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The Role of Economic Freedom and Institutional Quality in Driving Sustainable Development: Comparative Evidence from Developed and Developing Economies

Nguyen Thi Bach Tuyet, Le Quoc Dinh*

Faculty of Finance and Accounting, Lac Hong University, Bien Hoa 760000, Viet Nam

Corresponding Author Email: dinhlq@lhu.edu.vn

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ABSTRACT

The research explores the impact of economic freedom index (EFI) on sustainable development (SDGI), considering the role of institutional quality (IQ). Data were collected from 2008-2023 in 22 developing countries and 26 developed countries. Using Bayesian regression, the regression results show that, in developing countries, EFI and IQ have a negative impact on sustainable development with probabilities of 100% and 98.60% respectively. This implies that, in developing countries, the institutions and economic freedom of these countries often encourage growth and sacrifice the environment by focusing on "brown industries" that cause pollution. However, when economic freedom is associated with institutional policies, this relationship has a positive impact on sustainable development. The results are completely opposite for developed countries; specifically, EFI and IQ have a positive impact, while this interaction is negative, supporting that economic freedom and institutions should be independent of each other. Based on these results, the author proposes appropriate implications for the two groups of countries.

1. INTRODUCTION

Beginning in the 19th century, the world has witnessed numerous disruptions across economic, political, and social spheres. Major events such as the 1997 Asian financial crisis, the bursting of the dotcom bubble in 2000, the global financial meltdown in 2008, the COVID-19 outbreak in 2019, and recent geopolitical tensions like the Russia–Ukraine conflict in 2022 and the Hamas–Israel war have all exerted considerable pressure on the global economy. Beyond their financial consequences, these crises have underscored systemic global vulnerabilities, including escalating environmental pollution, resource exhaustion, climate change, and issues related to energy and food security. These challenges are closely tied to long-standing patterns of industrial activity and scientific advancement driven by human development over centuries. A prevailing focus on GDP expansion—often pursued without sufficient consideration for ecological impacts—has accelerated the depletion of natural assets, degraded ecosystems, and undermined environmental stability [1]. As a result, growing environmental deterioration has sparked global alarm over the feasibility of achieving sustainable development. Today, there is widespread consensus that genuine progress requires balancing the three foundational pillars of sustainability: economic viability, social well-being, and environmental preservation [2-5].

However, achieving SDGs is challenging due to environmental pollution and climate change, primarily caused by the industrialization process that is inseparable from continuous production [6]. The situation is even more complicated in developing countries, where economic and social development, poverty alleviation, and improving living standards are closely linked to economic freedom (EFI) [7]. Krueger [8] argued that a market is considered free if there are no quantity constraints to control both buyers and sellers. Thus, deregulation can be seen as the action of removing quantity controls. Broadly speaking, deregulation is considered any policy aimed at reducing state control, or completely eliminating it, or replacing it with a more relaxed form of control. There are numerous studies on the impact of economic freedom on economic growth today [9-11]. However, these studies often overlook environmental and social issues – issues related to sustainable development. Furthermore, in developing countries with low per capita income, they often focus more on economic development goals rather than environmental quality. In other words, the institutions of these countries often encourage growth and sacrifice the environment by focusing on "brown industries" that cause pollution. Conversely, in developed countries, although there is infrastructure for applying technologies to minimize environmental pollution, some countries are still on the list of environmentally polluting countries, including the United States [12], which remains an open question. One of the reasons is population growth. Therefore, the impact of economic freedom on sustainable development cannot ignore the role of the institutional quality (IQ) of countries.

Current studies on the impact of economic freedom on sustainable development are still very limited [13, 14]. Recently, Lima et al. [15] studied economic privacy and sustainable development, considering the role of circular economy, while Shahnazi and Shabani [16] studied the impact of economic freedom on sustainable development, considering the role of renewable energy. Despite a growing body of literature on economic freedom and development, several important research gaps remain.

First, most prior studies analyze only one or two dimensions of sustainable development—economic growth, environmental quality, or social progress—without capturing the full scope of sustainability. This study addresses this gap by employing the SDGI, which incorporates all 17 SDGs.

Second, although some research spans global or regional scales, few studies distinguish between developed and developing countries, despite their divergent institutional frameworks and sustainability priorities. This study fills that contextual gap by offering a comparative analysis between the two country groups.

Third, previous empirical works predominantly rely on frequentist methods that impose strict assumptions and treat model parameters as fixed. In contrast, this research applies Bayesian regression to offer more robust probabilistic inferences, particularly valuable in settings with limited or noisy data.

By addressing these three gaps, the study contributes novel insights into how economic freedom and IQ jointly shape sustainable development in varying contexts.

The structure of the research consists of five parts. The second part discusses the previous related literature, while the third part details the data and methodology. The findings and experimental discussions are presented in part four, and the conclusions and policy implications are presented in part five.

2. LITERATURE REVIEW

2.1 The impact of economic freedom on sustainable development, considering the role of institutional quality

In traditional economic theory, output is typically expressed through the function $Y = f(L, K)$, where labor (L) and capital (K) are the core inputs. Over time, with the evolution of economic thought, this model was extended to include technology (T), resulting in $Y = f(L, K, T)$, which has since become foundational in development planning across many nations. One well-known formulation is the Cobb-Douglas production function: $Y = AL\alpha\ K\beta\ T\gamma$, where Y indicates GDP or economic output, A stands for total factor productivity (TFP) — capturing all other unexplained growth — and $\alpha + \beta + \gamma = 1$. Notably, this model does not explicitly recognize environmental resources as an input; rather, their influence is absorbed into the TFP component (A). Consequently, the environmental dimension tends to be underestimated or omitted in growth analyses.

In response, contemporary economists have attempted to incorporate environmental and natural resource considerations (E) directly into the production function, reformulating it as $Y = f(L, K, T, E)$. However, quantifying E is inherently complex. While labor, capital, and technology can be measured relatively easily, environmental assets pose significant challenges due to their unique attributes — such as being finite, having intrinsic value, and being prone to depletion. Since the emergence of environmental economics in the 1970s, the field has struggled to establish robust tools for valuing natural resources effectively. Furthermore, conventional models often fall short in addressing the trade-offs between short-term resource exploitation and long-term ecological sustainability, particularly regarding non-renewable assets like fossil fuels and minerals.

Recognizing these limitations, economists are increasingly embedding environmental variables directly into models of output rather than treating them as externalities. At the same time, social considerations are also gaining prominence. As a result, economic output (Y) is evolving into a broader concept, often denoted as Y*, which reflects SDGs. The Brundtland Commission famously defined sustainable development as meeting present needs without jeopardizing the ability of future generations to meet theirs. This concept hinges on a delicate balance among three interconnected pillars: economic growth, environmental protection, and social equity [2-5].

Gwartney and Lawson [17] defined economic freedom as a condition in which individuals are able to retain and utilize the property they lawfully acquire—without coercion, fraud, or theft—while also being allowed to use, trade, or transfer such property freely, provided they do not infringe upon the rights of others. The idea that economic freedom fosters economic development is not new; it was originally advanced through Adam Smith's theory of the invisible hand (1723–1790), which emphasizes the importance of voluntary exchange, open markets, property rights, and competitive enterprise as engines of prosperity. Similar perspectives were later supported by economists such as David Ricardo (1821–1912) and Milton Friedman (1962), who underscored the critical role of individual choice and free markets in facilitating economic progress [18].

However, in some contexts, economic freedom may contradict the goals of sustainable development. In a free market, businesses can compete with each other to reduce prices and increase profits. This can lead to cost-cutting measures, including cutting production and waste management costs, thereby reducing environmental quality [19]. Moreover, according to the hidden pollution hypothesis put forward and developed by Copeland and Taylor [19], if two countries have identical economic and social conditions, but the wealthier country tends to pay more attention to environmental pollution policies due to increasing environmental quality requirements as income increases. Therefore, poorer countries will have a competitive advantage over environmentally sensitive goods. Therefore, economic freedom tends to shift environmentally polluting goods to poorer areas with lower living conditions, potentially turning them into 'pollution havens'.

Therefore, to aim for economic freedom in sustainable development, the role of IQ cannot be ignored. Institutions are constraints sanctioned by the state such as constitutions, laws, regulations. In other words, institutions are human-made constraints to structure interactions between people [20]. Without institutions, these activities cannot take place because one cannot interact with others without a shared understanding of how the other party will respond and some sort of sanction if the other party acts arbitrarily and contrary to the agreement. Individuals and firms can only exercise economic freedom if they have a certain level of confidence that their contractual agreements will be enforced [21]. Without institutions, interactions between people become uncertain and risky. In that case, the costs of economic transactions become very high and very risky, making these activities difficult and ineffective. The role of institutions is to reduce the uncertainty and risk of economic transactions, thereby maximizing the effectiveness of economic freedom, thus promoting sustainable development by promoting the economy through exchange, increasing economic scale and enhancing labor division (sustainable economy), improving income and reducing inequality (sustainable society), and ensuring environmental quality (sustainable environment) [22]. Additionally, improving IQ also creates conditions for innovation and improvement in production techniques as well as increasing competition to enhance efficiency and reduce emissions [23]. This shows that the impact of economic freedom on sustainable development cannot be examined without considering the role of IQ.

2.2 Research gaps

Existing research on the nexus between economic freedom and sustainable development remains relatively sparse and fragmented, often focusing on isolated aspects of sustainability. For instance, Easton and Walker [24] explored the effect of economic freedom on per capita income and growth across 57 countries using a cross-sectional analysis. Their findings indicated that market liberalization enhances private ownership and income generation, thereby supporting economic expansion. Similarly, Ayal and Karras [25] as well as Carlsson and Lundström [26] examined various dimensions of the economic freedom index (EFI) and concluded that these components jointly foster economic growth. However, contrasting results were found by Ali and Crain [27], whose study reported a negative relationship, arguing that while political and civil liberties may support growth, economic freedom alone could yield slower economic outcomes.

Doucouliagos and Ulubasoglu [9] analyzed both direct and indirect influences of economic freedom on growth using cross-sectional and panel data from 82 countries. Their analysis revealed that economic freedom not only stimulates growth directly but also indirectly via enhanced physical capital accumulation. Justesen [28] observed a robust causal effect of economic freedom—particularly trade and monetary freedom—on economic growth, while the reverse causality appeared weaker. Nystrom [29] extended the discussion by linking institutional aspects of economic freedom to entrepreneurship development. In a broader framework, Williamson and Mathers [30] studied the joint effects of economic and cultural freedom across 141 countries, concluding that while economic freedom bolsters growth, cultural freedom may have a constraining influence.

Other researchers [9-11] focused on how economic freedom shapes the economic dimension of sustainable development. Regarding environmental outcomes; other studies [16, 26, 31-34] examined the role of economic freedom in influencing environmental quality, particularly through CO_2 emissions. In terms of social sustainability, works by Esposto and Zaleski [35], Madan [13], and Gehring [36] evaluated how economic freedom relates to human development and well-being.

Despite these insights, most existing studies do not holistically assess the three pillars of sustainable development. More recent efforts, such as Lima et al. [15] on circular economy and Shahnazi and Shabani [16] on renewable energy, begin to explore this relationship in a broader context. Yet, a key omission in the literature is the mediating or moderating role of IQ—an essential element this study seeks to investigate. This constitutes the first major gap.

Regarding scope, earlier research spans global [14, 24, 30, 32] and regional contexts (e.g., study [16] on Europe). However, the institutional dynamics in developed and developing countries differ markedly. Developing nations often prioritize growth, sometimes at the cost of environmental sustainability, by favoring pollution-intensive industries. In contrast, although developed countries have access to advanced technologies and infrastructure, they still face serious pollution issues. This divergence in institutional behavior is rarely addressed in prior studies, highlighting the second gap this paper aims to address.

From a methodological standpoint, most existing analyses adopt traditional frequentist techniques. For example, Mushtaq and Khan [14] utilized GMM. These approaches rely heavily on strict statistical assumptions, which may not hold in real-world data, and treat model parameters as fixed values. Conversely, the Bayesian framework offers a flexible alternative by treating parameters as probabilistic, enabling more robust inference, especially in small samples. According to Oanh and Dinh [3], Bayesian techniques provide greater model accuracy and resilience to problems such as endogeneity, heteroscedasticity, and autocorrelation. Therefore, this study adopts the Bayesian method to examine the influence of economic freedom on sustainable development, accounting for IQ in both developed and developing nations. This forms the third and final gap addressed in this research.

3. RESEARCH MODELS AND METHODOLOGY

3.1 Research models and data

To evaluate the relationship between economic freedom and sustainable development, this study adopts a quantitative research approach. Following the methodology proposed by Oanh and Dinh [3] and Van and Le Quoc [4], the Sustainable Development Goal Index (SDGI) is computed by aggregating 17 indicators (see Appendix 1), each corresponding to one of the three core pillars of sustainability: economic, social, and environmental, as defined in the SDGs. This composite index is widely regarded as a comprehensive measure of a nation's sustainable development performance [37], with data sourced from the official sdgindex.org portal.

The EFI is formulated by integrating several economic and institutional variables that reflect ethical business conduct and the regulatory environment. Key components include property rights, judicial independence, government transparency, fiscal burden, public expenditure, macroeconomic stability, and freedoms related to business, labor, money, trade, investment, and finance. The EFI score is derived as the arithmetic mean of these indicators, where values range from 0 (no economic freedom) to 100 (maximum freedom). This metric has been extensively used in earlier empirical works [14, 38] with data obtained from the Heritage Foundation.

To capture IQ, the study utilizes the Worldwide Governance Indicators (WGI) compiled by the World Bank's World Development Indicators (WDI) database. These indicators assess a country's governance capacity across six dimensions: Voice and Accountability (VOA), Political Stability and Absence of Violence (POL), Government Effectiveness (GOV), Regulatory Quality (REG), Rule of Law (RUL), and Control of Corruption (COR). Each dimension is scored between -2.5 and 2.5. Although incorporating all six variables as regressors could provide a comprehensive portrayal of institutional performance [39], this approach may introduce multicollinearity due to potential overlap among the indicators. Additionally, including all components could lead to model overfitting and reduce statistical efficiency. To address these concerns, this study adopts Principal Component Analysis (PCA) to consolidate the governance indicators into a single index that robustly reflects IQ, following the approach of Ullah and Khan [40].

As emphasized by North [18] and Kasper et al. [21], institutions shape the rules of the game in economic exchange, and their quality determines how effectively economic freedom can function without leading to adverse consequences. In countries with weak IQ—where enforcement of environmental laws is limited and corruption is prevalent—economic freedom may inadvertently amplify pollution and unsustainable practices, as firms exploit lax regulation to maximize short-term profits. Conversely, in institutional environments with high accountability and strong RUL, economic freedom can foster innovation, encourage clean technologies, and enhance sustainable investment. Therefore, this study incorporates an interaction term between EFI and IQ to capture this moderating effect, reflecting the idea that the impact of economic freedom on sustainability is contingent upon institutional context.

Moreover, the selected control variables included in the model encompass economic growth, environmental quality, foreign direct investment (FDI), trade openness (OPEN), urbanization rate (UR), population growth rate (POP), and inflation rate (INF). The source and data of the research are presented in Appendix 1. The research model is as follows:

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

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 2022. The variable Z represents the control variables including: (1) CO_2 emissions (CO_2); (2) UR; (3) FDI; (4) POP; (5) GDP growth (GDP), (6) INF, (7) Financial development index (FD), and (8) OPEN.

UR: The share of the population living in urban areas reflects the level of urban development. Urbanization can support sustainability through better infrastructure, healthcare access, education, and technology adoption. As noted by Van and Quoc [4], urbanization positively influences sustainable development, especially in countries where public services are concentrated in urban centers.

FDI: FDI plays a dual role in sustainability. It can promote technological transfer, infrastructure development, and job creation, contributing positively to SD. However, in countries with lax regulations, it may also lead to "pollution havens" by relocating environmentally harmful industries. Due to this duality, we do not impose a directional assumption on its effect.

POP: Rapid population growth may exert pressure on public infrastructure, natural resources, and environmental quality. It can also lead to urban overcrowding and increased energy consumption, thereby constraining sustainable development. Hence, we expect a negative relationship between population growth and sustainability.

GDP Growth (GDP): Economic growth expands the fiscal space and investment capacity of governments, enabling higher spending on sustainability initiatives. However, unchecked growth—especially when driven by pollution-intensive sectors—may conflict with environmental goals. Therefore, we do not specify the expected sign of GDP growth in this study.

INF: High inflation is often associated with macroeconomic instability and inefficient resource allocation, especially in sectors essential for long-term sustainability such as healthcare and green technology. As highlighted by Van and Quoc [4], inflation tends to negatively affect sustainable development.

Financial Development Index (FD): Financial development improves the efficiency of capital allocation, enhances access to credit, and facilitates green investment. A well-developed financial system also supports innovation and sustainability-related entrepreneurship. Therefore, we expect a positive relationship between financial development and sustainable development [4].

OPEN: Trade openness allows countries to access advanced technologies and environmentally friendly practices, potentially supporting sustainable growth. However, it can also result in environmental degradation if a country becomes a destination for dirty industries. Due to this ambivalence, we do not predetermine the direction of the effect [4].

CO_2 Emissions (CO_2): CO_2 emissions per capita serve as a proxy for environmental degradation. Higher emissions are generally associated with increased industrial activity and fossil fuel consumption, which negatively affect environmental sustainability. Numerous studies (e.g., Adesina and Mwamba [31]; Wu et al. [34]) have demonstrated a significant negative relationship between CO_2 emissions and sustainable development outcomes.

3.2 Methodology

Bayesian statistics integrates empirical data with prior beliefs to generate a posterior distribution, which is interpreted as the probability distribution of parameter values. Unlike traditional methods, Bayesian inference does not heavily depend on large sample sizes, making it particularly suitable for small-sample studies [41-45]. Fundamentally, Bayesian and frequentist approaches are grounded in distinct philosophical frameworks. In Bayesian thinking, the observed data is treated as fixed, while the model parameters are viewed as random variables. In contrast, frequentist methods consider the data as arising from repeated sampling, with the parameters regarded as unknown but constant. Bayesian inference estimates the posterior distribution of parameters by combining the likelihood function derived from observed data with a prior distribution. This is expressed formally as:

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

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:

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

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

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

Regarding prior specification, this study employs weakly informative normal priors centered at zero for the regression coefficients. This reflects a conservative assumption that the parameters are more likely to be close to zero in the absence of strong empirical signals. Such priors help minimize prior-driven bias and are widely used in Bayesian regression modeling when the goal is to allow the data to dominate inference [46-52]. For variance parameters, standard inverse-gamma priors are used. To estimate the posterior distributions, the model applies Markov Chain Monte Carlo (MCMC) simulation using the Metropolis–Hastings algorithm. To ensure the reliability of the simulations, we monitor the Gelman–Rubin convergence diagnostic (Rc). This statistic compares the variance between multiple MCMC chains to the variance within each chain. A Rc value close to 1.0000 indicates strong convergence, confirming that the chains have mixed well and that posterior estimates are stable. This approach ensures that the Bayesian model is both theoretically sound and computationally reliable.

4. EMPIRICAL RESULTS

4.1 Descriptive statistics

Table 1 shows that the mean of the variables show that, in developed countries, the average of SDGI; EFI and IQ are 77.87; 7.67 and 1.20 respectively, which are superior to those of developing countries with corresponding indices of 69.94; 7.29 and 0.34. This shows that developed countries are always leading in sustainable development, institutions quality, and economic freedom.

4.2 Bayesian regression results and discussion

Unlike the frequentist approach, which typically presents point estimates of regression coefficients, Bayesian regression—implemented via the Metropolis-Hastings (MH) algorithm—generates distributions by simulating the model multiple times. In this study, the model is run for 10,000 iterations, yielding a distribution of coefficient values from which the posterior mean is derived. Consequently, the regression output includes not only the mean estimates of the coefficients but also their standard deviations and Monte Carlo Standard Errors (MCSEs). According to Table 2, the average acceptance rates for the MH algorithm are 0.9578 in developing countries and 0.9781 in developed countries—both significantly above the conventional threshold of 0.1, indicating good mixing in the sampling process. Additionally, the lowest sampling efficiency in each model is reported as 0.7554 and 0.8863, respectively—well above the minimum acceptable level of 0.01, confirming that the simulations are efficient. MCSE values for all estimated parameters are extremely small, which aligns with the stability criteria proposed by Flegal et al. [43]. Specifically, they suggest that MCSE values should be under 6.5% of the standard deviation to be considered reliable, with values under 5% being ideal. All parameters in this analysis satisfy these benchmarks. Moreover, the maximum autocorrelation function (ACF) values of the coefficient chains are equal to 1, providing strong evidence that the MCMC process has converged properly. Taken together, these diagnostic indicators confirm that the Bayesian simulation results presented in Table 2 are both statistically sound and robust.

Table 1. Descriptive statistics of the variables

Developing Countries				
Variable	**Mean**	**Std. Dev.**	**Minimum**	**Maximum**
SDGI	69.9436	6.4908	50.0278	81.6834
EFI	7.2908	0.6616	5.3912	8.2195
IQ	0.3387	0.6414	-0.6766	1.6950
GDP	3.2258	4.8606	-29.0690	13.9000
CO_2	5.3621	3.1658	0.6001	14.2994
UR	59.8463	20.6250	18.1960	95.6880
POP	0.4628	0.8080	-2.2170	2.3902
OPEN	94.4616	55.0481	32.9756	322.6750
FDI	10.0878	29.8042	-4.3375	279.3474
FD	0.5337	0.2250	0.1457	0.9550
INF	4.9686	5.5369	-2.0970	49.7211
Developed Countries				
Variable	**Mean**	**Std. Dev.**	**Minimum**	**Maximum**
SDGI	77.8666	3.8521	68.2315	86.7606
EFI	7.6664	0.4777	6.1906	8.6595
IQ	1.1990	0.6015	-0.5600	2.0866
GDP	1.6724	3.5168	-11.0310	24.4750
CO_2	7.5484	4.3228	1.3737	22.5570
UR	75.2272	13.1421	41.2420	98.1530
POP	0.6962	0.9571	-6.1873	3.2848
OPEN	105.0295	62.8876	23.3838	389.6547
FDI	4.7389	14.1992	-41.6510	138.2150
FD	0.4870	0.2428	0.0867	0.9893
INF	2.2172	2.5786	-4.4781	15.5344

Source: Analysis results using Stata 17.0 software

Table 2. Bayesian regression results for 2 country groups

SDGI	Developing Countries			Developed Countries		
	Mean	**Std. Dev.**	**MCSE**	**Mean**	**Std. Dev.**	**MCSE**
EFI	-6.5227	0.4076	0.0025	1.5811	0.6583	0.0039
IQ	-6.1632	2.8255	0.0163	14.4564	3.2344	0.0188
EFI_IQ	0.7674	0.3765	0.0022	-1.4747	0.4264	0.0025
GDP	-0.2328	0.0532	0.0003	-0.0224	0.0397	0.0002
CO_2	-0.3071	0.0847	0.0005	-0.4032	0.0362	0.0002
UR	0.0819	0.0162	0.0001	0.0103	0.0136	0.0001
POP	-0.9153	0.3453	0.0020	-0.7062	0.1508	0.0009
OPEN	0.0248	0.0054	0.0000	-0.0001	0.0024	0.0000
FDI	-0.0280	0.0089	0.0001	-0.0124	0.0099	0.0001
FD	-0.6075	1.1940	0.0069	4.5416	0.5916	0.0034
INF	0.2425	0.0456	0.0003	0.0688	0.0561	0.0003
CONS	17.1907	2.7706	0.0173	62.8047	4.7566	0.0282
Acceptance rate		0.9578			0.9781	
Efficiency: min		0.7554			0.8863	
Max Gelman-Rubin Rc		1.0000			1.0000	

Table 2 shows that in developing countries, EFI and IQ have negative impacts on sustainable development with coefficients of -6.522 and -6.1632, respectively. This implies that, in developing countries with low per capita income, they tend to focus more on economic development rather than environmental quality. In other words, in developing countries, their institutions and economic freedom often encourage growth and sacrifice the environment by focusing on "brown" industries that cause pollution. Moreover, evidence from Table 3 also indicates that the pursuit of GDP growth in countries is causing significant waste of natural resources, environmental degradation, and ecological imbalances. Additionally, Table 3 also shows that CO_2 has a negative impact on SDGI, which suggests that industrial activities generate large amounts of emissions, causing environmental pollution and negatively affecting sustainable development. However, under the role of institutions, economic freedom (EFI_IQ) has a positive impact on sustainable development. This indicates that, to address the issue of sustainable development in these countries, economic freedom cannot be separated from IQ, meaning that government intervention is needed. Unlike previous studies that offer mixed evidence on both positive and negative aspects when only studying one of the three aspects of sustainable development, such as the economic aspect [9-11], or the environmental aspect [13, 16, 26, 31-34]; regarding the social aspect of sustainability [35, 36], this study uses the SDGI composite measure to explore the impact of economic freedom considering the role of institutions on SDGI, thereby contributing to the academic literature. Furthermore, different from previous research methods used, the Bayesian method also provides additional probabilities of the impact of the independent variable on the dependent variable (Table 3). The results of Table 3 show that the probability of the negative impact of EFI and IQ on SDGI is almost absolute (100% and 98.60%); and the probability of the positive impact of EFI_IQ on SDGI is 95.38%. This further reinforces the role of institutions in economic freedom as an inseparable relationship if sustainable development is to be promoted.

Table 3. Probability of the independent variable's impact on the dependent variable

Probability	Developing Countries			Developed Countries		
	Mean	Std. Dev.	MCSE	Mean	Std. Dev.	MCSE
{SDGI: EFI} < 0	1.0000	0.0000	0.0000			
{SDGI: EFI} > 0				0.9918	0.0901	0.0005
{SDGI: IQ} < 0	0.9860	0.1179	0.0006			
{SDGI: IQ} > 0				1.0000	0.0000	0.0000
{SDGI: EFI_IQ} > 0	0.9538	0.2099	0.0001			
{SDGI: EFI_IQ} < 0				0.9999	0.0216	0.0001
{SDGI: GDP} < 0	1.0000	0.0000	0.0000	0.7121	0.4528	0.0026
{SDGI: UR} > 0	1.0000	0.0000	0.0000	0.7742	0.4181	0.0242
{SDGI: CO_2} < 0	0.9999	0.0082	0.0000	1.0000	0.0000	0.0000
{SDGI: POP} < 0	0.9954	0.0674	0.0004	1.0000	0.0000	0.0000
{SDGI: OPEN} < 0				0.5192	0.4996	0.0298
{SDGI: OPEN} >0	1.0000	0.0000	0.0000			
{SDGI: FDI} < 0	0.8200	0.3842	0.0038	0.8958	0.3056	0.0017
{SDGI: FD} > 0				1.0000	0.0000	0.0000
{SDGI: FD} > 0	1.0000	0.0000	0.0000	1.0000	0.0000	0.0000
{SDGI: INF} > 0	1.0000	0.0000	0.0000	0.8905	0.3123	0.0018
{SDGI :CONS} > 0	1.0000	0.0000	0.0000	1.0000	0.0000	0.0000

Source: Analysis results using Stata 17.0 software

On the other hand, for developed countries, the research results are contrary to those of developing countries. Specifically, EFI and IQ have a positive impact on SDGI with probabilities of 99.18% and 100%, respectively. A free market and efficient institutions in developed countries can create a favorable business environment, attract investment, and promote economic growth. This can create many job opportunities, reduce inequality, and contribute to sustainable economic development. Furthermore, in developed countries, the infrastructure for developing technologies to minimize environmental pollution is also applied, thereby enhancing efficiency in sustainable development. However, the interaction result of EFI_IQ has a negative impact on SDGI, indicating that economic freedom in the institutional environment of these countries hinders sustainable development. The results support the independence of economic freedom and institutions. In other words, economic freedom is most effective in an unconstrained institutional environment. Additionally, the results also show that, in both groups of countries, GDP, CO_2, and POP have a negative impact on SDGI, while UR and INF promote SDGI.

5. CONCLUSION AND POLICY IMPLICATIONS

This study investigates how economic freedom influences sustainable development, incorporating IQ as a moderating factor. The analysis is based on data from 2008 to 2023, covering 22 developing and 26 developed countries. Traditional frequentist approaches in macroeconomic research often face challenges such as multicollinearity, autocorrelation, and issues related to small sample sizes. To address these limitations, this study employs a Bayesian regression framework, which offers greater robustness against common econometric issues including heteroscedasticity, endogeneity, and limited data.

A notable advantage of the Bayesian approach is its ability to provide probabilistic interpretations of coefficient estimates. The findings reveal contrasting dynamics between developing and developed countries. In developing nations, both economic freedom (EFI) and IQ negatively affect sustainable development, with posterior probabilities of 100% and 98.6%, respectively. These results suggest that in these countries, economic policies and institutional frameworks may prioritize industrial growth at the expense of environmental sustainability. However, the interaction between EFI and IQ yields a positive influence, indicating that coordinated efforts between economic freedom and institutional policies can lead to more sustainable outcomes.

Conversely, in developed economies, EFI and IQ show a positive impact on sustainable development, while their interaction is associated with a negative effect. This supports the perspective that institutional mechanisms and market freedoms may function more effectively when operating independently in these contexts.

The study also highlights that in both country groups, variables such as GDP, CO_2 emissions, and population (POP) are negatively associated with the SDGI, whereas unemployment (UR) and inflation (INF) exhibit a positive correlation with SDGI.

Bayesian model diagnostics further confirm the reliability of the results. The lowest average acceptance rates for the Metropolis-Hastings algorithm are 0.9578 (developing countries) and 0.9788 (developed countries), both exceeding the commonly accepted threshold of 0.1. Furthermore, the minimum efficiency values recorded are 0.7554 and 0.8863, respectively—well above the benchmark of 0.01. All parameter chains exhibit Rc values equal to 1, confirming convergence of the MCMC process. These indicators collectively affirm the robustness and reliability of the Bayesian simulation results.

For Developing Countries

Strengthen IQ to support environmental regulation: Governments should enforce stricter rules on energy use, waste disposal, and pollution control to mitigate environmental harm. Clear and enforceable regulations can create a healthier living environment and align economic growth with sustainability.

Promote green innovation through institutional incentives: Institutions should facilitate access to finance, technology, and infrastructure for green industries. Encouraging a transition to renewable energy—despite its upfront costs—requires targeted policies and institutional support for technological innovation.

Ensure fair market competition and accountability: Economic freedom must be grounded in transparent, rule-based systems. Governments should enact and enforce clear competition laws, internalize environmental costs (e.g., pollution taxes), and discourage monopolistic behavior to foster dynamic and sustainable markets.

For Developed Countries

Maintain the independence between institutions and market freedom: In mature economies, excessive institutional interference in markets may hinder efficiency. Policymakers should allow economic freedom to operate independently while maintaining strong legal frameworks for oversight.

Prioritize public-sector investment in sustainability innovation: Institutions should focus on funding research, infrastructure, and public-private partnerships that accelerate clean technologies, sustainable production, and circular economy models.

Promote balanced growth through institutional coordination: While minimizing overregulation, institutions should still guide the private sector toward sustainable practices through incentives, environmental standards, and long-term strategic planning.

For Developed Countries

Institutions should be independent of economic freedom. In a strong free-market economy, the market often determines business and consumer behavior. In some cases, this can lead to conflicts of interest, such as businesses focusing on maximizing profits without considering the environmental or social impact. Therefore, the independence of economic freedom and institutions in developed countries is necessary. Furthermore, the institutions of developed countries should focus on public sector, where they can provide financial support and collaborate with research organizations to promote innovation and industrial development, enhance sustainable environments, and foster the development of the private sector to promote sustainable economies.

One important limitation of this study lies in its use of the aggregate SDGI as a proxy for a country's overall level of sustainable development. Although the SDGI is a comprehensive indicator encompassing progress across all 17 SDGs, relying on a composite index may obscure the nuanced differences among the three individual pillars of sustainable development—economic, social, and environmental. For instance, a country might perform well in achieving economic-related SDGs while lagging significantly in environmental or social goals. The use of a single aggregate measure could mask these imbalances, potentially leading to less precise conclusions about the specific influence of economic freedom and IQ on each aspect of sustainability. Therefore, future research is encouraged to disaggregate the SDGI into its constituent components—such as separate indices for economic, social, and environmental sustainability—or to examine selected SDGs individually. This would allow for a more detailed and targeted assessment of how economic freedom and governance institutions affect different dimensions of sustainable development.

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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	

Appendix 2. Description of variables in the model

Symbol	Measurement	Studies	Data source
	Dependent Variable		
SDGI	**Appendix 1**	**[3, 4, 45, 46]**	**SDGIndex.org**
	Independent Variables		
EFI	Measured through 12 components: property rights, government integrity, judicial effectiveness, tax burden, government spending, fiscal health, business freedom, labor freedom, monetary freedom, trade freedom, investment freedom, and financial freedom.	[14, 38]	Heritage Foundation.
IQ VOA POL GOV REG RUL COR	The six indices of the WGI range from -2.5 to 2.5	[39, 46]	WDI
GDP	GDP per capita (annual growth, %)	[4]	World Bank
CO_2	CO_2 emissions per capita	[44]	World Bank
UR	Urban population as a percentage of total population (Urbanization rate, %)	[4]	World Bank
POP	Annual population growth rate (%)	[4]	World Bank
OPEN	The ratio of total goods and services exports and imports to GDP (%)	[4]	World Bank
FDI	FDI/GDP (%)	[4]	World Bank

FD	The financial development index is obtained from the IMF	[4]	IMF
INF	Annual inflation growth rate (%)	[4]	World Bank

Source: Compiled by the authors

Appendix 3.

Developing Countries Included in the Study:

Armenia, Cambodia, Chile, Costa Rica, Cyprus, Dominican Republic, El Salvador, Estonia, Georgia, India, Indonesia, Jamaica, Latvia, Lithuania, Mali, Malta, Moldova, Philippines, Romania, Sri Lanka, Uruguay, and Vietnam.

Developed Countries Included in the Study:

Australia, Austria, Belgium, Canada, Croatia, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Israel, Italy, the Republic of Korea, Luxembourg, the Netherlands, New Zealand, Poland, Portugal, the Slovak Republic, Slovenia, Sweden, Switzerland, the United Kingdom, and the United States.