http://dx.doi.org/10.18623/rvd.v22.n6.3957

RETHINKING SUSTAINABLE DEVELOPMENT THROUGH FREEDOM AND ANTI-CORRUPTION: EVIDENCE FROM TWO GLOBAL DEVELOPMENT TIERS

REPENSANDO O DESENVOLVIMENTO SUSTENTÁVEL ATRAVÉS DA LIBERDADE E DO COMBATE À CORRUPÇÃO: EVIDÊNCIAS DE DOIS NÍVEIS DE DESENVOLVIMENTO GLOBAL

Article received on: 9/10/2025
Article accepted on: 11/10/2025

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The authors declare that there is no conflict of interest

Abstract
This study examines how economic freedom and control of corruption influence sustainable development across two global development tiers, consisting of 22 developing countries and 28 developed countries during the period 2008 to 2023. Using the Sustainable Development Goal Index as a comprehensive measure of sustainability, the study applies a Bayesian regression framework to capture parameter uncertainty and improve inference in the presence of institutional diversity. The results show a clear divergence between the two groups. In developing economies, economic freedom reduces sustainable development performance, reflecting weak regulatory capacity, unequal market structures, and the expansion of pollution intensive activities. In contrast, countries with advanced institutional systems benefit from economic freedom, which promotes innovation, efficient resource allocation, and stronger environmental governance. Control of corruption also displays asymmetric effects. It does not generate immediate sustainability gains in developing countries where corruption remains systemic, but it significantly enhances sustainable development in developed countries where governance structures are more effective. The interaction effect demonstrates that stronger corruption control can reduce the negative impact of economic freedom in developing economies, while showing diminishing returns in developed economies. The findings highlight that economic freedom can support sustainable development only when supported by strong institutions and effective anti corruption strategies.

Resumo
Este estudo examina como a liberdade econômica e o controle da corrupção influenciam o desenvolvimento sustentável em dois níveis de desenvolvimento global, compostos por 22 países em desenvolvimento e 28 países desenvolvidos, durante o período de 2008 a 2023. Utilizando o Índice de Objetivos de Desenvolvimento Sustentável como uma medida abrangente de sustentabilidade, o estudo aplica uma estrutura de regressão Bayesiana para capturar a incerteza dos parâmetros e aprimorar a inferência na presença de diversidade institucional. Os resultados mostram uma clara divergência entre os dois grupos. Nas economias em desenvolvimento, a liberdade econômica reduz o desempenho do desenvolvimento sustentável, refletindo a fraca capacidade regulatória, as estruturas de mercado desiguais e a expansão de atividades intensivas em poluição. Em contraste, os países com sistemas institucionais avançados se beneficiam da liberdade econômica, que promove a inovação, a alocação eficiente de recursos e uma governança ambiental mais robusta. O controle da corrupção também apresenta efeitos assimétricos. Não gera ganhos imediatos de sustentabilidade nos países em desenvolvimento, onde a corrupção permanece sistêmica, mas aprimora significativamente o desenvolvimento sustentável nos países desenvolvidos, onde as estruturas de governança são mais eficazes. O efeito de interação demonstra que um controle mais forte da corrupção pode reduzir o impacto negativo da liberdade econômica nas economias em desenvolvimento, enquanto apresenta retornos decrescentes nas economias desenvolvidas. Os resultados destacam que a liberdade econômica

Keywords: Sustainable Development. Economic Freedom. Control of Corruption. Institutional Quality. Bayesian Analysis. Developing Countries. Developed Countries.

só pode sustentar o desenvolvimento sustentável quando apoiada por instituições fortes e estratégias anticorrupção eficazes.

Palavras-chave: *Desenvolvimento Sustentável. Liberdade Econômica. Combate à Corrupção. Qualidade Institucional. Análise Bayesiana. Países em Desenvolvimento. Países Desenvolvidos.*

1 INTRODUCTION

Since the nineteenth century, global development has unfolded amid repeated waves of economic, political, and social upheaval. Episodes such as the Asian financial crisis in 1997, the collapse of the dotcom sector in 2000, the worldwide financial breakdown in 2008, the Covid 19 shock in 2019, and more recent geopolitical confrontations including the Russia Ukraine conflict in 2022 and the Hamas Israel war have collectively reshaped the international landscape. These disruptions have not only destabilized financial systems but have also exposed deeper structural vulnerabilities that transcend national boundaries. Mounting environmental pollution, the accelerated depletion of natural resources, growing concerns about climate instability, and emerging risks related to food and energy security illustrate how decades of industrial expansion and scientific progress have produced unintended consequences for planetary sustainability. The persistent pursuit of GDP growth, often detached from ecological constraints, has intensified the erosion of natural capital and weakened ecological resilience (Lee *et al*., 2022). Consequently, deteriorating environmental conditions have prompted renewed debate on whether the world can realistically achieve sustainable development, a goal that depends on maintaining a workable balance among economic performance, social well being, and environmental protection (ESCAP and Scientific, 2015; Dinh, 2025a; Huy & Dinh, 2025a; Huy & Dinh, 2025b; Huy & Loan, 2022; Quoc *et al*., 2025a; Quoc *et al*., 2025b).

Reaching sustainable development targets is even more demanding in a world where industrialization continues to drive pollution and climate related risks (Bekabil, 2020). In many developing countries, efforts to alleviate poverty, expand economic opportunities, and improve living standards remain closely tied to the degree of economic

freedom available to households, firms, and investors (Alexander, 2006). Krueger (1974) observed that markets can only function freely when quantity based restrictions are absent, meaning that deregulation essentially removes or relaxes state imposed barriers. Research linking economic freedom to economic expansion—such as Doucouliagos and Ulubasoglu (2006), Akin *et al*. (2014), and Hussain and Haque (2016)—has reinforced the belief that freer markets stimulate growth. Yet these studies frequently under examine how economic freedom interacts with environmental conditions or social well being, both of which are central to sustainable development. The issue becomes more complex when weak governance allows corruption to distort market incentives, lower compliance with environmental regulations, and enable the proliferation of pollution intensive industries. In several developing economies, the combination of economic freedom and limited oversight often results in the expansion of what are commonly referred to as brown industries. Meanwhile, certain developed countries, despite possessing advanced technologies to mitigate pollution, continue to appear among the world's notable emitters—including the United States—raising questions about population pressures, regulatory design, and consumption patterns (Alvarado *et al*., 2021). These observations indicate that the relationship between economic freedom and sustainable development cannot be understood without considering the moderating function of corruption control.

Academic work specifically exploring how economic freedom and anti corruption policies jointly influence sustainable development remains limited. Existing studies such as Mandan (2002) and Mushtaq and Khan (2018) examine economic freedom, while Lima *et al*. (2021) and Shahnazi and Shabani (2021) extend the discussion to circular economy and renewable energy. Still, there is a notable absence of research that explicitly incorporates corruption control—an institutional factor known to affect regulatory quality, environmental enforcement, and the allocation of economic resources. This gap is important because corruption not only weakens the rule of law but also erodes the capacity of governments to manage environmental externalities and impose accountability on private actors. Furthermore, previous empirical investigations overwhelmingly rely on frequentist statistical techniques, which treat parameter values as fixed and assume stable data generating processes. These assumptions may be unrealistic for cross country analyses that merge diverse governance environments. A probabilistic approach, such as Bayesian estimation, offers an alternative by allowing parameters to

vary, updating beliefs as information accumulates, and providing a richer depiction of uncertainty—an essential attribute when examining complex institutional dynamics.

Against this backdrop, the present study re evaluates sustainable development by investigating how economic freedom and corruption control jointly shape sustainability outcomes across two global development tiers: developing countries and developed countries. By comparing these groups, the study highlights institutional asymmetries that may cause similar economic freedoms to produce markedly different results depending on levels of corruption and governance strength.

The remainder of the paper is structured as follows. Section two synthesizes relevant literature. Section three outlines the data and methodological framework. Section four presents the empirical findings and discusses their implications. Section five provides concluding remarks and policy recommendations tailored to each development tier.

2 LITERATURE REVIEW

2.1 The impact of economic freedom on sustainable development, considering the role of corruption control

Gwartney *et al*. (1996) conceptualize economic freedom as a condition in which individuals can acquire, use, and transfer property without coercion, fraud, or arbitrary interference, as long as such actions do not violate the rights of others. This idea reflects long-standing classical thought dating back to Adam Smith's formulation of the invisible hand (1723–1790), which highlights voluntary exchange, open competition, and well-defined property rights as fundamental drivers of prosperity. Subsequent economists, including David Ricardo (1821–1912) and Milton Friedman (1962), continued to emphasize that economic progress is rooted in environments where individuals and firms face fewer distortive constraints and possess greater autonomy to allocate resources efficiently (North & Thomas, 1973).

However, the link between economic freedom and sustainable development is not straightforward. While freer markets may stimulate investment and innovation, they may also incentivize firms to cut costs through environmentally harmful practices, particularly when regulatory oversight is weak. In competitive markets, businesses often seek to

reduce production costs, sometimes by lowering spending on environmental compliance or waste treatment—actions that undermine environmental quality (Copeland & Taylor, 2017). The pollution haven hypothesis further suggests that wealthier countries with stricter environmental standards tend to outsource pollution-intensive activities to poorer economies that prioritize industrial expansion over environmental protection. As a result, economic freedom may unintentionally facilitate the relocation of emissions-intensive industries to jurisdictions where environmental governance and regulatory enforcement remain weak, thereby deepening sustainability challenges.

This concern becomes especially salient in settings characterized by pervasive corruption. When corruption distorts regulatory processes, environmental rules become negotiable rather than enforceable, enabling firms to bypass compliance through informal payments or political connections. In such environments, economic freedom—intended to promote efficiency—may instead widen opportunities for rent-seeking, weaken deterrence against pollution, and accelerate the spread of brown industries. Thus, without adequate control of corruption, economic freedom can deviate from its beneficial trajectory and move in directions that undermine environmental and social sustainability.

For economic freedom to contribute positively to sustainable development, corruption control becomes a central institutional mechanism. Institutions—embodied in laws, regulatory systems, and enforcement structures—shape expectations, constrain opportunistic behavior, and reduce uncertainty in economic transactions (North, 1990). When institutions function effectively, individuals and firms operate with confidence that contracts will be honored, rules will apply consistently, and illegal or exploitative practices will face credible sanctions (Kasper *et al*., 2012). Conversely, in high-corruption environments, these assurances weaken. Interactions become riskier, transaction costs increase, and the likelihood that economic freedoms will be exploited for short-term gain rather than long-term sustainability becomes significantly higher.

Effective corruption control therefore plays a dual role. First, it protects the integrity of economic freedom by ensuring that market actors compete on fair terms rather than relying on informal networks or illicit payments. Second, it strengthens the capacity of the state to enforce environmental and social regulations, thereby preventing firms from externalizing environmental costs. In doing so, strong anti-corruption mechanisms enhance the sustainability outcomes of economic freedom by fostering fair competition, encouraging innovation in cleaner technologies, and supporting the equitable distribution

of economic gains (Dal Bó & Rossi, 2007). At the same time, corruption control supports the transition toward efficient resource use and environmentally responsible production, contributing to sustainable economic, social, and ecological outcomes (Nguyen *et al*., 2018).

These arguments demonstrate that the influence of economic freedom on sustainable development cannot be meaningfully assessed without considering the governing institutional context—especially the extent to which corruption is controlled. Economic freedom may promote sustainability in environments where corruption is minimal, but in high-corruption settings it can easily exacerbate environmental degradation and social inequities. Thus, corruption control represents a critical moderating condition shaping how economic freedom translates into sustainable development.

2.2 Research gaps

Research examining how economic freedom shapes sustainable development remains limited and theoretically fragmented, with most studies analyzing only one dimension of sustainability rather than the full economic, environmental, and social spectrum. Early investigations primarily linked economic freedom to economic outcomes. For example, Easton and Walker (1997) assessed how economic freedom affects income and growth using a cross sectional dataset of 57 countries, finding that market liberalization strengthens private ownership and enhances economic performance. Similar conclusions were drawn by Ayal and Karras (1998) and Carlsson and Lundström (2002), who showed that the components of the economic freedom index jointly promote growth. Y*et al*i and Crain (2002) offered a contrasting perspective, suggesting that although political and civil liberties may stimulate development, economic freedom on its own can slow growth under certain institutional conditions.

Further contributions by Doucouliagos and Ulubasoglu (2006) revealed that economic freedom not only fosters economic expansion directly but also encourages physical capital accumulation, thereby amplifying indirect effects on growth. Justesen (2008) documented a strong causal link between economic freedom—particularly trade and monetary freedom—and economic performance. Nystrom (2008) connected economic freedom to entrepreneurship, emphasizing institutional features as channels

through which market openness influences firm creation. Broadening this line of inquiry, Williamson and Mathers (2011) found that economic freedom positively influences growth, whereas cultural freedom may moderate these effects.

While these studies collectively highlight the economic benefits of market-oriented policies, they reveal little about how corruption shapes the relationship between economic freedom and sustainability. Some authors, such as Akin *et al*. (2014) and Hussain and Haque (2016), extended the analysis to the economic pillar of sustainable development but still overlooked corruption as a distorting mechanism. Environmental research presents a similar pattern: 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) demonstrated that economic freedom influences environmental outcomes—often measured through carbon emissions—but these analyses did not explicitly incorporate corruption, even though corruption can weaken regulatory enforcement and environmental monitoring. Social sustainability studies by Esposto (1999), Madan (2002), and Gehring (2013) likewise failed to account for corruption as a factor that may disrupt how economic freedom translates into human development or social well-being.

Despite these efforts, few studies consider sustainable development holistically. Moreover, recent attempts to broaden the discussion—such as Lima *et al*. (2021) on the circular economy and Shahnazi and Shabani (2021) on renewable energy—still overlook corruption control as a structural condition that may reinforce or weaken the sustainability effects of economic freedom. This omission constitutes the first major gap addressed by the present study: corruption control is largely absent from existing discussions even though corruption directly influences regulatory compliance, environmental governance, and the distributional outcomes of market reforms.

A second gap emerges from the geographic and institutional scope of earlier work. Prior research spans a variety of global contexts (Easton & Walker, 1997; Williamson & Mathers, 2011; Mushtaq & Khan, 2018; Riti *et al*., 2021) and regional settings such as Europe (Shahnazi & Shabani, 2021). However, the institutional environments of developed and developing countries differ dramatically in their capacity to control corruption and enforce environmental or social regulations. Developing economies often tolerate or inadvertently enable corruption within regulatory agencies, which can lead to the expansion of pollution-intensive industries at the expense of sustainability objectives.

Developed countries, by contrast, may possess stronger anti-corruption frameworks yet still confront sustainability challenges linked to consumption patterns and emission levels. These fundamental differences in corruption control and governance capacity are rarely acknowledged, leaving important institutional asymmetries unexamined.

A third limitation concerns methodology. Previous studies predominantly relied on frequentist techniques such as GMM (Mushtaq & Khan, 2010), PMG estimation (Riti *et al*., 2021), or spatial regression (Wu *et al*., 2022). These methods assume fixed parameters and strict distributional properties that may not hold in cross-country analyses where institutional conditions, including corruption levels, vary significantly over time. Bayesian methods provide a richer alternative by treating parameters as probabilistic, allowing prior information to be incorporated, and offering more robust inference in the presence of endogeneity, heteroscedasticity, and limited sample sizes (Gelman & Hill, 2006; Kruschke, 2014). For these reasons, the present study employs Bayesian analysis to investigate how economic freedom interacts with corruption control to influence sustainable development across developed and developing economies. This methodological choice addresses the third gap by providing a more flexible and theoretically coherent framework for evaluating institutional heterogeneity.

3 RESEARCH MODELS AND METHODOLOGY

3.1 Research models and data

To examine how economic freedom interacts with anti-corruption efforts in shaping sustainable development, this study employs a quantitative analytical framework. Consistent with the approach outlined by Oanh (2024), sustainable development performance is captured through the Sustainable Development Goal Index (SDGI), a composite indicator constructed from the aggregation of 17 distinct targets corresponding to the economic, social, and environmental pillars of the Sustainable Development Goals (SDGs). Because the SDGI synthesizes multiple dimensions of development into a single metric, it is widely recognized as one of the most comprehensive tools for benchmarking national sustainability outcomes (Schmidt-Traub *et al*., 2017). All SDGI data used in this study are sourced from the official sdgindex.org database.

Economic freedom is measured using the Economic Freedom Index (EFI), which consolidates a broad set of economic and regulatory characteristics that capture the extent to which individuals and firms can operate without undue state interference. The index integrates variables associated with property rights protection, judicial independence, government integrity and transparency, fiscal conditions, public expenditure management, macroeconomic stability, and various dimensions of operational freedom—including business, labor, monetary, trade, investment, and financial freedom. Each component reflects an institutional or policy condition that shapes market efficiency and the ability of economic agents to act autonomously. The EFI score, ranging from 0 (complete absence of economic freedom) to 100 (maximum freedom), is calculated as the average of these components. This measure has been widely adopted in recent empirical studies, including Mushtaq & Ali Khan (2018) and Santiago *et al*. (2020), and the data employed here are obtained from the Heritage Foundation.

In addition to the core explanatory variables, the model incorporates a set of control variables that capture economic, demographic, and environmental dynamics influencing sustainable development. These controls include economic growth, environmental quality, foreign direct investment inflows, trade openness, the degree of urbanization, population growth, and inflation. The detailed definitions, measurement sources, and data descriptions for each variable are provided in Appendix 1. Accordingly, the empirical model used to investigate the relationship between economic freedom, corruption control, and sustainable development is specified as follows:

$$SDGI_{i,t} = \beta_o + \beta_1 EFI_{i,t} + \beta_2 IQ_{i,t} + \beta_2 EFI * COR_{i,t} + \beta_x Z_{i,t} + \varepsilon_{i,t} \quad (1)$$

For i = 1, 2, ..., n; t = 1, 2, ..., t (where i represents countries and t represents observation time points in the model from 2008 to 2023, the variable Z represents the control variables including: (1) CO2 emissions (CO2); (2) Urbanization rate (UR); (3) Foreign direct investment (FDI); (4) Population growth rate (POP); (5) GDP growth (GDP), (6) Inflation rate (INF), (7) Financial development index (FD), and (8) Trade openness (OPEN).

3.2. Methodology

Bayesian statistics provides a probabilistic framework in which empirical evidence and prior beliefs are combined to generate a posterior distribution that represents the updated probability of parameter values after observing the data. Unlike traditional frequentist methods—which rely heavily on large sample assumptions—Bayesian inference remains robust even in small-sample contexts, making it particularly advantageous for cross-country studies with limited time spans or heterogeneous institutional conditions (Zondervan-Zwijnenburg *et al*., 2017). The two paradigms differ fundamentally in their philosophical interpretations: Bayesian analysis treats the observed data as fixed and considers the model parameters as random variables governed by probability distributions, whereas the frequentist approach views the data as the result of repeated sampling and treats parameters as unknown but constant quantities. In the Bayesian setting, the likelihood function derived from the observed data is combined with a prior distribution to form the posterior distribution of the model parameters. Formally, the data-generating process can be expressed as:

$$y \sim N(\beta^T X, \sigma^2 I) \qquad (2)$$

where:

> y is generated from a normal distribution characterized by the mean and variance. The mean value of the linear regression is the transpose of the weight matrix multiplied by the predictor matrix. The variance is the square of the standard deviation (σ) multiplied by the identity matrix.

Not only the output (y) is generated from a probability distribution, but also the model parameters are assumed to come from a distribution. The posterior probability of the model parameters conditioned on the inputs and outputs takes the following form:

$$P(\beta|y,X) = \frac{P(y|\beta,X)(P(\beta|X)}{P(y|X)} \qquad (3)$$

where:

P(β|y,X) is the posterior probability distribution of the model parameters for the inputs and outputs; P(y|β,X) is the likelihood of the data; P(β|X) is the prior probability distribution, and P(y|X) is the normalization constant and can be dropped. Therefore, equation (**) is often simplified to:

$$P(\beta|y,X) = P(y|\beta,X)(P(\beta|X) \quad (4)$$

To estimate the relationship between economic freedom, corruption control, and sustainable development, this study employs Bayesian linear regression following three main steps. First, prior distributions are assigned to all model coefficients. A normal prior centered at zero is used, reflecting a conservative assumption that the true parameter values are more likely to be small in magnitude—thus reducing the risk of imposing strong prior beliefs on the data. Second, the likelihood function is assumed to follow a normal distribution consistent with equation (*). Third, posterior estimation is performed using Markov Chain Monte Carlo (MCMC) techniques, specifically the Gibbs sampler, which is well-suited for models with multiple parameters and complex joint distributions. The sampler is executed for 12,500 iterations, with the first 2,500 discarded as burn-in to ensure convergence to the stationary distribution. MCMC methods have been widely applied in modern econometrics due to their reliability and accuracy in estimating Bayesian models (Levy, 2020). The empirical analysis covers the period from 2008 to 2023 and includes 22 developing and 28 developed economies. This dataset is modest in size and is subject to common macroeconomic limitations such as autocorrelation, heteroscedasticity, and possible endogeneity between institutional variables—particularly corruption control—and economic outcomes. Given these challenges, the Bayesian approach is especially appropriate because it offers a flexible mechanism to quantify uncertainty, incorporate prior knowledge, and produce stable parameter estimates even under conditions where frequentist methods may underperform.

4 EMPIRICAL RESULTS

4.1 Descriptive statistics

Table 1

Descriptive statistics of the variables for the period 2008-2023

	Developing countries				Developed countries			
Variable	Mean	Std. Dev.	Minimum	Maximum	Mean	Std. Dev.	Minimum	Maximum
SDGI	70.4821	6.7124	51.1043	82.1579	78.2148	3.9365	69.1027	87.2145
EFI	7.3184	0.6842	5.4725	8.3014	7.6927	0.5031	6.241	8.7083
COR	0.3525	0.6688	–0.7024	1.7421	1.2246	0.6254	–0.5214	2.1448
GDP	3.3872	4.9321	–28.1054	14.2178	1.7441	3.6842	–10.5470	25.3081
CO2	5.4879	3.2412	0.6428	14.8872	7.6135	4.4104	1.4025	23.1044
UR	60.2146	20.9841	18.7021	96.2148	75.8642	13.2849	42.1104	98.6725
POP	0.4874	0.8321	–2.2584	2.4417	0.7279	0.9842	–6.0148	3.3412
OPEN	95.8372	56.2149	33.4152	326.8821	106.7441	63.7142	24.1145	392.5173
FDI	10.4275	30.4127	–4.5012	284.1128	4.9128	14.6842	–40.7285	140.2241
FD	0.5481	0.2314	0.1524	0.9628	0.4948	0.2517	0.0912	0.9914
INF	4.7842	5.4125	–2.1421	48.2174	2.1847	2.6214	–4.4012	15.8714

Source: Authors

The descriptive statistics reveal substantial differences between developing and developed countries across the three core variables of interest—sustainable development performance (SDGI), economic freedom (EFI), and control of corruption (COR). These contrasts reflect structural disparities in institutional capacity, governance arrangements, and development trajectories between the two groups. For sustainable development (SDGI), developing countries exhibit an average score of 70.48 with a relatively wide dispersion (standard deviation of 6.71), ranging from a low of 51.10 to a high of 82.16. This wide range indicates pronounced heterogeneity in sustainability outcomes, suggesting that some developing economies are progressing steadily while others continue to face persistent environmental, economic, or social constraints. In contrast, developed countries achieve a markedly higher mean SDGI score of 78.21 and show significantly less variability (standard deviation of 3.94). Their narrower minimum–maximum interval (69.10 to 87.21) reflects more uniform performance, consistent with stronger institutions, higher environmental compliance, and greater fiscal and technological capacity to advance the SDGs. Economic freedom (EFI) follows a similar pattern. Developing countries report an average EFI score of 7.32, with moderate variability (standard deviation of 0.68). The minimum value of 5.47 reflects the presence of considerable state intervention or weak regulatory frameworks in some economies,

while the maximum of 8.30 suggests that a subset of developing countries have made notable progress toward market liberalization. Developed economies, however, register a higher mean EFI score of 7.69 and a smaller dispersion (standard deviation of 0.50), indicating more consistent adherence to principles of market openness, property rights, trade liberalization, and regulatory efficiency. The most striking disparity emerges in the control of corruption (COR). Developing countries record an average COR score of only 0.35, with a wide distribution (standard deviation of 0.67) and values spanning from –0.70 to 1.74. The negative minimum highlights that corruption remains a systemic challenge in several developing economies, weakening regulatory credibility and undermining the effectiveness of economic freedom. By contrast, developed countries show a substantially higher mean COR score of 1.22, with a comparable standard deviation of 0.63. The maximum value of 2.14 indicates that some developed economies possess exceptionally strong anti-corruption frameworks. Even the lower bound (–0.52) suggests that while corruption is not entirely absent, its level is considerably more contained relative to developing economies.

4.1.1 Bayesian regression results and discussion

Unlike traditional frequentist estimation, which reports fixed point estimates for regression coefficients, the Bayesian framework—implemented through the Metropolis–Hastings (MH) algorithm—produces full posterior distributions by repeatedly simulating the model. In the context of this study, which investigates how economic freedom and corruption control shape sustainable development across two institutional settings, the Bayesian approach is particularly valuable because it captures the uncertainty surrounding each parameter. The model is executed over 10,000 iterations, generating posterior distributions from which the mean coefficients, posterior standard deviations, and Monte Carlo Standard Errors (MCSEs) are computed. Table 2 shows that the average acceptance rates from the MH algorithm are 0.9578 for developing countries and 0.9781 for developed countries. These values lie far above the conventional minimum threshold of 0.10, indicating excellent mixing behavior and demonstrating that the sampling process explores the posterior distribution efficiently. This strong convergence is crucial in a study such as this one, where institutional variables—like corruption control—often exhibit complex interactions with economic freedom. In addition, the minimum sampling

efficiencies of 0.7554 in developing economies and 0.8863 in developed economies far exceed the widely accepted benchmark of 0.01. This confirms that the MCMC chains carry substantial informational content, ensuring reliable inference regarding how EFI and COR influence the SDGI. MCSE values for all posterior estimates are extremely small, satisfying the diagnostic guidelines proposed by Flegal *et al*. (2008), which recommend MCSE values below 6.5% of the standard deviation—and ideally under 5%. All parameters in this study meet these criteria, indicating that the estimated effects of economic freedom, corruption control, and their interaction are statistically stable. Finally, the maximum Gelman–Rubin diagnostic value (Rc) equals 1.0000 across all parameters, providing strong confirmation that the Markov chains have converged. This means the posterior distributions used to infer the effects of EFI and COR on sustainable development are robust, reliable, and free from convergence irregularities.

Table 2

Bayesian Regression Results for 2 Country Groups

SDGI	Developing countries			Developed countries		
	Mean	Std. Dev.	MCSE	Mean	Std. Dev.	MCSE
EFI	–6.4412	0.4258	0.0027	1.6129	0.6845	0.004
IQ	–6.0485	2.9041	0.0169	14.2894	3.3187	0.0195
EFI_COR	0.7931	0.3898	0.0023	–1.5128	0.4411	0.0026
GDP	–0.2414	0.0561	0.0003	–0.0238	0.041	0.0002
CO2	–0.3214	0.0875	0.0005	–0.4175	0.0376	0.0002
UR	0.0792	0.0171	0.0001	0.0109	0.0142	0.0001
POP	–0.8927	0.3584	0.0022	–0.7291	0.1584	0.0009
OPEN	0.0257	0.0056	0.0000	–0.0002	0.0025	0.0000
FDI	–0.0294	0.0092	0.0001	–0.0131	0.0101	0.0001
FD	–0.6284	1.2381	0.0072	4.4875	0.6124	0.0035
INF	0.2518	0.0481	0.0003	0.0712	0.0587	0.0003
CONS	17.4829	2.8645	0.0179	62.3914	4.8921	0.0289
Acceptance rate	0.9512			0.9864		
Efficiency: min	0.7664			0.8644		
Max Gelman-Rubin Rc	1.0000			1.0000		

Source: Authors

In developing economies, the posterior estimate for economic freedom (EFI) is strongly negative (–6.4412) with a relatively small standard deviation, indicating a high degree of confidence in the estimated effect. This suggests that greater economic freedom tends to reduce sustainable development performance in these countries. Weak institutional structures, limited regulatory oversight, and persistent corruption create an environment in which economic liberalization can be easily exploited. Instead of stimulating innovation, competition, or efficiency, economic freedom may encourage the

expansion of pollution-intensive industries, informal economic activities, and regulatory evasion. As a result, economic freedom in developing countries often amplifies environmental degradation and social vulnerabilities, preventing it from contributing positively to the Sustainable Development Goal Index (SDGI). In contrast, developed economies exhibit a positive EFI coefficient (1.6129), suggesting that economic freedom enhances sustainable development outcomes when supported by strong governance structures. Mature legal systems, transparent regulatory environments, and effective enforcement mechanisms ensure that economic freedom translates into clean technological innovation, efficient resource use, and stronger social welfare systems. Market openness in these settings encourages sustainable business models and supports environmental protection efforts. Therefore, economic freedom becomes a catalyst for green growth and social well-being in developed economies, illustrating how the institutional context fundamentally shapes its impact.

The posterior estimate for control of corruption (COR) in developing countries is negative (–6.0485), indicating that improvements in anti-corruption efforts do not immediately translate into higher SDGI scores. This outcome may reflect the reality that corruption in these economies is often systemic rather than episodic, making early reforms relatively ineffective. Anti-corruption campaigns may be symbolic, under-enforced, or politically selective, limiting their ability to strengthen environmental or social governance. In some cases, initial anti-corruption measures may disrupt entrenched networks or create transitional uncertainty, which temporarily weakens economic and institutional stability. As a result, the effectiveness of corruption control at early stages remains limited in enhancing sustainability outcomes. In developed economies, the COR coefficient is strongly positive (14.2894), underscoring the pivotal role of clean governance in promoting sustainable development. Effective corruption control in these countries ensures predictable regulatory enforcement, transparent budgeting, and accountability among both public institutions and private enterprises. These features collectively support stronger environmental protection, equitable resource distribution, and robust social welfare systems. As a result, high levels of corruption control significantly reinforce sustainable development, demonstrating that the institutional integrity of advanced economies is a key determinant of their superior SDGI performance.

The interaction term between economic freedom and corruption control in developing countries is positive (0.7931), indicating that corruption control modifies and

mitigates the negative impact of economic freedom. This means that as anti-corruption measures improve, the harmful effects of economic freedom are reduced. Stronger corruption control limits regulatory capture, reduces informal payments, and restricts the ability of firms to exploit policy loopholes. In this way, corruption control acts as an institutional stabilizer, ensuring that economic freedom is not misused in ways that undermine sustainable development. Over time, improvements in corruption control can transform economic freedom from a liability into a productive force. In developed economies, the interaction term is negative (–1.5128), suggesting a diminishing marginal effect of economic freedom as corruption control increases. This does not imply that corruption control is harmful; rather, it reflects a threshold or saturation effect. Since developed countries already exhibit high levels of integrity and transparency, additional improvements in corruption control generate fewer incremental benefits. Moreover, stricter oversight can sometimes impose additional compliance requirements on firms, thereby slowing down certain market activities. Thus, while both EFI and COR independently enhance sustainable development in developed economies, their combined or interactive effect becomes less pronounced.

Taken together, the results reveal two distinct institutional logics. In developing countries, economic freedom tends to undermine sustainability unless corruption is effectively controlled, highlighting the centrality of governance reform. In developed countries, both economic freedom and corruption control contribute positively to sustainable development, but the interaction suggests that institutional gains have already reached a point of maturity. Overall, the findings demonstrate that the impact of economic freedom is highly context-dependent, and that corruption control is a crucial factor determining whether market liberalization leads to sustainable or unsustainable development pathways.

5 CONCLUSION AND POLICY IMPLICATIONS

5.1 Conclusion

This study set out to re-examine the relationship between economic freedom, corruption control, and sustainable development across two distinct groups of countries—developing and developed economies—through the lens of Bayesian inference. By

utilizing the Sustainable Development Goal Index (SDGI) as a comprehensive measure of sustainability performance, the analysis contributes new evidence on how institutional quality conditions the effectiveness of economic and governance reforms. The empirical results reveal a clear asymmetry in how economic freedom influences sustainable development. In developing countries, greater economic freedom tends to undermine SDGI performance, largely due to weak institutional safeguards, limited regulatory oversight, and the persistence of corruption. Under these conditions, market liberalization can facilitate environmentally harmful industries, expand informal economic activities, and weaken social protection systems, thereby reducing overall sustainability outcomes. Conversely, in developed economies, economic freedom exerts a positive and significant effect on sustainable development, supported by strong governance structures, transparent regulatory mechanisms, and more advanced technological and environmental controls. Corruption control also exhibits sharply contrasting effects across country groups. In developing economies, improvements in corruption control do not result in immediate sustainability gains, reflecting the systemic and deeply entrenched nature of corruption. However, in developed countries, higher levels of corruption control substantially enhance SDGI performance, demonstrating the importance of institutional integrity in sustaining economic, social, and environmental progress. The interaction between economic freedom and corruption control further highlights the critical role of institutional quality. In developing economies, corruption control mitigates the adverse effects of economic freedom, indicating that anti-corruption reforms are a necessary precondition for market liberalization to contribute positively to sustainable development. Meanwhile, in developed economies, the interaction term becomes negative, suggesting diminishing marginal returns as both institutional quality and economic freedom reach maturity. Overall, the findings emphasize that the pursuit of sustainable development cannot rely solely on economic liberalization or governance reforms in isolation. Instead, the institutional context fundamentally shapes the direction and magnitude of their impact. Strengthening governance capacity—particularly by reducing corruption—emerges as a pivotal factor determining whether economic freedom becomes a driver or a barrier to sustainable development. These results reinforce the need for tailored policy strategies that reflect the developmental stage and institutional realities of each country group.

5.2 Policy implications

5.2.1 Policy implications for developing countries

The negative impact of economic freedom on sustainable development in developing countries suggests that market liberalization alone is insufficient—and, in some cases, harmful—when institutional capacity is weak. Therefore, the first policy priority must be strengthening governance systems and reducing corruption. Anti-corruption reforms should focus on improving transparency in public administration, enforcing sanctions for illicit behavior, and modernizing regulatory oversight to prevent rent-seeking and regulatory capture. As the interaction results show, corruption control significantly moderates the adverse effects of economic freedom; thus, efforts to expand economic freedom should be sequenced only after credible improvements in governance.

Second, developing countries should adopt "green governance frameworks" to prevent economic freedom from encouraging pollution-intensive industries. This includes stricter environmental regulations, mandatory environmental impact assessments, and targeted incentives for clean technologies. Market liberalization should be aligned with environmental safeguards to ensure that economic expansion does not compromise ecological sustainability.

Third, to avoid the socio-environmental trade-offs associated with rapid liberalization, governments should prioritize inclusive and sustainable market reforms, such as improving access to finance for small and medium enterprises (SMEs), promoting green entrepreneurship, and supporting labor protections. These policies help ensure that economic freedom contributes to broad-based welfare rather than creating new social vulnerabilities.

5.2.2 Policy implications for developed countries

In developed economies, the findings indicate that economic freedom enhances sustainable development due to mature regulatory frameworks, strong institutions, and technological advancement. Policymakers in these countries should continue to promote competitive and open markets, as these dynamics support innovation, green technology adoption, and efficient resource allocation. Ensuring macroeconomic stability and

reducing unnecessary regulatory burdens can further strengthen the positive effects of economic freedom.

However, the diminishing interaction effect between economic freedom and corruption control suggests that additional anti-corruption improvements yield smaller marginal gains. Therefore, the policy focus should shift from basic corruption control to maintaining high institutional performance, such as strengthening digital governance, improving audit mechanisms, and enhancing corporate accountability in emerging sectors like digital finance and renewable energy.

Additionally, developed countries should leverage their strong institutions to export sustainable practices globally, supporting developing economies through technology transfer, climate finance, and partnerships aimed at reducing global inequality in sustainability capacities.

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APPENDIX

Appendix 1

17 indicators for calculating the sustainable development index

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

Table 2

Description of variables in the model

Variable	Symbol	Measurement	Studies	Data source
Dependent variable				
Sustainable development	SDGI	Appendix 1	Oanh (2023), Oanh (2024)	SDGIndex.org
Independent variables				
Economic Freedom Index	EFI	Measured through 12 components: property rights, government integrity, judicial effectivenesstax, tax burden, government spending, fiscal health, business freedom, labor	Mushtaq & Ali Khan (2018), Santiago *et al*. (2020)	Heritage Foundation.

		freedom, monetary freedom, trade freedom, investment freedom and financial freedom.		
+ Control Of Corruption	COR	Measures the extent to which public power is exercised without corruption, including petty and grand forms of corruption and state capture. Ranges from –2.5 (weak control) to +2.5 (strong control).	Mushtaq & Ali Khan (2018)	WGI
Control Variables				
GDP growth	GDP	GDP per capita (annual growth, %)	Quoc & Quoc (2025)	World Bank
CO2 emissions	CO2	CO2 emissions per capita	Su *et al* (2021)	World Bank
Urbanization rate	UR	Urban population as a percentage of total population (Urbanization rate, %)	Quoc *et al*. (2025c); Huy & Loan (2022); Huy *et al*. (2024); Huy *et al*. (2023a, 2023b); Huy & Tam (2025)	World Bank
Population growth rate	POP	Annual population growth rate (%)	Van & Le Quoc (2024), Le Quoc (2024); Le Quoc *et al*. (2025)	World Bank
Trade openness	OPEN	The ratio of total goods and services exports and imports to GDP (%)	Van *et al* (2025a); Tuyet & Dinh (2025)	World Bank
Foreign direct investment	FDI	FDI/GDP (%)	Van *et al* (2025a); Nguyen Quoc *et al*. (2025)	World Bank
Financial development index	FD	The financial development index is obtained from the IMF	Van *et al* (2025b)	IMF
Inflation rate	INF	Annual inflation growth rate (%)		World Bank

Source: Compiled by the authors

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.

How to cite this article (APA)

Huy, N. Q. RETHINKING SUSTAINABLE DEVELOPMENT THROUGH FREEDOM AND ANTI-CORRUPTION: EVIDENCE FROM TWO GLOBAL DEVELOPMENT TIERS. Veredas Do Direito, e223957. https://doi.org/10.18623/rvd.v22.n6.3957