

STATE MANAGEMENT EFFICIENCY, TRADE OPENNESS, AND SUSTAINABLE DEVELOPMENT: A DYNAMIC BAYESIAN PERSPECTIVE

EFICIÊNCIA DA GESTÃO ESTADUAL, ABERTURA COMERCIAL E DESENVOLVIMENTO SUSTENTÁVEL: UMA PERSPECTIVA BAYESIANA DINÂMICA

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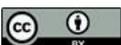
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Abstract

This study examines the relationship between trade openness and sustainable development, with particular emphasis on the conditioning role of government effectiveness. Using a cross-country dataset covering the period 2005–2023, the study employs a Bayesian regression framework to address parameter uncertainty and cross-country heterogeneity. Sustainable development is measured by the Sustainable Development Goal Index (SDGI), while trade openness is proxied by the ratio of total exports and imports to GDP, and government effectiveness reflects state management efficiency. The empirical findings indicate that trade openness, when considered in isolation, has a negative impact on sustainable development, suggesting that increased trade integration may intensify environmental degradation and social pressures in the absence of adequate governance. Government effectiveness also exhibits a negative standalone effect, implying that improvements in administrative efficiency do not automatically translate into sustainability gains when policy priorities remain predominantly growth oriented. In contrast, the interaction between trade openness and government effectiveness exerts a positive and robust effect on sustainable development. This result

Resumo

Este estudo examina a relação entre abertura comercial e desenvolvimento sustentável, com ênfase particular no papel condicionante da eficácia governamental. Utilizando um conjunto de dados de diversos países, abrangendo o período de 2005 a 2023, o estudo emprega uma estrutura de regressão Bayesiana para lidar com a incerteza dos parâmetros e a heterogeneidade entre os países. O desenvolvimento sustentável é medido pelo Índice de Objetivos de Desenvolvimento Sustentável (IODS), enquanto a abertura comercial é representada pela razão entre o total de exportações e importações e o PIB, e a eficácia governamental reflete a eficiência da gestão estatal. Os resultados empíricos indicam que a abertura comercial, quando considerada isoladamente, tem um impacto negativo sobre o desenvolvimento sustentável, sugerindo que o aumento da integração comercial pode intensificar a degradação ambiental e as pressões sociais na ausência de governança adequada. A eficácia governamental também apresenta um efeito negativo isolado, o que implica que melhorias na eficiência administrativa não se traduzem automaticamente em ganhos de sustentabilidade quando as prioridades políticas permanecem



demonstrates that effective state management plays a crucial role in internalizing trade related externalities and aligning economic integration with environmental and social objectives. Overall, the study highlights that trade openness is neither inherently beneficial nor detrimental to sustainable development. Its impact critically depends on government effectiveness, underscoring the importance of strengthening state capacity to harness the sustainability benefits of trade liberalization.

Keywords: Trade Openness. Government Effectiveness. Sustainable Development.

predominantemente orientadas para o crescimento. Em contraste, a interação entre abertura comercial e eficácia governamental exerce um efeito positivo e robusto sobre o desenvolvimento sustentável. Este resultado demonstra que a gestão estatal eficaz desempenha um papel crucial na internalização das externalidades relacionadas ao comércio e no alinhamento da integração econômica com os objetivos ambientais e sociais. De modo geral, o estudo destaca que a abertura comercial não é inerentemente benéfica nem prejudicial ao desenvolvimento sustentável. Seu impacto depende criticamente da eficácia governamental, ressaltando a importância de fortalecer a capacidade do Estado para aproveitar os benefícios da liberalização comercial em termos de sustentabilidade.

Palavras-chave: Abertura Comercial. Eficácia Governamental. Desenvolvimento Sustentável.

1 INTRODUCTION

Since the early nineteenth century, profound transformations in economic structures, political systems, and social organization have reshaped the global development trajectory. Alongside economic expansion, humanity has increasingly confronted transboundary challenges such as environmental degradation and food insecurity—outcomes closely linked to prolonged technological advancement and intensive human exploitation of natural resources. An excessive emphasis on GDP-led growth has accelerated resource depletion, exacerbated environmental pollution, and disrupted ecological balance (Lee *et al.*, 2022). As a result, achieving sustainable development (SD)—which requires a balanced integration of economic progress, social welfare, and environmental protection—has become a central global concern (Oanh, 2024).

Nevertheless, the pursuit of SD remains highly challenging in the context of persistent environmental pollution and climate change, particularly in economies undergoing rapid industrialization characterized by continuous production expansion (Bekabil, 2020). These challenges are more pronounced in developing countries, where the imperatives of poverty reduction, income improvement, and socio-economic transformation often necessitate deeper engagement with economic freedom (EF) and

market-oriented reforms (Alexander, 2006). From a classical perspective, Krueger (1974) defines a free market as one operating without quantitative restrictions on buyers and sellers, implying that liberalization fundamentally entails the removal or relaxation of state-imposed controls. In practice, liberalization broadly encompasses policy measures that reduce direct government intervention or replace rigid controls with more flexible regulatory frameworks.

A substantial body of empirical literature has examined the contribution of trade openness (TO) to economic growth, with recent evidence provided by Amna *et al.* (2020), Ho *et al.* (2021), Kong *et al.* (2021), Nwadike *et al.* (2020), and Nguyen *et al.* (2021). However, these studies largely prioritize growth outcomes while paying limited attention to the environmental and social dimensions that are integral to sustainable development. This omission is particularly problematic given that, in many low-income economies, policy priorities continue to favor economic expansion over environmental quality. In such contexts, institutional arrangements often implicitly support growth strategies centered on pollution-intensive “brown” sectors. By contrast, although developed economies have made significant investments in cleaner technologies and environmental infrastructure, several remain among the world’s major polluters, including the United States (Alvarado *et al.*, 2021), raising unresolved questions about the sustainability of growth under trade liberalization.

Accordingly, the relationship between trade openness and sustainable development cannot be adequately understood without accounting for the role of institutional quality (IQ). Despite its importance, empirical research explicitly linking TO and SD remains scarce (Mandan, 2002; Mushtaq & Khan, 2018). More recent studies have extended the analysis by incorporating mediating mechanisms such as the circular economy (Lima *et al.*, 2021) or renewable energy deployment (Shahnazi & Shabani, 2021). Nevertheless, the institutional dimension—particularly the effectiveness of state management—has not been systematically integrated into existing frameworks. Moreover, most prior investigations rely on conventional frequentist estimation techniques, which may be sensitive to restrictive assumptions and provide limited insight into the probabilistic nature of parameter effects.

To address these gaps, the present study adopts a Bayesian approach to examine the impact of economic freedom and trade openness on sustainable development across both developed and developing countries, with explicit consideration of institutional

quality. By doing so, the analysis not only captures the uncertainty and heterogeneity inherent in macroeconomic relationships but also offers probabilistic evidence on the role of institutions in shaping sustainable development outcomes. The findings contribute novel insights and inform differentiated policy implications tailored to countries at varying stages of development.

The remainder of the paper is organized as follows. Section 2 reviews the relevant literature. Section 3 describes the data and methodological framework. Section 4 presents and discusses the empirical results, while Section 5 concludes with policy implications.

2 LITERATURE REVIEW

2.1 Impact of TO and IQ on SD

Sustainable development (SD) was formally articulated by the United Nations Brundtland Commission in 1987 as a development paradigm that satisfies current needs without undermining the capacity of future generations to meet their own. This concept inherently rests on the balanced integration of economic performance, social inclusion, and environmental protection—commonly referred to as the triple bottom line (Nogueira *et al.*, 2022). In parallel, classical economic thought has long emphasized the role of market freedom in promoting efficiency and growth. Adam Smith’s notion of the “invisible hand” highlights the importance of free choice, competition, and decentralized decision-making in resource allocation. Subsequent contributions by Ricardo and Friedman further reinforced the view that voluntary exchange, secure property rights, and market competition are fundamental drivers of economic progress (North & Thomas, 1973; Friedman, 1962).

Despite its explanatory power, the classical free trade framework exhibits notable limitations, particularly in its insufficient consideration of environmental degradation and income inequality. As argued by Copeland and Taylor (2017), intensified competition in liberalized markets may induce firms to minimize costs to sustain profitability, often by relaxing environmental safeguards or reducing waste management expenditures, thereby deteriorating environmental quality. Building on this argument, the pollution haven hypothesis suggests that when countries share similar economic structures, wealthier nations tend to enforce stricter environmental regulations as societal demand for

environmental quality rises with income. Consequently, pollution-intensive activities are more likely to relocate toward lower-income countries with weaker environmental standards, granting them a comparative advantage in environmentally sensitive industries. Under such conditions, greater trade openness (TO) can accelerate the geographical concentration of polluting production in poorer regions, effectively transforming them into “pollution havens” (Copeland & Taylor, 2017).

Against this backdrop, the pursuit of economic freedom (EF) within a sustainable development framework necessitates careful attention to institutional quality (IQ), particularly the effectiveness of state management. Institutions—comprising constitutions, legal systems, and regulatory frameworks—constitute the formal constraints that structure economic and social interactions (North, 1990). These institutional arrangements provide the rules and enforcement mechanisms that underpin market transactions, ensuring predictability and compliance. Without such foundations, economic exchanges become fraught with uncertainty, elevating transaction costs and discouraging productive activity. As emphasized by Kasper *et al.* (2012), individuals and firms can only fully exercise economic freedom when there is sufficient confidence that contracts will be honored and property rights protected.

Well-functioning institutions play a pivotal role in mitigating transaction risks, thereby enabling trade openness to operate more effectively. When supported by strong state management and governance capacity, trade can foster sustainable economic growth through specialization, economies of scale, and enhanced productivity, while simultaneously supporting social outcomes such as improved public revenues and reduced inequality. Moreover, robust institutional frameworks can align trade expansion with environmental objectives by enforcing standards, incentivizing cleaner technologies, and discouraging excessive emissions (Dal Bo & Rossi, 2007; Nguyen *et al.*, 2018). However, it is also recognized that overly rigid regulatory environments may constrain trade flows, suggesting a potential trade-off between governance intensity and openness. This duality underscores that the impact of economic freedom and trade openness on sustainable development cannot be adequately assessed without explicitly accounting for the role of institutional quality and state management efficiency.

2.2 Research gap

From a research perspective, existing studies on the nexus between trade openness (TO) and sustainable development (SD) remain fragmented and uneven, with most contributions concentrating on a single dimension of sustainability rather than adopting a holistic framework. Early evidence by Easton and Walker (1997), for example, examined the effect of free trade on per capita income and economic growth using cross-sectional data from 57 countries, concluding that market freedom enhances property rights and, in turn, promotes income growth. Subsequent studies by Ayal and Karras (1998) and Ali and Crain (2002) further investigated the relationship between economic freedom (EF) and economic growth, though their findings unexpectedly suggested a negative association, attributing this outcome to persistently low growth rates in certain contexts. In contrast, Doucouliagos and Ulubasoglu (2006) provided evidence from 82 countries showing that EF exerts both direct and indirect positive effects on economic growth through capital accumulation. These findings were reinforced by Justesen (2008), who identified a strong and positive causal link between EF—particularly monetary and trade freedom—and economic growth, as well as by Williamson and Mathers (2011), who documented the growth-enhancing role of trade and cultural freedom across 141 countries.

Beyond growth-oriented outcomes, a number of studies have emphasized the economic pillar of sustainable development influenced by economic freedom (Doucouliagos & Ulubasoglu, 2006; Akin *et al.*, 2014; Hussain & Haque, 2016). However, research explicitly integrating environmental and social dimensions remains relatively limited. With respect to environmental sustainability, empirical evidence has increasingly focused on the relationship between trade openness and environmental quality, particularly CO₂ emissions, as documented by Carlsson and Lundström (2001), Adesina and Mwamba (2019), Riti *et al.* (2021), Shahnazi and Shabani (2021), Sart *et al.* (2022), and Wu *et al.* (2022). In terms of social sustainability, Madan (2002) assessed the impact of free trade on social outcomes using the Human Development Index, while Gehring (2013) constructed a welfare-based social index to capture broader societal effects.

More recent contributions have attempted to extend the SD framework by incorporating additional mediating channels. For instance, Lima *et al.* (2021) emphasized

the role of the circular economy in linking economic freedom to sustainable development, whereas Shahnazi and Shabani (2021) highlighted the importance of renewable energy in shaping sustainability outcomes. In parallel, a limited number of studies have directly examined the relationship between trade openness and sustainable development (Mandan, 2002; Mushtaq & Khan, 2018; Wang *et al.*, 2024). Nevertheless, these studies largely overlook the conditioning role of institutional quality—particularly state management efficiency—in shaping how trade openness translates into sustainable development outcomes. As a result, the interaction between TO and SD under varying levels of institutional capacity remains insufficiently explored, revealing a substantive gap in the existing literature.

From a methodological standpoint, prior empirical investigations have predominantly relied on traditional frequentist approaches, including generalized method of moments (GMM) estimations (Mushtaq & Khan, 2010), pooled mean group (PMG) techniques (Riti *et al.*, 2021), and spatial econometric models (Wu *et al.*, 2022). While these methods offer valuable insights, their inference is often contingent on restrictive assumptions that may not fully capture the complexity, heterogeneity, and uncertainty inherent in cross-country sustainability dynamics. To address these limitations, the present study employs a Bayesian framework to examine the impact of trade openness on sustainable development across 114 countries, explicitly accounting for the role of institutional quality. This approach enables a probabilistic assessment of parameter effects and provides more nuanced policy implications tailored to different institutional contexts.

3 RESEARCH MODELS AND METHODS

3.1 Research models

To examine the impact of economic freedom on sustainable development, this study adopts a quantitative empirical approach. Following Oanh (2024), sustainable development is proxied by the Sustainable Development Goal Index (SDGI), which aggregates 17 indicators corresponding to the three core pillars of sustainability—economic, social, and environmental—consistent with the United Nations Sustainable Development Goals (SDGs). Owing to its comprehensive coverage, the SDGI is widely

recognized as one of the most inclusive indicators for assessing a country's overall sustainable development performance (Schmidt-Traub *et al.*, 2017). Data for the SDGI are obtained from the SDG Index database (sdgindex.org).

Trade openness is measured as the ratio of total exports and imports of goods and services to gross domestic product (GDP), reflecting the extent of a country's integration into the global trading system. This indicator has been widely applied in empirical research examining the economic and development implications of trade liberalization (Mandan, 2002; Mushtaq & Khan, 2018; Wang *et al.*, 2024).

Given the specific focus of this study, government effectiveness (GOV) is employed as the sole institutional variable capturing state management efficiency. Government effectiveness reflects the quality of public service provision, the competence of the civil service, the credibility of policy commitments, and the capacity of governments to design and implement effective policies. In the context of trade openness, this dimension of governance is particularly relevant, as it determines how effectively governments manage the environmental and social externalities arising from increased trade integration. By concentrating exclusively on government effectiveness rather than a broader composite institutional index, the analysis directly captures the operational capacity of the state, while avoiding potential multicollinearity and over-parameterization issues associated with the simultaneous inclusion of multiple governance indicators.

In addition to the core explanatory variables, the empirical model incorporates a set of control variables commonly linked to sustainable development dynamics. These include economic growth (GDP), environmental quality measured by CO₂ emissions, foreign direct investment (FDI), urbanization rate (UR), population growth rate (POP), inflation rate (INF), and financial development (FD). Detailed definitions, measurement approaches, and data sources for all variables are reported in Table 1.

Research model:

$$SDGI_{i,t} = \beta_0 + \beta_1 OPEN_{i,t} + \beta_2 GOV_{i,t} + \beta_3 OPEN * GOV_{i,t} + \beta_x Z_{i,t} + \varepsilon_{i,t} \quad (1)$$

with:

$i = 1, 2, \dots, n$; $t = 1, 2, \dots, t$ (i is the country and t is the observation time in the model by year from 2008 to 2021).

Variable Z represents control variables including: (1) Environmental quality (CO2); (2) Urbanization rate (UR); (3) Foreign direct investment (FDI); (4) Population growth rate (POP); (5) Economic growth (GDP), (6) Inflation rate (INF), (7) Financial development index (FD) and (8) Trade openness (OPEN).

Table 1*Description of variables*

Variable	Symbol	Measurement	Studies	Data source
Dependent variable				
Sustainable Development	SDGI	17 indicators are in Appendix 1.	Dinh (2025a, 2025b, 2025c, 2025d); Huy <i>et al.</i> (2025a, 2025b), Quoc <i>et al.</i> , (2025c)	SDGIndex.org
Independent variables				
Trade openness	OPEN	Ratio of total import and export of goods and services to GDP. (%)	Wang <i>et al.</i> (2024)	WDI
Government effectiveness	GOV	Index from the World Bank's Worldwide Governance Indicators (WGI), ranging from -2.5 to 2.5, capturing the quality of public services and the effectiveness of policy formulation and implementation.	Van <i>et al.</i> (2025a, 2025b)	WDI
Control variable				
Economic growth	GDP	GDP per capita (annual growth, %)	Huy & Loan (2022); Huy <i>et al.</i> (2024), Quoc & Quoc (2025)	WDI
Environmental quality	CO2	CO2 emission rate per capita	Su <i>et al.</i> (2021)	WDI
Urbanization rate	UR	Ratio of urban population to total population (%)	Huy <i>et al.</i> , (2023a, 2023b), Nguyen Quoc <i>et al.</i> (2025), Quoc <i>et al.</i> (2025a, 2025b), Van & Le Quoc (2024)	WDI
Population growth rate	POP	Annual population growth rate (%)	Huy & Tam (2025)	WDI
Foreign Direct Investment	FDI	FDI/GDP (%)	Khoi & Dinh (2025); Tuyet & Dinh (2025)	WDI
Financial development index	FD	The financial development index is taken from the IMF	Oanh <i>et al.</i> (2023)	IMF
Inflation rate	INF	Annual inflation growth (%)	Oanh <i>et al.</i> (2023); Le Quoc (2024), Le Quoc <i>et al.</i> (2025)	WDI

Source: Compiled by author

3.2 Research methods

In Bayesian statistics, the study data are combined with a priori information to calculate a posterior distribution, and the results are interpreted as a probability distribution of parameter values, regardless of sample size. Therefore, the Bayesian method can overcome the disadvantage of small samples in studies (Zondervan-Zwijenburg *et al.*, 2017). From a Bayesian perspective, we construct a Bayesian linear regression using a probability distribution of the following form:

$$P(\beta|y, X) = P(y|\beta, X)(P(\beta|X)) \quad (2)$$

We utilize the Markov Chain Monte Carlo (MCMC) and Gibbs Sampler techniques to obtain the posterior distributions of the coefficients. This involves estimating and simulating 12,500 draws from the posterior distribution, with the initial 2,500 draws typically discarded. The MCMC technique is a commonly employed method for fitting complex models across diverse domains (Levy, 2020).

3.3 Research data

In addition to SD collected from Sdindex.org and financial development index at IMF. The remaining variables are collected from the World Bank. Because of data limitations, in this study, the author conducted research for the period from 2005-2023 including 114 countries, missing or absent countries will be excluded. With the presence of endogeneity problems, multicollinearity between GDP and variables in the model. then the Bayesian method is ideal.

Table 2

Descriptive statistical results of variables for the period 2005-2023

Variable	Mean	Std. Dev.	Minimum	Maximum
SDGI	74.72	6.86	53.69	91.49
OPEN	104.09	66.29	34.05	409.64
GOV	0.77	0.58	-0.71	2.45
GDP	3.29	4.34	-30.52	25.68
CO2	6.64	2.14	0.59	24.48
UR	69.63	22.19	17.99	103.06
POP	0.54	0.85	-2.33	3.48

FDI	6.47	19.07	-4.55	145.55
FD	0.52	0.22	0.14	0.94
INF	3.38	3.29	-2.20	16.31

Source: Authors

The descriptive statistics indicate substantial cross-country heterogeneity in sustainable development, trade openness, and government effectiveness over the study period. The average Sustainable Development Goal Index (SDGI) is 74.72, with a standard deviation of 6.86, suggesting moderate dispersion in sustainability performance across countries. The SDGI ranges from a minimum of 53.69 to a maximum of 91.49, highlighting pronounced disparities between countries with relatively low sustainability outcomes and those approaching advanced levels of sustainable development.

Trade openness (OPEN) exhibits considerable variability, with a mean value of 104.09 and a large standard deviation of 66.29. The wide range—from 34.05 to 409.64—reflects stark differences in the degree of integration into the global trading system. While some economies remain relatively closed, others display exceptionally high trade intensity, often associated with small open economies or countries serving as global trade hubs. This substantial dispersion underscores the potential for trade openness to exert heterogeneous effects on sustainable development, depending on national contexts.

Government effectiveness (GOV) has an average value of 0.77, indicating that, on average, countries in the sample exhibit moderately strong state management capacity. However, the standard deviation of 0.58 and the broad range from -0.71 to 2.45 reveal significant variation in governance quality. This suggests that while some countries possess highly effective governments capable of implementing and enforcing policies, others face notable governance constraints. Such heterogeneity reinforces the relevance of government effectiveness as a critical conditioning factor in the relationship between trade openness and sustainable development.

4 BAYESIAN RESEARCH RESULTS

Table 3 presents the Bayesian regression results examining the relationship between trade openness, government effectiveness, and sustainable development. The findings reveal a clearly conditional and governance-dependent relationship, indicating that the sustainability effects of trade openness crucially depend on state management efficiency.

The coefficient of trade openness (OPEN) is negative (Mean = -0.0247), suggesting that, on average, greater integration into global trade is associated with a decline in the Sustainable Development Goal Index (SDGI) when the role of government effectiveness is not explicitly accounted for. This result implies that trade liberalization, in the absence of strong governance mechanisms, may intensify resource exploitation, expand pollution-intensive production, and reinforce growth-oriented strategies that prioritize economic efficiency over environmental protection and social inclusion. The relatively small posterior uncertainty (Std. Dev. = 0.0138) and near-zero Monte Carlo Standard Error (MCSE) indicate that this negative effect is estimated with high precision.

Government effectiveness (GOV) exhibits a large negative coefficient (Mean = -5.43), pointing to a counterintuitive but economically meaningful outcome. This finding suggests that improvements in state management efficiency do not automatically translate into higher sustainable development performance. In many countries, effective governments may primarily focus on accelerating economic growth, improving administrative efficiency, and facilitating market expansion, while environmental and social objectives remain secondary. Under such circumstances, stronger government effectiveness may inadvertently reinforce “brown growth” trajectories—characterized by industrial expansion, rising emissions, and environmental stress—thereby exerting a negative effect on overall sustainability. The relatively large standard deviation (2.44) reflects substantial cross-country heterogeneity, indicating that the sustainability implications of government effectiveness vary depending on national policy priorities and development models.

Crucially, the interaction term $OPEN \times GOV$ displays a positive coefficient (Mean = 0.352), highlighting the central contribution of this study. This result demonstrates that government effectiveness fundamentally alters the sustainability impact of trade openness. When state management capacity is sufficiently strong, governments are better able to internalize the environmental and social externalities generated by trade liberalization through effective regulation, enforcement of environmental standards, and strategic industrial and trade policies. In such contexts, trade openness can facilitate technology transfer, promote cleaner production, and support inclusive growth, thereby enhancing sustainable development outcomes. The positive interaction effect confirms that trade openness becomes sustainability-enhancing only when embedded within a robust governance framework.

The Bayesian diagnostics confirm the reliability of the estimation results. The acceptance rate of 0.986 indicates excellent mixing of the Markov Chain Monte Carlo (MCMC) algorithm, well above conventional thresholds. The minimum efficiency of 0.874 suggests a high effective sample size, ensuring precise posterior inference. Moreover, the maximum Gelman–Rubin statistic (R_c) of 1.000 provides strong evidence of full convergence across chains. Collectively, these diagnostics affirm the robustness and stability of the Bayesian estimates.

The results underscore a key policy insight: trade openness alone is insufficient to promote sustainable development. Without effective state management, trade liberalization may undermine sustainability objectives. However, when combined with strong government effectiveness, trade openness can be transformed into a powerful driver of sustainable economic, social, and environmental progress.

Table 3

Bayesian regression results

Variable	Dependent variable: SDGI		
	Mean	Std. Dev.	MCSE
OPEN	-0.0247	0.0138	0.0000
GOV	-5.43	2.44	0.0248
GOV_IQ	0.352	0.408	0.0023
GDP	-0.193	0.089	0.0004
CO2	-0.533	0.086	0.0004
UR	0.061	0.0141	0.0001
POP	-0.897	0.377	0.0031
FDI	-0.033	0.0084	0.0001
FD	0.645	0.205	0.0071
INF	0.151	0.046	0.0004
CONS	19.23	3.29	0.0014
Acceptance rate	0.986		
Efficiency: min	0.874		
Max Gelman-Rubin R_c	1.000		

Source: Authors

5 CONCLUSION AND POLICY IMPLICATIONS

5.1 Conclusion

This study examines the relationship between trade openness and sustainable development, with a particular emphasis on the conditioning role of government effectiveness. Using a Bayesian regression framework and a cross-country dataset

spanning the period 2005–2023, the analysis provides new insights into how trade liberalization and state management efficiency jointly shape sustainable development outcomes.

The empirical results reveal that trade openness, when considered in isolation, exerts a negative effect on sustainable development. This finding suggests that increased integration into global trade may intensify resource extraction, pollution-intensive production, and growth-oriented strategies that undermine environmental quality and social cohesion if not properly regulated. Similarly, government effectiveness on its own is found to be negatively associated with sustainable development, indicating that improvements in administrative efficiency and policy implementation do not automatically translate into sustainability gains. In many countries, effective governance structures may prioritize economic expansion and market efficiency over environmental protection and social inclusion, thereby reinforcing unsustainable development patterns.

Crucially, the interaction between trade openness and government effectiveness yields a positive and statistically meaningful effect on sustainable development. This result underscores that the sustainability implications of trade liberalization are fundamentally conditional on state capacity. When governments possess strong implementation capabilities, credible policy commitments, and effective regulatory oversight, trade openness can be leveraged to promote cleaner production, technological upgrading, and more inclusive growth. In such institutional environments, the negative externalities associated with trade are more likely to be internalized, allowing trade openness to contribute positively to sustainable development objectives.

From a methodological perspective, the Bayesian approach employed in this study offers several advantages over traditional frequentist methods. By providing full posterior distributions and robust convergence diagnostics, the Bayesian framework allows for more reliable inference under conditions of cross-country heterogeneity and parameter uncertainty. The strong convergence properties observed in the estimation further enhance confidence in the empirical findings.

5.2 Policy implications

The empirical findings of this study carry several important policy implications for countries seeking to leverage trade openness as a pathway toward sustainable

development. First, the negative standalone effect of trade openness highlights that trade liberalization should not be pursued as an end in itself. Policymakers need to recognize that increased trade integration, in the absence of effective governance, may exacerbate environmental degradation and social inequalities. Consequently, trade policies should be systematically aligned with sustainability objectives rather than focusing solely on export expansion or competitiveness.

Second, the results emphasize the pivotal role of government effectiveness in shaping sustainability outcomes. Improving state management efficiency is essential for ensuring that trade-related externalities are effectively regulated and internalized. Governments should strengthen their capacity to design and implement coherent policy frameworks that integrate trade, environmental protection, and social development. This includes enhancing regulatory enforcement, improving inter-agency coordination, and ensuring policy credibility to reduce compliance gaps and regulatory arbitrage.

Third, the positive interaction between trade openness and government effectiveness suggests that trade can become a catalyst for sustainable development when supported by strong governance. Policymakers should therefore prioritize institutional reforms that enable governments to channel trade and investment toward environmentally friendly and socially inclusive sectors. Measures such as enforcing environmental standards in export-oriented industries, promoting green technologies through trade incentives, and embedding sustainability criteria into trade and investment agreements can help transform trade openness into a driver of long-term sustainability.

Finally, the findings underscore the need for differentiated policy strategies across countries. In economies with weaker government effectiveness, policy efforts should initially focus on strengthening state capacity and regulatory institutions before further expanding trade openness. In contrast, countries with relatively strong governance structures can pursue deeper trade integration while simultaneously advancing sustainability goals. Overall, the results suggest that sustainable development requires a coordinated policy approach in which trade openness and government effectiveness are jointly addressed rather than treated as separate policy domains.

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APPENDIX

Appendix 1

17 indicators for calculating the sustainable development index

Sustainable Development Index (SDGI)		SDGIndex.org
Target 1	No Poverty	
Target 2	No Hunger	
Target 3	Good Health and Well-Being	
Target 4	Quality Education	
Target 5	Gender Equality	
Target 6	Clean Water and Sanitation	
Target 7	Affordable and Clean Energy	
Target 8	Decent Work and Economic Growth	
Target 9	Industry, Innovation and Infrastructure	
Target 10	Reduced Inequalities	
Target 11	Sustainable Cities and Communities	
Target 12	Responsible Consumption and Production	
Target 13	Climate Action	
Target 14	Life Below Water	
Target 15	Life on Land	
Target 16	Peace, Justice and Strong Institutions	
Target 17	Partnerships for the Goals	

Authors' Contribution

All authors contributed equally to the development of this article.

Data availability

All datasets relevant to this study's findings are fully available within the article.

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