{\beta_3} \tag{5}$$

Q^* represents the level of institutional quality at which environmental taxes begin to have a significant effect on trade. For example, if $Q_{it} > Q^*$, institutional quality is sufficient to amplify or mitigate the effects of environmental taxes on trade. However, if $Q_{it} < Q^*$, institutional quality is insufficient, the environmental tax may have little or no significant impact on trade.

A potential endogeneity problem arises in this study due to several factors. First, reverse causality may exist between trade openness and environmental taxation; thus, countries with greater trade integration may adjust their environmental tax regimes in response to external competitiveness pressures. Second, omitted variable bias may occur if unobserved institutional or structural factors simultaneously influence both environmental policy and trade outcomes. Third, measurement errors in institutional quality indicators could further bias ordinary least squares estimates.

To address these issues, the study employs the two-step system generalised method of moments (system GMM) estimator. This approach exploits the internal instruments generated

from lagged levels and differences of the endogenous variables, effectively controlling for unobserved heterogeneity, simultaneity and dynamic feedback effects. System GMM is particularly suitable for the panel structure of SSA data characterised by a large cross-section (N) and a relatively short-time dimension (T) and ensures consistent and efficient estimation of the moderating relationship between environmental taxation, institutional quality and trade openness.

The SGMM provides a systematic way to estimate parameters based on sample moments and their theoretical counterparts using the two-step procedure. This procedure involves, first, employing the initial guess for $\widehat{\theta}_0$, compute the sample moments and the initial weighting matrix W_0. Also, using $\widehat{\theta}_0$, update the weighting matrix W_1 and re-estimate $\widehat{\theta}_1$ by minimising the objective function with the updated weighting matrix.

After the two-step procedure, the final GMM estimator $\widehat{\theta}_{GMM}$ is obtained by minimising the objective function as:

$$\widehat{\theta} = \arg\min \theta \left(\frac{1}{N} \sum_{i=1}^{N} [T_{it} - \gamma_0 - \gamma_1 P_{it} - \gamma_2 E_{it} - \gamma_3 Q_{it} - \gamma_4 (E_{it}.Q_{it}) - \gamma_5 Z_{it} - \gamma_6 X_i] \right)' . W \left(\frac{1}{N} \sum_{i=1}^{N} [T_{it} - \gamma_0 - \gamma_1 P_{it} - \gamma_2 E_{it} - \gamma_3 Q_{it} - \gamma_4 (E_{it}.Q_{it}) - \gamma_5 Z_{it} - \gamma_6 X_{it}] \right)' \tag{6}$$

Where the vector of parameters $\theta = (\gamma_0,\gamma_1,\gamma_2,\gamma_3,\gamma_4,\gamma_5)$ is the set of parameters we are estimating using the GMM framework. This final system GMM framework allows the estimation of the model parameters in the presence of potential endogeneity in the regressors, with X_{it} serving as instruments.

To establish the threshold level of institutional quality that triggers the significant impact of environmental tax on trade development in SSA the study utilised Seo *et al.*'s (2019) dynamic threshold technique, as it stands out for its unique ability to identify thresholds directly from the data, eliminating the need for arbitrary and often inefficient quadratic or cubic terms typically used in conventional threshold models (Hidalgo *et al.*, 2023). Moreover, the model incorporates unobserved individual effects, an essential factor frequently neglected in simpler threshold approaches, thereby providing a more robust and thorough analytical framework (Seo *et al.*, 2019). The general dynamic threshold models for the study are specified as follows:

$$y_{it} = \beta_0 + \beta_1 x_{it} I(q_{it} \leq \gamma) + \beta_2 x_{it} I(q_{it} > \gamma) + Z_{it}\delta + \varepsilon_{it} \tag{7}$$

where y_{it} is the trade development, x_{it} is environmental tax and q_{it} is institutional quality. $I(\cdot)$ is an indicator function that equals 1 if the condition is true and 0 otherwise. γ is the threshold value to be estimated. β_1 and β_2 are the coefficients below and above the threshold, respectively. Z_{it} is a vector of control variables (carbon emission, energy usage, FDI, agricultural growth and GDP growth). δ is the vector of coefficients for the control variables and ε_{it} is the error term. Empirically, the model is expressed as:

$$Trade_{it} = \beta_0 + \beta_1 Environmental\ Tax_{it} I(Institutional\ quality_{it} \leq \gamma) + \beta_2 Environmental\ tax_{it} I(Institutional\ quality_{it} > \gamma) + Z_{it}\delta + \varepsilon_{it} \tag{8}$$

3.2 Data

The study used annual panel data of 24 countries in SSA as a sample [1], from 2010 to 2024, a 15-year secondary data source. This period was dictated by the availability of data. The data employed were from multiple reliable data sources, which include the World Development Indicators (WDI), Transparency International, International Monetary Fund (IMF), International Energy Agency (IEA) and Worldwide Governance Indicators (WGI). This strategy was employed to ensure a comprehensive and robust analysis by cross-verifying the accuracy and reliability of the variables to enhance the validity of the study findings. Table 1 provides the variable description, measurement and expected signs for the study.

3.3 Justification of variables

This study concentrates on trade openness rather than disaggregated trade flows (exports or imports) for both conceptual and empirical reasons. Conceptually, trade openness captures the aggregate exposure of an economy to international markets, encompassing both export performance and import penetration. This aggregate view aligns with the study's core objective, to assess how environmental taxation and institutional quality shape the overall degree of trade integration under varying governance conditions.

Empirically, SSA economies often exhibit data asymmetries and sectoral overlaps between exports and imports, particularly in resource-dependent industries where value chains are intertwined. Focusing on trade openness mitigates measurement inconsistencies and allows for a more consistent cross-country comparison. Moreover, trade openness reflects the net outcome of environmental and institutional dynamics, offering a broader lens through which to evaluate the developmental implications of environmental fiscal policy.

The inclusion of environmental tax as the principal independent variable is analytically justified by its critical role in shaping trade behaviour via regulatory intervention aimed at internalising environmental externalities. Environmental taxes do not merely raise production costs; they serve as incentive-altering instruments that influence firm-level innovation, sectoral competitiveness and resource allocation, particularly in pollution-intensive industries (Fu *et al.*, 2021; Levinson, 2023). Within the context of SSA, where institutional fragility often

Table 1. Variable description, measurement and expected sign

Variable	Measurement	Expected sign	Source
Trade	Total Trade (Exports + Imports)/GDP		World Bank (WDI)
Environmental tax	A composite index of tax rates	−/+	IMF (Climate data)
Political stability	Political Stability Index	+	World Bank (WGI)
Government effectiveness	Government Effectiveness Index	+	World Bank (WGI)
Control of corruption	Control of Corruption Index	−	World Bank (WGI)
Rule of law	Rule of Law Index	+	World Bank (WGI)
Regulatory quality	Regulatory Quality Index	+	World Bank (WGI)
Carbon emission (CO_2)	Metric tonnes of CO_2 emitted per capita or total national emissions	−	International Energy Agency (IEA)
Energy usage	Energy consumption as a percentage of GDP	+	International Energy Agency (IEA)
Foreign direct investment (FDI)	Net FDI inflows as a percentage of GDP	+	World Bank (WDI)
Agricultural growth	Agricultural value-added as a percentage of GDP	+	World Bank (WDI)
GDP growth	Annual GDP growth rate (%)	+	World Bank (WDI)

Source(s): Authors' construct, 2025

impairs environmental governance, probing the efficacy and trade-offs of such taxes is vital for understanding their implications for economic performance and trade diversification.

To ensure empirical precision, this study integrates key control variables that reflect critical dimensions of trade development. Carbon emissions (CO_2) serve as a proxy for environmentally intensive trade activity and offer insights into the potential behavioural response to tax-induced cost structures (Fabrizi *et al.*, 2024). Energy consumption captures the role of energy-dependent sectors susceptible to regulatory shifts, aligning with existing studies on energy intensity and environmental taxation (Wahab *et al.*, 2021). FDI is incorporated to reflect the sensitivity of capital flows to regulatory environments, given evidence that environmental standards can either deter or reallocate investment (Danquah and Barnor, 2025).

Further, agricultural growth is especially relevant in SSA's trade composition, as it links natural resource dependency with potential ecological vulnerabilities. GDP growth provides a macroeconomic anchor, capturing the overall trajectory of economic development against which trade-environment linkages are assessed (Orhan *et al.*, 2021).

Finally, the inclusion of institutional quality dimensions, including political stability, regulatory quality, rule of law, control of corruption and government effectiveness, is indispensable. Strong institutions enhance policy enforcement, reduce uncertainty and mitigate rent-seeking (Acemoglu and Robinson, 2025), whereas institutional deficits amplify implementation failures, undermining the efficacy of environmental taxes (Wani and Yasmin, 2023; Onafowora and Owoye, 2024).

4. Findings and discussions

4.1 Preliminary statistics

The descriptive statistics in Table 2 reveal a clear picture of SSA's trade-environment landscape, marked by institutional fragility and structural volatility. Trade, averaging 31.04% of GDP, varies widely, reflecting divergent integration levels across economies. Environmental taxes remain marginal at just 1.06%, underlining limited fiscal leverage for ecological correction. Carbon emissions average 3.65 metric tonnes per capita and energy use 2.66, consistent with low industrialisation but also indicative of shared environmental vulnerability. FDI averages 3.99% of GDP but displays extreme volatility, highlighting the region's exposure to regulatory and political uncertainty. Agricultural growth averages 18.99%, robust yet unstable, stressing its dependence on ecological conditions and vulnerability to poorly designed green taxes. GDP growth, averaging 3.64%, reveals

Table 2. Descriptive statistics

Variable	Mean	Std. dev	Min	Max
Trade	31.038	13.436	8.524	85.758
Environmental tax	1.06	0.698	0.01	3.11
Carbon emission (CO_2)	3.65	0.558	2.696	5.652
Energy usage	2.66	0.144	2.049	3.449
Foreign direct investment	3.988	4.818	−17.292	37.323
Agricultural growth	18.986	12.64	1.054	64.354
GDP growth	3.639	4.405	−20.805	21.079
Political stability	3.332	0.454	2	4.5
Government effectiveness	−0.667	0.593	−1.756	1.15
Control of corruption	−0.57	0.635	−1.645	1.017
Rule of law	−0.555	0.585	−1.822	1.024
Regulatory quality	−0.536	0.559	−1.733	1.197

Source(s): Authors' compilation, 2025

episodic crises, reinforcing the need for countercyclical policy design. Institutional indicators are uniformly negative, confirming weak governance structures that impair regulatory credibility and policy enforcement. Thus, without institutional reform, environmental taxation in SSA risks being ineffective or regressive, potentially undermining both trade competitiveness and sustainable development objectives.

Table 3 presents the pairwise correlation coefficients among the key variables used in the analysis. As shown, trade openness exhibits a statistically significant but weak negative correlation with environmental tax (−0.123). This inverse association aligns with theoretical expectations, suggesting that higher trade exposure may constrain governments' fiscal space for environmental taxation due to competitiveness concerns or potential relocation of pollution-intensive industries. Conversely, trade openness is positively correlated with energy usage (0.149) and FDI inflows (0.171), which reflects the trade–energy–investment nexus often observed in open developing economies. The positive association implies that greater openness may encourage energy-intensive industrial activity, reinforcing the importance of regulatory capacity in mitigating environmental costs.

The strong negative correlation between trade openness and agricultural growth (−0.569) suggests potential structural reallocation effects, where trade expansion may shift resources away from agriculture towards more industrial or service-oriented sectors. Similarly, the negative associations with GDP growth (−0.197) and institutional indicators such as political stability (−0.312) and regulatory quality (−0.167) imply that trade expansion in weak institutional settings may not translate directly into sustainable growth or stable governance outcomes.

Finally, the correlations among institutional quality indicators (government effectiveness, control of corruption, rule of law and regulatory quality) are low and statistically insignificant, indicating no serious multicollinearity concerns. This supports their joint inclusion as distinct components of institutional quality in subsequent regressions. However, it is important to note that these correlations do not imply causation; rather, they provide preliminary insights that guide and justify the subsequent econometric analysis.

4.2 Environmental tax, institutional quality and trade development

The results in Table 4 compellingly demonstrate the path-dependent nature of trade in SSA. Across models 1–5, the lagged trade variable remains consistently high, ranging from 0.828 to 0.906, affirming that trade flows are strongly conditioned by historical structures and embedded economic patterns. This persistence is expected in economies where trade is driven by long-standing resource extraction, infrastructure constraints and limited diversification (Beverelli *et al.*, 2023).

The role of environmental taxation, however, proves theoretically and empirically nuanced. In the five specifications, environmental tax exerts a negative and statistically significant effect on trade, with coefficients from −1.806 to −5.713. These findings reflect the concern articulated in the PHH (Levinson, 2023): that in settings with high export dependence on carbon-intensive goods and weak regulatory capacity, green taxation may raise production costs and reduce competitiveness. This is especially salient in SSA, where trade is often narrowly concentrated in raw materials, agriculture and low-value manufacturing sectors most sensitive to price shocks and compliance burdens (Ibrahim and Law, 2016).

The institutional variables provide critical insights into the mechanisms at play. Political stability (0.968), government effectiveness (0.327) and rule of law (1.431) all exhibit positive and significant effects on trade, validating the institutional quality hypothesis (Abreo *et al.*, 2021). These institutions reduce uncertainty, enhance contract enforcement and lower transaction costs, which factors in essential trade facilitation and investor confidence. In contrast, control of corruption shows a negative coefficient (−1.398). While counterintuitive, this aligns with findings by Onafowora and Owoye (2024) that initial anti-corruption drives in

Table 3. Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) traopen	1.000											
(2) envtax	−0.123*	1.000										
	(0.019)											
(3) co2	−0.020	0.226*	1.000									
	(0.700)	(0.000)										
(4) energyusage	0.149*	0.223*	0.407*	1.000								
	(0.005)	(0.000)	(0.000)									
(5) fdi	0.171*	−0.114*	−0.218*	−0.134*	1.000							
	(0.001)	(0.031)	(0.000)	(0.011)								
(6) agrigrowth	−0.569*	−0.028	−0.285*	−0.269*	0.115*	1.000						
	(0.000)	(0.592)	(0.000)	(0.000)	(0.029)							
(7) gdpgrowth	−0.197*	0.025	−0.058	−0.066	0.042	0.217*	1.000					
	(0.000)	(0.642)	(0.274)	(0.211)	(0.424)	(0.000)						
(8) Polystab	−0.312*	0.192*	0.097*	−0.046	−0.171*	0.015	0.105*	1.000				
	(0.000)	(0.000)	(0.067)	(0.386)	(0.001)	(0.771)	(0.046)					
(9) govteffec	−0.025	0.381*	0.129*	0.276*	−0.082	−0.382*	0.015	0.397*	1.000			
	(0.637)	(0.000)	(0.015)	(0.000)	(0.120)	(0.000)	(0.781)	(0.000)				
(10) corruption	−0.051	0.219*	−0.129*	0.159*	−0.021	−0.241*	0.051	0.407*	0.829*	1.000		
	(0.337)	(0.000)	(0.015)	(0.003)	(0.689)	(0.000)	(0.330)	(0.000)	(0.000)			
(11) ruleoflaw	−0.023	0.359*	0.003	0.225*	−0.050	−0.301*	0.016	0.413*	0.937*	0.891*	1.000	
	(0.658)	(0.000)	(0.959)	(0.000)	(0.348)	(0.000)	(0.759)	(0.000)	(0.000)	(0.000)		
(12) regqual	−0.167*	0.444*	0.135*	0.286*	−0.123*	−0.218*	0.105*	0.399*	0.921*	0.799*	0.909*	1.000
	(0.002)	(0.000)	(0.011)	(0.000)	(0.019)	(0.000)	(0.047)	(0.000)	(0.000)	(0.000)	(0.000)	

Note(s): *$p < 0.1$

Trade- (1), Environmental tax -(2), Carbon emission (CO_2) –(3), Energy usage –(4), Foreign Direct Investment –(5), Agricultural growth –(6), GDP growth –(7), Environmental sustainability policy –(8), Government effectiveness –(9), Control of corruption –(10), Rule of law –(11), Regulatory quality –(12)

Source(s): Authors' compilation, 2025

Table 4. Environmental tax and trade development

Variables	(1) Trade	(2) Trade	(3) Trade	(4) Trade	(5) Trade
Trade = Lag,	0.906***	0.877***	0.866***	0.870***	0.828***
	(0.0309)	(0.0323)	(0.0210)	(0.0198)	(0.0273)
Environmental tax	−2.881**	−1.806**	−1.713***	−5.713***	−2.415**
	(0.974)	(0.525)	(0.020)	(1.020)	(1.065)
Political stability	0.968***				
	(0.015)				
Government effectiveness		0.327***			
		(0.025)			
Control of corruption			−1.398**		
			(0.464)		
Rule of law				1.431***	
				(0.248)	
Regulatory quality					5.098**
					(0.191)
Carbon emission (CO_2)	−0.468	−0.575	−0.889***	−0.598**	−1.043***
	(1.031)	(1.295)	(0.093)	(0.185)	(0.050)
Energy usage	4.568***	−0.0248	1.605**	0.933	7.933**
	(1.492)	(4.558)	(0.470)	(2.754)	(3.397)
Foreign direct investment	0.398***	0.309***	0.325***	0.310***	0.389***
	(0.0733)	(0.0496)	(0.0491)	(0.0408)	(0.0356)
Agricultural growth	−0.0670	−0.112**	−0.127***	−0.125***	−0.160***
	(0.0415)	(0.0447)	(0.0379)	(0.0415)	(0.0450)
GDP growth	0.281***	0.378***	0.384***	0.380***	0.353***
	(0.0594)	(0.0495)	(0.0502)	(0.0559)	(0.0444)
Constant	−13.28	4.423	1.223	1.872	−17.14*
	(12.20)	(8.120)	(6.082)	(5.459)	(8.376)
AR1	0.005	0.007	0.008	0.008	0.011
AR2	0.180	0.165	0.175	0.168	0.130
Sargan test	0.462	0.444	0.586	0.488	0.538
Hansen Test	0.547	0.571	0.568	0.550	0.631
Country effect	Yes	Yes	Yes	Yes	Yes
Time effect	Yes	Yes	Yes	Yes	Yes
Observations	375	375	375	375	375
Number of countries	25	25	25	25	25

Note(s): Standard errors in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

Source(s): Authors' compilation, 2025

low-capacity states can disrupt entrenched patronage networks, creating short-term trade friction before long-term gains are realised.

Most strikingly, regulatory quality emerges with a strong positive effect (5.098) on trade openness. This underlines the idea that environmental regulation, when well-designed and transparent, is not a trade barrier but a catalyst for sustainable competitiveness. The evidence resonates with the Porter Hypothesis (Fu *et al.*, 2021), which argues that well-structured environmental policy can drive innovation, efficiency and, eventually, trade expansion.

To further unpack these dynamics, the disaggregated results for exports and imports reveal the underlying asymmetries shaping total trade outcomes in SSA. From Table A1, environmental taxation exerts a pronounced negative effect on exports, particularly in pollution-intensive and resource-based sectors, where higher compliance and production costs reduce external competitiveness. This contractionary effect on exports explains the negative coefficients observed for total trade. Conversely, the positive and mild response of imports to environmental taxation in Table A2 suggests that rising domestic costs stimulate import

substitution, especially for cleaner capital goods and intermediate inputs. In both cases, institutional quality emerges as a decisive factor; thus, countries with stronger regulatory frameworks, effective governance, and political stability experience smaller export losses and more efficient import adjustment. These patterns imply that the adverse aggregate trade effects of environmental taxation in SSA are not uniform but hinge critically on the institutional capacity to absorb and reallocate adjustment pressures across the trade structure.

The Dumitrescu–Hurlin panel causality results in Table A3 reinforce the earlier findings by confirming a unidirectional causality running from environmental taxation and institutional quality to trade, exports and imports. This implies that changes in environmental tax policy and governance dynamics actively drive trade performance in SSA, rather than merely responding to it, validating the direct impact relationships identified in the disaggregated models.

Building on the direct effects, which reveal that environmental taxes tend to reduce trade openness in SSA, the study turns to the deeper question:

Under what conditions can these adverse effects be mitigated or even reversed?

This leads us to explore the interactive role of institutional quality, where governance variables act not merely as controls but as critical moderators that shape the effectiveness of environmental taxation in influencing trade outcomes.

Across Models 6 to 10, in Table 5, the interaction terms provide a deeper insight into when environmental taxes may, in fact, become trade-enhancing. First, political stability, when interacted with environmental tax, yields a positive effect of 5.169. This implies that in politically stable environments, firms are more willing to absorb or adapt to green regulatory costs, perceiving them as part of a credible, long-term policy framework. This complements literature suggesting that policy predictability enhances investor confidence and facilitates cleaner trade transitions (Wani and Yasmin, 2023).

Government effectiveness demonstrates the strongest moderating impact, with an interaction coefficient of 7.630. This supports institutional theory arguments that capable states are not only better at enforcing taxes but also at deploying complementary policies such as green subsidies or technical assistance that mitigate trade distortions (Acemoglu and Robinson, 2025; Peiró-Palomino *et al.*, 2022).

Furthermore, control of corruption shows a negative interaction effect at −6.392. This paradoxically suggests that anti-corruption efforts, if abrupt or disconnected from broader reforms, can introduce uncertainty or disrupt established (albeit informal) trade networks. This reinforces Rodrik's (2000) caution that institutional reform must be sequenced carefully to avoid transitional costs that outweigh benefits.

Finally, the rule of law and regulatory quality also yield strong positive interaction effects (4.483 and 4.363, respectively), indicating that credible legal frameworks and coherent regulatory institutions convert green taxation into a signal for structured, rule-based economic upgrading. These findings resonate with the Porter hypothesis, which posits that stringent but well-designed regulation can induce innovation and enhance competitiveness (Zhang, 2021).

The total effects, ranging from 2.833 to 17.945, confirm that when institutional quality is high, the net impact of environmental tax on trade becomes positive and significant. The computed marginal effects ($\beta_2 + \beta_3$*Institutional Quality) confirm this, with all five institutional dimensions yielding trade-enhancing effects when interacting with environmental tax, except corruption, where the distortionary effects persist.

These findings provide compelling empirical validation for an extended pollution haven framework, one that no longer views environmental regulation and trade performance as opposed but rather sees their relationship as institutionally moderated. This study contributes to the literature by offering an interaction-based approach that explains the conditional efficacy of environmental taxation.

The controlled variables in models (1) through (10) present consistent and theoretically robust insights into the structural drivers of trade development in SSA. Their significance affirms that trade openness in the region is shaped not solely by policy instruments such as environmental taxes but also by the broader economic and ecological landscape. Carbon

Table 5. The role of institutional quality on environmental tax and trade development

Variables	(6) Trade	(7) Trade	(8) Trade	(9) Trade	(10) Trade
I. Trade = L,	0.902***	0.844***	0.865***	0.867***	0.836***
	(0.0306)	(0.0420)	(0.0273)	(0.0293)	(0.0320)
Environmental tax	−3.933***	−2.271***	−1.354***	−1.015***	−1.705*
	(0.116)	(0.289)	(0.193)	(0.040)	(0.965)
Political stability	0.722***				
	(0.613)				
Government effectiveness		3.176***			
		(0.191)			
Control of corruption			2.610***		
			(0.430)		
Rule of law				1.844***	
				(0.174)	
Regulatory quality					5.172*
					(1.778)
Carbon emission (CO_2)	−0.273	−1.603*	−1.006***	−0.793	−0.485
	(1.523)	(0.739)	(0.293)	(1.347)	(0.904)
Energy usage	−1.937	1.429***	1.102***	0.930	5.429**
	(2.024)	(0.169)	(0.174)	(2.948)	(2.013)
Foreign direct investment	0.287***	0.330***	0.338***	0.304***	0.351***
	(0.0533)	(0.0609)	(0.0419)	(0.0492)	(0.0614)
Agricultural growth	−0.0740*	−0.147**	−0.141***	−0.125**	−0.143***
	(0.0404)	(0.0640)	(0.0419)	(0.0453)	(0.0429)
GDP growth	0.352***	0.393***	0.392***	0.399***	0.392***
	(0.0596)	(0.0512)	(0.0790)	(0.0714)	(0.0657)
Pol. Stability *Environmental Tax	5.169***				
	(1.829)				
Govt. Effective*Environmental Tax		7.630***			
		(2.027)			
Con. Corruption*Environmental Tax			−6.392***		
			(2.345)		
Rule of Law* Environmental Tax				4.483***	
				(1.903)	
Reg. Quality*Environmental Tax					4.363***
					(0.926)
Total effect ($\beta_1 * \beta_2 * \beta_3$)	5.169**	8.535***	−5.136**	5.312**	7.830***
	(2.326)	(1.929)	(2.108)	(2.037)	(2.739)
Marginal effect	17.945***	−1.913	6.253***	4.349***	2.833***
$\beta_2 + \beta_3$*Institutional quality	(6.707)	(0.161)	(1.767)	(1.221)	(1.281)
Constant	5.636**	3.287*	1.874**	2.315*	−12.28***
	(2.672)	(1.268)	(0.786)	(1.529)	(6.19)
AR1	0.006	0.008	0.009	0.008	0.009
AR2	0.157	0.168	0.173	0.165	0.107
Sargan test	0.636	0.498	0.517	0.384	0.511
Hansen test	0.736	0.869	0.631	0.647	0.606
Country effect	Yes	Yes	Yes	Yes	Yes
Time effect	Yes	Yes	Yes	Yes	Yes
Observations	375	375	375	375	375
Number of countries	25	25	25	25	25

Note(s): Standard errors in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

Source(s): Authors' compilation, 2025

emissions show a negative and statistically significant effect in several models (e.g. −0.889, −1.043, −1.006), reinforcing the argument that pollution-intensive trade structures may be declining as environmental constraints, whether regulatory or resource-driven, tighten. This

supports the hypothesis that carbon-intensive sectors are becoming less viable export engines unless mitigated by technological adaptation or policy innovation (Abreo *et al.*, 2021).

In addition, energy usage, while more variable, frequently exhibits a positive and significant association with trade (e.g. 4.568, 1.605, 5.429), indicating that energy access and consumption remain foundational to SSA's tradable sectors, particularly manufacturing and processing. However, this link may also reflect the carbon intensity of trade, raising concerns about environmental sustainability unless decoupled via cleaner energy transitions (Wahab *et al.*, 2021).

FDI consistently and significantly promotes trade (coefficients ranging from 0.287 to 0.398), in line with global empirical evidence that FDI facilitates export diversification, technology transfer and supply chain integration, particularly in institutionally open economies (Beverelli *et al.*, 2023; Danquah and Barnor, 2025). Furthermore, agricultural growth shows a persistently negative relationship with trade openness (e.g. −0.127, −0.160, −0.143), meaning that agricultural output is either inward-facing or structurally disconnected from global markets, likely due to low value addition, logistical bottlenecks or weak export competitiveness.

Finally, GDP growth, by contrast, is positively and significantly associated with trade across all models (e.g. 0.352 to 0.399), validating classic trade-growth dynamics. This reflects the mutual reinforcement between economic expansion and market integration but also signals that trade-environment policy must be sensitive to growth cycles and distributional effects, particularly in fragile economies.

The diagnostic statistics presented affirm the credibility and robustness of the dynamic panel estimations employed to assess the interaction between environmental taxation, institutional quality and trade development in SSA.

The Arellano-Bond tests for autocorrelation show that AR(1) *p*-values range from 0.006 to 0.011, confirming the expected presence of first-order serial correlation in differenced residuals – an inherent feature of dynamic models. Crucially, the AR(2) *p*-values exceed conventional significance levels, ranging from 0.107 to 0.180. This indicates an absence of second-order serial correlation, thereby validating the legitimacy of lagged instruments in capturing endogeneity without biasing the estimators (Blundell and Bond, 2023).

Both the Sargan and Hansen tests for over-identifying restrictions yield *p*-values well above the 0.05 threshold across all models, ranging from 0.384 to 0.736. These results confirm that the instruments used are statistically valid and not overfitting the endogenous regressors, thus reinforcing the reliability of the GMM estimates. The absence of instrument proliferation further safeguards the Hansen test from the downward bias often associated with small samples. The inclusion of country and time fixed effects across all models helps to control for unobserved heterogeneity and time-specific shocks, critical given the structural and institutional diversity across the 25 SSA economies and over time.

Additionally, the diagnostic results in Table A4 lend strong empirical support to the robustness of the estimated GMM models. The absence of cross-sectional dependence and heteroskedasticity indicates that country-specific shocks do not bias the results, while the confirmed stationarity of variables upholds the validity of the dynamic specification. Moreover, the low VIF values and clean Ramsey test suggest that the relationships between environmental taxation, institutional quality and trade performance in SSA are not artefacts of model instability or omitted variables, reinforcing confidence in the reliability of the reported findings.

4.3 The threshold level of institutional quality that triggers a significant impact of environmental tax on trade development

Having established that institutional quality moderates the relationship between environmental taxation and trade, thus enhancing or suppressing its effects depending on the governance dimension, the study formed a more refined questions:

What level of institutional quality is required for this moderation to become significantly beneficial?

This leads to exploring threshold effects, where distinct institutional benchmarks delineate when environmental taxes shift from trade-reducing to trade-enhancing, offering deeper insight into the conditional nature of policy effectiveness in SSA. The threshold regression results in Table 6 present compelling evidence that the impact of environmental taxation on trade is not only nonlinear but also institutionally contingent, shaped decisively by the level of institutional quality. In each model, a statistically significant threshold (r) demarcates two distinct regimes; thus, a lower regime characterised by weak institutions and an upper regime where institutional strength enables trade-environment constructive interaction to materialise effectively.

For political stability, the threshold value of 3.296 represents a meaningful institutional boundary. Below this level, environmental taxes exert a large, negative impact on trade (−10.01), reflecting the destabilising effects of policy unpredictability. In politically fragile environments, regulatory changes, especially those that impose new costs, are often met with investor hesitancy, capital flight or evasion via informal markets. However, once this stability threshold is crossed, the relationship inverts dramatically: environmental taxes enhance trade (20.34), signalling that stability reduces perceived regulatory risk and enables firms to make long-term investments in compliance and green innovation. This corroborates Peiró-Palomino *et al.* (2022), who found that political predictability is a necessary precondition for fiscal tools to stimulate sustainable value chain reconfiguration. It also aligns with the broader institutionalist view that predictability, rather than rigidity, underpins investor confidence and regulatory credibility.

The case of government effectiveness with a threshold at −1.400 offers equally compelling evidence. Below this level, environmental taxes depress trade (−5.467), due to limited administrative capacity, enforcement inconsistency and weak policy coordination. In such settings, taxes may be levied without clear monitoring mechanisms or fail to be recycled into productive sectors, thereby magnifying their distortive effects. However, when government effectiveness surpasses the threshold, the effect reverses and becomes positive (4.921). This supports the argument, rooted in institutional theory (Němečková and Hayat, 2023), that effective governance enables the delivery of complementary public goods such as environmental infrastructure, technical support and credible rule enforcement that mitigate compliance costs and foster productive restructuring. It also echoes empirical studies by Beverelli *et al.* (2023), which show that trade gains from regulation only emerge in high-capacity states.

Turning to control of corruption, the threshold of −1.375 reveals a more nuanced dynamic. In states with pervasive corruption, environmental taxes reduce trade (−1.991), a result of rent-seeking behaviour, uneven tax enforcement and policy capture. Green taxation in such contexts becomes a tool of distortion rather than discipline. However, once the corruption index improves beyond the threshold, the effect becomes positive (2.580), reflecting the credibility gain associated with clean governance. This dynamic resonates with Onafowora and Owoye (2024) who emphasised institutional sequencing, where anti-corruption efforts must precede or accompany regulatory reforms to avoid backlash and administrative dysfunction. Moreover, it highlights the risk of premature green fiscal reform in fragile states, where enforcement can disrupt informal trade equilibria without delivering policy legitimacy.

With respect to the rule of law, a threshold of −1.283 indicates that formal legal institutions play a foundational role in shaping trade responses to environmental taxation. Below this point, firms perceive regulatory enforcement as arbitrary or selective, leading to trade suppression due to uncertainty, contractual risks and limited judicial redress. Yet once this threshold is exceeded, green tax policies begin to support trade (5.971), suggesting that legal credibility transforms environmental taxation from a punitive measure into a compliance-based governance tool. This aligns with the institutional economics literature, particularly in

Table 6. The threshold level of institutional quality dimensions that trigger a significant impact of environmental tax on trade development

Variables	(11) Political stability		(12) Government effectiveness		(13) Control of corruption		(14) Rule of law		(15) Regulatory quality	
	Lower regime	Upper regime	Lower regime	Upper regime	Lower regime	Upper regime	Lower regime	Upper regime	Lower regime	Upper regime
Trade development = Lag	0.471***	7.67***	0.619***	8.87***	0.651***	9.593**	0.489***	4.56***	0.557***	6.670***
	(0.0430)	(1.02)	(0.0429)	(1.071)	(0.0585)	(4.874)	(0.0746)	(0.508)	(0.0890)	(1.389)
Environmental tax	−10.01	20.34**	−5.467**	4.921***	−1.991**	2.580***	−1.672	5.971***	−22.69**	23.39**
	(6.971)	(10.27)	(1.48)	(1.50)	(0.686)	(0.046)	(1.286)	(2.710)	9.60)	(9.222)
Carbon emission (CO_2)	−5.401**	−20.49**	−66.97***	67.81***	63.85	−63.69	−3.668	7.063***	−2.749*	12.39**
	(1.50)	(5.45)	(17.01)	(11.40)	(85.26)	(89.71)	(8.44)	(2.81)	(1.84)	(6.17)
Energy usage	−101.8*	43.51***	−315.2***	254.3***	−106.6***	−17.19	−40.97*	91.2***	77.82***	−70.2***
	(45.95)	(14.02)	(59.9)	(50.9)	(32.6)	(35.8)	(18.6)	(18.3)	(13.3)	(22.5)
Foreign direct investment	−0.146	0.561**	−0.571	0.644**	−0.505***	0.626***	0.0265	−0.211	−0.143	0.226
	(0.235)	(0.225)	(0.552)	(0.241)	(0.136)	(0.142)	(0.166)	(0.560)	(0.153)	(0.509)
Agricultural growth	−0.534	0.306	−2.007	1.729	−0.126	0.183	−0.611	0.119	−0.492	0.406
	(0.462)	(0.514)	(1.476)	(1.730)	(2.402)	(2.338)	(0.545)	(0.753)	(0.918)	(0.447)
GDP growth	0.129	0.388	−1.281*	2.103**	−2.512*	−2.349**	−0.559*	0.601***	0.00491	0.464***
	(0.243)	(0.311)	(0.773)	(0.800)	(1.372)	(0.842)	(0.261)	(0.181)	(0.136)	(0.126)
cons_<	−27.88		−490.7		284.7		1,278**		683.0**	
	(183.0)		(1,010)		(1,098)		(509.2)		(344.7)	
Threshold (r)	3.296***		−1.400***		−1.375***		−1.283***		−1.066***	
	(0.463)		(0.167)		(0.137)		(0.173)		(0.179)	
Kink slope	16.9***		−33.41***		−10.61***		−21.72***		11.10***	
	(1.272)		(5.22)		(2.484)		(5.057)		(3.641)	
Countries	25		25		25		25		25	

Note(s): Standard errors in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$
Threshold estimation based on grid_num (50), trim_rate (0.1), boost (100)
Dependent variable is trade development; threshold variables are dimensions of institutional quality [Political stability –(11); Government effectiveness –(12); Control of corruption – (13); Rule of law – (14); Regulatory quality – (15)

Source(s): Authors' compilation, 2025

contexts where formal dispute resolution and legal predictability are critical for cross-border transactions.

Lastly, regulatory quality, with a threshold of −1.066, delineates the shift from incoherent, unstable policy environments to those with coherent, transparent and strategically aligned regulatory frameworks. Below this threshold, environmental taxes risk distorting incentives, misallocating resources or creating investor uncertainty. Above it, however, their impact becomes significantly positive (23.39), highlighting that institutional coherence, not merely regulation, enables long-run competitiveness. This finding strongly resonates with the Porter hypothesis (Zhang, 2021) which argued that well-designed environmental regulations can stimulate innovation, enhance efficiency and strengthen export capability. Recent work by Du *et al.* (2023) similarly found that market-based environmental regulations outperform command-and-control regimes, but only when embedded within consistent regulatory environments.

The magnitude of kink slopes reinforces these findings, statistically significant and sharp in all models, indicating regime shifts in how environmental taxes interact with trade. The shift under political stability is 16.9 and under government effectiveness rises to 33.41. These figures suggest that not just the presence, but the *depth* of institutional quality determines whether green taxation is economically viable.

In policy terms, these results suggest that "green fiscal policy" in SSA must be tailored to the governance capacity of individual states. In strong institutional settings, environmental taxation can align trade with sustainability objectives. In weak settings, the same policies may be counterproductive, highlighting the importance of sequencing institutional reform alongside environmental policy rollout.

5. Conclusion, implications and future research

This study provides critical empirical and theoretical insight into the complex interplay between environmental taxation, institutional quality and trade development in SSA. The results affirm that environmental taxes, while designed to internalise ecological costs, do not yield uniform outcomes. In fact, their effects on trade are highly contingent upon the strength and functionality of the institutional environment in which they are implemented.

In contexts marked by weak governance, low regulatory quality, political instability or poor rule of law, environmental taxes tend to suppress trade by increasing production costs, deterring investment and exacerbating policy uncertainty. However, once institutional thresholds are crossed, these same taxes become trade-enhancing, signalling regulatory credibility, lowering compliance risk and fostering investment in cleaner, more competitive sectors. This nonlinear relationship confirms that institutional quality is not peripheral but central to the trade outcomes of environmental regulation.

These findings build on and extend both the PHH and institutional theory, showing that the interaction between green fiscal policy and trade flows is regime-dependent. Unlike prior studies that treated institutional quality as a control or background factor, this research demonstrates it to be a threshold condition, one that decisively determines whether environmental taxes function as obstacles or catalysts for trade-based development. Moreover, by applying dynamic panel estimations and threshold regressions across five institutional dimensions, this study offers novel empirical evidence tailored to SSA's unique policy context. It contributes not only to academic discourse but also to the policy arena by offering a concrete framework for sequencing reforms in fragile states.

In line with the conclusion, the study recommends that: first, environmental tax policies should be scaled according to existing institutional capacity. In fragile states, priority must be placed on building foundational governance, such as enforcement infrastructure and policy coherence, before implementing broad green tax regimes. Second, regional institutions, such as the African Union and UNECA, should develop a threshold-based readiness assessment to help countries evaluate whether their institutional indicators meet the minimum requirements

for effective environmental tax implementation. Third, environmental taxes should not operate in isolation. They must be integrated into national trade and industrial policy to stimulate investment in cleaner production, incentivise technological upgrading, and align with WTO-compatible trade instruments. Finally, intra-African trade integration efforts such as AfCFTA should include regulatory convergence on environmental taxation to prevent carbon leakage, strengthen regional supply chains and enhance the competitiveness of African exports in green global markets.

Despite the study's contribution, it is limited by the reliance on secondary governance indicators, which may not fully capture informal institutional dynamics prevalent in SSA. Therefore, future research should incorporate micro-level, firm-level data or diverse types of goods (such as polluting goods or environmentally friendly goods) to determine heterogeneity in tax responses across industries.

Note

1. The 24 countries considered in this study are Burkina Faso, Cabo Verde, Cameroon, Chad, Democrat Republic of Congo, Congo Republic, Cote d'Ivoire, Equatorial Guinea, Ghana, Kenya, Lesotho, Madagascar, Mali, Mauritania, Mauritius, Namibia, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, South Africa, Togo and Uganda.

Supplementary material

The supplementary material for this article can be found online.

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