THE MODERATING ROLE OF INCOME INEQUALITY IN THE RELATIONSHIP BETWEEN SUSTAINABLE DEVELOPMENT AND GEOPOLITICAL RISK

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ABSTRACT

This study investigates the moderating role of income inequality (INEQ) in the relationship between geopolitical risk (GPR) and sustainable development (SD). Using Bayesian regression techniques on panel data from 27 countries over the period 2010–2021, the study provides robust empirical evidence on how INEQ and GPR jointly shape SD outcomes. The results indicate that INEQ exerts a statistically significant and negative effect on SD, with a posterior probability of 100%. This finding suggests that unequal income distribution weakens human capital formation, institutional quality, and social consensus for environmental policies. In contrast, GPR is found to positively influence SD within the sample, potentially reflecting short-term economic–environmental adjustment effects, whereby conflicts reduce growth, investment, and energy consumption, leading to temporary environmental improvements. However, the interaction term between INEQ and GPR is negative and highly significant (posterior probability of 99.96%), indicating that inequality substantially weakens the positive impact of GPR on SD. In highly unequal societies, adaptive capacity to external shocks is more limited, thereby undermining sustainable outcomes. Additionally, green innovation, urbanization, trade openness, government size, and renewable energy consumption are found to promote SD, while extensive GDP growth, FDI inflows, population growth, and reliance on natural resources exert adverse effects.

Keywords: Bayesian regression, Geopolitical risk, Income inequality, Sustainable development

JEL classification: C11, D31, F51, Q01

1. Introduction

In the context of deepening globalization and increasingly complex geopolitical dynamics, ensuring the progress of sustainable development has become one of the most critical challenges facing countries worldwide. The concept of Sustainable Development (SD) has been widely institutionalized since the adoption of the 17 Sustainable Development Goals (SDGs) by the United Nations in 2015. Beyond economic growth, SD emphasizes the balanced integration of economic, social, and environmental dimensions to enhance quality of life while preserving resources for future generations. However, major disruptions such as armed conflicts, political tensions, and shifting power balances among global powers pose substantial risks to social stability and the achievement of these SD objectives.

An expanding body of empirical research indicates that geopolitical risk (GPR) may significantly hinder progress toward the SDGs. For instance, empirical evidence based on the global SDG index and its 17 sub-indicators suggests that rising GPR slows progress toward

Decent Work and Economic Growth (SDG 8) and Climate Action (SDG 13), as well as the overall SDG performance, particularly in resource-dependent economies. Moreover, institutional quality has been shown to partially mitigate these adverse effects (Nguyen et al., 2023). These impacts operate through multiple transmission channels, including disruptions to global supply chains, reduced investment in long-term development programs, and weakened international cooperation in sustainability initiatives.

In addition, a growing number of studies demonstrate that GPR extends beyond macroeconomic instability and exerts profound effects on social, environmental, and financial dimensions. For example, GPR has been found to influence the behavior of sustainable financial markets and green assets in both the short and long term, with heterogeneous outcomes depending on contextual and methodological differences (Helmi et al., 2024). Other research suggests that heightened GPR may increase consumption-based carbon emissions, thereby indirectly undermining environmental development indicators when environmental regulatory frameworks are insufficiently robust (Luo & Sun, 2024).

Despite these advances, most existing studies primarily focus on the direct relationship between GPR and SD indicators, while paying limited attention to how this relationship may vary according to countries' internal structural conditions. In particular, income inequality, one of the most pressing socio-economic concerns of the twenty-first century, may serve as a critical moderating factor that either amplifies or attenuates the impact of GPR on SD.

Income inequality (INEQ) is widely recognized as a fundamental socio-economic issue closely linked to the distribution of resources, access to public services, and the capacity to withstand exogenous shocks. Persistent income disparities not only increase the Gini coefficient but may also erode social capital and public trust, thereby constraining collective consensus in the implementation of public policies aimed at common welfare. Although further large-scale quantitative evidence is needed, several analyses suggest that inequality heightens societal vulnerability to shocks such as pandemics or international economic policy fluctuations, which in turn may impede progress toward achieving the SDGs.

Nevertheless, the interrelationship among GPR, INEQ, and SD has yet to be systematically examined within a unified econometric framework, particularly from the perspective of INEQ as a moderating variable in the GPR–SD nexus. This gap gives rise to an important research question: Does the impact of GPR on SD depend on the level of income inequality within a country? If so, to what extent and through which mechanisms does this moderating effect operate?

Addressing this question is not only theoretically relevant but also of substantial practical significance. In a world characterized by widening disparities in income and power, understanding the moderating role of income inequality can assist policymakers in designing more resilient and adaptive strategies to cope with geopolitical shocks, while safeguarding SD goals from external disruptions.

This study is designed to address the aforementioned issues. Specifically, we propose an econometric model in which income inequality is not merely treated as a dependent or independent explanatory variable, but as a moderator interacting with GPR to influence countries' levels of SD. This framework enables us to examine whether the adverse effects of GPR on SD intensify at higher levels of inequality, and to quantify the magnitude of such interaction effects.

Methodologically, the study employs a multi-country panel dataset covering the period 2010–2022 to capture cross-country heterogeneity. The model incorporates key control variables,

including GDP growth, trade openness, population growth, government size, and natural resource endowments. By testing the interaction between GPR and INEQ, this research aims to provide a more comprehensive understanding of how GPR and income inequality jointly shape the trajectory of SD. The findings are expected to contribute to the literature on political economy and SD, while offering meaningful policy implications for countries seeking to reconcile resilience to geopolitical shocks with long-term sustainability objectives.

2. Theoretical review

2.1. The impact of geopolitical risk on sustainable development

Geopolitical risk (GPR) is widely regarded as a factor that may hinder the progress of SD through multiple transmission channels. From the perspective of institutional theory, governance quality, transparency, and the effectiveness of legal frameworks play a central role in containing GPR and maintaining socio-economic stability. Countries characterized by strong institutions, high accountability, and the rule of law are generally better equipped to mitigate the adverse effects of geopolitical instability, thereby safeguarding economic growth, social cohesion, and environmental protection. Conversely, weak institutional structures may exacerbate tensions and undermine the effective implementation of SD objectives (Meyer & Rowan, 1977; DiMaggio & Powell, 1983).

From the standpoint of conflict theory as articulated by Karl Marx, competition over scarce resources is an inherent feature of society, and geopolitical conflict represents a concrete manifestation of such competition. Wars, civil conflicts, terrorism, and territorial disputes disrupt economic activity, weaken institutions, divert resources away from development programs, and intensify environmental degradation. Moreover, competition for strategic resources, such as water, forests, land, oil, and natural gas, may increase pollution and resource depletion, thereby threatening long-term ecological sustainability.

Empirically, a growing body of literature has examined the GPR–SD nexus from diverse perspectives. Wang et al. (2024) document a substantial increase in global research on this topic, particularly within environmental and ecological sciences. The proportion of related studies rose from 36.44% prior to the Russia–Ukraine conflict to 38.13% thereafter, reflecting heightened scholarly attention to the sustainability implications of geopolitical instability.

Some empirical evidence highlights the beneficial role of effective political risk management in promoting SD. Ahmad et al. (2024), employing the Common Correlated Effects Mean Group (CCEMG) estimator for OECD countries over the period 1990–2019, find that a 5% improvement in the GPR index is associated with a 0.013% increase in SD performance. This result is attributed to the institutional capacity, resource accessibility, and international cooperation mechanisms characteristic of OECD economies, which enable them to manage GPR effectively while sustaining political and economic stability. Similarly, Feng et al. (2024) argue that sound governance reduces GPR and enhances environmental quality.

However, numerous studies report adverse environmental consequences of heightened GPR. Farooq et al. (2023), using linear and nonlinear ARDL models for China (1990–2018), show that rising political risk increases CO_2 emissions. Their findings also support the "pollution haven" hypothesis, indicating that foreign direct investment (FDI) contributes to higher emissions, while renewable energy consumption mitigates environmental degradation. Comparable evidence is found for the BRICS economies (Bashir et al., 2023), and Wang et al. (2024) similarly document the deteriorating effect of GPR on environmental quality.

Conversely, some studies suggest a countervailing effect, implying a trade-off between geopolitical instability and environmental quality. Nawaz et al. (2023), applying ARDL and wavelet approaches to Italy (1997–2019), find that GPR reduces pollution levels, whereas FDI and transportation intensify environmental degradation. Likewise, Husnain et al. (2022), examining the E7 countries (1990–2015) using ecological footprint and CO_2 indicators, report that a 1% increase in GPR reduces CO_2 emissions by 8%. The authors argue that political and military tensions suppress investment and production–consumption activities, thereby lowering emissions. Similar conclusions are drawn by Anser et al. (2021) for emerging economies and Zhao et al. (2021) for BRICS countries, where GPR reduces ecological footprints by dampening economic growth and energy consumption.

Overall, GPR constitutes a significant factor in the pursuit of SD. While most studies emphasize its detrimental effects on environmental quality and long-term development, some evidence points to emission-reducing effects resulting from economic contraction during periods of instability. This inconsistency suggests that the GPR–SD relationship depends on institutional quality, economic structure, and country-specific contexts, thereby underscoring the need for further research into underlying mechanisms and moderating factors.

2.2. The Impact of Income Inequality on Sustainable Development

The relationship between income inequality and SD can be understood through multiple theoretical lenses encompassing economic, social, and environmental dimensions. From an economic growth perspective, the Kuznets hypothesis posits that inequality initially rises during early industrialization and declines as economies mature (Kuznets, 1955). However, contemporary evidence indicates that persistent inequality may hinder long-term growth by constraining human capital accumulation. According to endogenous growth theory, human capital is a central driver of sustained economic growth; when lower-income groups face limited access to education and healthcare, long-term growth potential diminishes (Lucas Jr., 1988). Thus, inequality represents not merely a distributional issue but also a structural barrier to SD.

From a political economy perspective, high inequality may intensify social unrest and redistributive pressures, resulting in short-term and unstable policy choices (Alesina & Rodrik, 1994). Policy instability discourages private investment, particularly long-term investments in green infrastructure and technological innovation, both crucial for SD. Furthermore, inequality is often associated with extractive institutions, in which power is concentrated among elites, thereby undermining inclusiveness and long-run development prospects (Robinson & Acemoglu, 2012). Institutional and political channels therefore provide a key mechanism linking inequality to sustainability outcomes.

From a human development standpoint, Sen (1999) conceptualizes development as the expansion of capabilities rather than mere income growth. Income inequality restricts access to education, healthcare, and labor markets for vulnerable groups, impeding inclusive growth and the achievement of the Sustainable Development Goals (SDGs). Unequal resource distribution reduces collective consensus and weakens social momentum for green transitions and long-term transformation.

In addition, effective demand theory underscores the macroeconomic implications of income distribution. Since lower-income households exhibit higher marginal propensities to consume, rising inequality may weaken aggregate demand, generate cyclical instability, and constrain resources available for sustainable investment (Keynes, 2018). Imbalances between consumption and savings may also fuel asset bubbles and financial crises, thereby undermining SD trajectories.

Empirical findings reinforce these theoretical arguments. In Europe, Andriuskevicius et al. (2017), analyzing panel data for 25 EU countries (2005–2013), find that interactions between inequality, savings, growth, and social welfare expenditures exert heterogeneous effects on environmental and growth indicators, with stronger emission impacts in lower-income countries. In ASEAN-5 economies, Masud et al. (2020) employ FMOLS and DOLS estimators to demonstrate that income inequality exacerbates environmental degradation in the long run.

Similarly, Mushta et al. (2020) show that in China (1995–2015), both income inequality and economic growth increase CO_2 emissions, although technological innovation mitigates this adverse effect. Li et al. (2023), using a geographically and temporally weighted regression (GTWR) model across 19 Chinese urban regions (2007–2018), find that industrial land expansion influences urban–rural income disparities in heterogeneous ways, highlighting the importance of resource allocation structures. Khan et al. (2022), examining 18 developing Asian economies, report that poverty and income inequality increase ecological footprints, while confirming the inverted-U Environmental Kuznets Curve (EKC).

In sum, both theoretical and empirical evidence indicate that income inequality affects SD through human capital accumulation, institutional and political stability, aggregate demand, and resource allocation structures. Although the magnitude and direction of these effects vary across contexts, reducing inequality generally appears to be a prerequisite for achieving inclusive and long-term sustainable growth.

2.3. The moderating role of income inequality in the GPR–SD nexus

Existing empirical studies typically examine either the relationship between GPR and economic–environmental indicators or the linkage between income inequality and development outcomes. Integrating these two strands of literature provides a logical foundation for hypothesizing a moderating role of income inequality in the impact of GPR on SD.

The GPR index developed by Matteo Iacoviello and Dario Caldara demonstrates that geopolitical shocks reduce output and investment at the global level (Caldara & Iacoviello, 2018). Subsequent research indicates that GPR negatively affects economic growth, financial markets, and environmental quality through heightened policy uncertainty and reduced long-term investment (Apergis et al., 2022). Because SD encompasses economic, social, and environmental pillars, increased capital costs and policy reallocation toward short-term security objectives may slow progress toward the SDGs established by the United Nations.

Simultaneously, substantial empirical evidence shows that income inequality significantly influences macroeconomic stability and resilience to shocks. Alesina and Perotti (1996) demonstrate that high inequality increases political instability and reduces investment. Berg et al. (2018) find that higher inequality is associated with shorter growth spells and greater vulnerability to shocks. Rodrik (1999) argues that economies characterized by deep social conflict, often linked to inequality, tend to respond less effectively to external shocks.

Building upon these insights, income inequality may moderate the GPR–SD relationship through at least three mechanisms. First, in highly unequal societies, geopolitical shocks may exert more severe welfare impacts because low-income groups possess limited coping capacity, thereby amplifying negative effects on the social pillar of SD. Second, inequality may weaken policy coordination and reduce the efficiency of public resource allocation for long-term investments in education, healthcare, and green energy transitions. During periods of heightened GPR, public resources may be redirected toward defense or short-term stabilization, crowding out sustainable investment. Third, inequality may shape consumption patterns and

emission structures, thereby influencing the environmental dimension of sustainability (Grunewald et al., 2017; Knight et al., 2017).

Although few studies directly test the interaction between GPR and income inequality within a SD framework, existing empirical evidence suggests that inequality may alter both the magnitude and direction of GPR's impact on sustainability outcomes. Incorporating this moderating factor into empirical models not only clarifies transmission mechanisms but also yields important policy implications: reducing inequality may enhance resilience and help preserve SD trajectories amid escalating geopolitical instability.

3. Methodology

3.1. Variables and data

Based on the theoretical framework and empirical evidence discussed in the previous sections, the proposed research model is specified as follows:

$$SDGI_{i,t} = \beta_i + \beta_1 INEQ_{i,t} + \beta_2 GPR_{i,t} + \beta_3 Z_{i,t} + \varepsilon_{i,t} \qquad (1)$$

where i = 1, 2, …, N denotes countries and t = 1, 2, …, T denotes time periods.

To examine the moderating role of income inequality (INEQ) in the relationship between geopolitical risk (GPR) and sustainable development (SDGI), the study incorporates the interaction term INEQ×GPR into the empirical model presented below:

$$SDGI_{i,t} = \beta_i + \beta_1 INEQ_{i,t} + \beta_2 GPR_{i,t} + \beta_3 INEQ_{i,t} \times GPR_{i,t} + \beta_4 Z_{i,t} + \varepsilon_{i,t} \qquad (2)$$

where SDGI represents the sustainable development variable, INEQ denotes income inequality, GPR is geopolitical risk, and Z is a vector of control variables, including economic growth (GDP), green innovation (GI), foreign direct investment (FDI), natural resources rent (NRR), renewable energy consumption (REC), urbanization level (URB), trade openness (TRADE), government size (SIZE), and population growth (POG). Detailed measurements of these variables are presented in Table 1.

Table 1. Variable description

Variable	Description	Measurement	Research	Data sources
SDGI	Sustainable development	Sustainable development goals index	Oanh (2023), Dinh et al. (2024), Nguyen et al. (2025)	Sustainable Development Report
INEQ	Income inequality	GINI index	Andriuskevicius et al. (2017), Masud et al. (2020)	WDI
GPR	Geopolitical risks	The geopolitical risk index, developed by Dario Caldara and Matteo Iacoviello.	Nguyen et al. (2025)	www.matteoia-coviello.com
GI	Green innovation	The ratio of environmental-related	Chien et al. (2023), Nguyen et al. (2025)	OECD

Variable	Description	Measurement	Research	Data sources
		technology patents to total technology patents (%)		
GDP	Economic growth	GDP growth rate (%)	Wang et al. (2023)	WDI
FDI	Foreign direct investment	Foreign direct investment, net inflows (% of GDP)	Oanh (2023), Izadi & Madirimov (2023)	WDI
NRR	Natural resources rent	Total natural resources rents (% of GDP)	Dastgeer et al. (2023)	WDI
REC	Renewable energy consumption	% of total final energy consumption	Sueyoshi et al. (2022), Dastgeer et al. (2023)	
URBAN	Urbanization	Urban population (% of total population)	Chen & Liu (2020), Li & Xu (2023)	
OPEN	Trade openness	Sum of exports and imports of goods and services (% of GDP)	Yang et al. (2020), Hui & Martinez-Vazquez (2021), Nguyen et al. (2025)	
SIZE	Government size	Government revenue (% of GDP)	Jin & Jakovljevic (2023), Nguyen et al. (2025)	
POP	Population	Population growth rate (%)	Vo & Vo (2021)	

Because of constraints in data availability for the variables incorporated in the research model, this study utilizes a balanced panel dataset comprising 27 countries spanning the period 2010–2021. The variables included in the analysis are compiled from various sources, as detailed in Table 1.

3.2. Research methodology

This study employs Bayesian regression methods to analyze data from 27 countries over the 2010–2021 period. Under the Bayesian framework, statistical inference is conducted by combining prior information with observed data to generate a posterior distribution, which enables direct evaluation of parameter uncertainty. Consequently, interpretation centers on the entire probability distribution of the parameters rather than on large-sample asymptotic assumptions, making Bayesian techniques particularly suitable when the dataset is relatively limited.

Within this approach, the observed dataset is treated as fixed, whereas model parameters are considered random variables. Prior distributions reflect pre-existing knowledge or assumptions about the parameters before empirical evidence is incorporated, representing the researcher's initial beliefs. As data are introduced, these priors are updated to produce posterior estimates that integrate both prior information and sample evidence. The resulting posterior distribution therefore facilitates inference that accounts for uncertainty in a coherent and systematic manner, providing a flexible and robust framework for handling data limitations and cross-country heterogeneity.

4. Results and discussion

Table 2 below shows the significant variability of the variables in the research model.

Table 2. Descriptive statistics

Variable	Obs	Mean	Std. dev.	Min	Max
SDGI	324	4.33351	0.07279	4.12295	4.46080
INEQ	324	3.51731	0.17049	3.17805	4.00915
GPR	324	0.28559	0.44025	0.00588	2.62763
GI	324	0.12513	0.03637	0.05041	0.26616
GDP	324	0.02325	0.03428	-0.10940	0.13363
FDI	324	0.02630	0.06828	-0.36140	0.43487
URBAN	324	0.76902	0.12079	0.43856	0.98117
TRADE	324	0.75497	0.34009	0.23393	1.74084
SIZE	324	0.37878	0.11051	0.12461	0.57498
POG	324	0.00547	0.00599	-0.01854	0.01981
REC	324	0.19323	0.14317	0.01300	0.61400
NRR	324	0.02069	0.03251	0.00008	0.18511

The descriptive statistics indicate that the dataset consists of 324 observations for all variables, suggesting a balanced sample. The dependent variable, SGDI - representing the level of sustainable development - has a mean value of 4.33351 with a relatively small standard deviation (0.07279), ranging from 4.12295 to 4.46080. This narrow dispersion implies that differences in sustainable development levels across countries in the sample are not substantial, with values clustered closely around the mean. Regarding the main explanatory variables, income inequality (INEQ), measured by the Gini index, has a mean of 3.51731 and a standard deviation of 0.17049, indicating noticeable cross-country variation in income distribution. Geopolitical risk (GPR) has an average value of 0.28559 but a relatively high standard deviation (0.44025), with a maximum of 2.62763, reflecting considerable volatility in geopolitical conditions during the study period.

The control variables also exhibit varying degrees of dispersion. Economic growth (GDP) has a mean of 0.02325, ranging from -0.10940 to 0.13363, indicating the presence of both economic contraction and strong expansion episodes. Green innovation (GI) and renewable energy consumption (REC) show mean values of 0.12513 and 0.19323, respectively, highlighting

differences in green transition efforts among countries. Foreign direct investment (FDI) and natural resource rents (NRR) display relatively low mean values but wide ranges, suggesting heterogeneity in external capital inflows and resource dependence. Meanwhile, urbanization (URBAN) and trade openness (TRADE) have relatively high average values (approximately 0.75–0.77), implying that most countries in the sample are characterized by relatively advanced urbanization and openness.

Table 3. Bayesian regression results

SDGI	Mean	Std. dev.	MCSE	Median	Probability		
					Mean	Std. Dev.	MCSE
INEQ	-0.1194	0.0182	0.0002	-0.1194	1.0000	0.0000	0.0000
GPR	0.0221	0.0051	0.0001	0.0221	1.0000	0.0000	0.0000
GI	0.0875	0.0551	0.0006	0.0875	0.9442	0.2296	0.0023
GDP	-0.0152	0.0581	0.0006	-0.0152	0.5994	0.4900	0.0049
FDI	-0.0264	0.0277	0.0003	-0.0265	0.8312	0.3746	0.0037
URBAN	0.1509	0.0207	0.0002	0.1508	1.0000	0.0000	0.0000
TRADE	0.0100	0.0075	0.0001	0.0101	0.9074	0.2899	0.0028
SIZE	0.1483	0.0273	0.0003	0.1486	1.0000	0.0000	0.0000
POG	-2.6323	0.4136	0.0040	-2.6299	1.0000	0.0000	0.0000
REC	0.1713	0.0180	0.0002	0.1710	1.0000	0.0000	0.0000
NRR	-0.6858	0.0623	0.0006	-0.6854	1.0000	0.0000	0.0000
_cons	4.5529	0.0738	0.0007	4.5533			
Avg acceptance rate			0.827	Avg efficiency: min			0.0427

The regression results reported in Table 3 indicate that income inequality (INEQ) exerts a negative effect on sustainable development (SDGI), with a posterior probability of 100%. According to endogenous growth theory, income inequality constrains access to education and healthcare for low-income groups, thereby hindering human capital accumulation and undermining long-term economic growth. Institutional theory further suggests that high levels of inequality intensify social conflict, corruption, and policy capture, ultimately weakening governance quality. From the perspective of environmental economics, substantial income disparities reduce social consensus for environmental protection policies, thus impeding the achievement of sustainable development goals. These findings are consistent with the empirical evidence reported by Andriuskevicius et al. (2017) and Masud et al. (2020).

The results in Table 3 also reveal that geopolitical risk (GPR) positively influences SD across the sampled countries, with a posterior probability of 100%. Geopolitical conflicts tend to negatively affect economic growth and reduce investment activities due to heightened risk aversion among investors. Consequently, national energy consumption may decline significantly, leading to improvements in environmental quality. These findings are in line with previous studies by Nawaz et al. (2023), Husnain et al. (2022), Anser et al. (2021), and Zhao et al. (2021), which examine the nexus between GPR and SD.

The study further investigates the moderating role of income inequality in the relationship between GPR and SDGI. The corresponding regression results are presented in Table 4 below.

Table 4. Regression results with interaction term

SDGI	Mean	Std. dev.	MCSE	Median	Probability		
					Mean	Std. Dev.	MCSE
INQE	-0.1003	0.0188	0.0002	-0.1002	1.0000	0.0000	0.0000
GPR	0.4659	0.1424	0.0014	0.4655	0.9998	0.0141	0.0001
INEQxGPR	-0.1206	0.0387	0.0004	-0.1206	0.9996	0.0200	0.0002
GI	0.0872	0.0541	0.0005	0.0877	0.9466	0.2248	0.0022
GDP	-0.0083	0.0580	0.0006	-0.0077	0.5530	0.4972	0.0050
FDI	-0.0220	0.0268	0.0003	-0.0219	0.7906	0.4069	0.0041
URBAN	0.1510	0.0203	0.0002	0.1508	1.0000	0.0000	0.0000
TRADE	0.0124	0.0074	0.0001	0.0125	0.9518	0.2142	0.0021
SIZE	0.1450	0.0273	0.0003	0.1453	1.0000	0.0000	0.0000
POG	-2.6500	0.4108	0.0041	-2.6501	1.0000	0.0000	0.0000
REC	0.1885	0.0184	0.0002	0.1883	1.0000	0.0000	0.0000
NRR	-0.7115	0.0620	0.0006	-0.7120	1.0000	0.0000	0.0000
_cons	4.4783	0.0762	0.0008	4.4778			
Avg acceptance rate			0.818	Avg efficiency: min			0.1167

The results indicate that the impact of geopolitical risk (GPR) on sustainable development (SDGI) changes significantly in environments characterized by high levels of income inequality. Specifically, the posterior mean coefficient of the interaction term INEQ×GPR is negative, with a posterior probability of approximately 99.96%. This finding suggests a very high likelihood that income inequality alters both the direction and magnitude of the effect of GPR on SDGI. In other words, in economies with higher levels of inequality, the positive impact of GPR on sustainable development is substantially weakened. This is consistent with the argument that in highly polarized societies, the capacity to mobilize policy consensus and equitably share the adjustment burden in response to external shocks is more limited. Consequently, the ability to adapt to GPR is constrained.

In addition, the findings show that green innovation promotes sustainable development in developed countries, with a posterior probability of 100%. According to the Green Solow model proposed by Taylor and Brock (2004), green innovation represents a form of technological progress oriented toward environmentally sustainable solutions. By investing in research and development (R&D) to generate cleaner technologies, improve energy efficiency, and reduce environmental damage, economies can enhance productivity and achieve sustainable growth while mitigating environmental degradation. Through the promotion of green innovation, countries can attain higher productivity levels while simultaneously strengthening

environmental sustainability and resilience. These results are consistent with endogenous growth theory and the empirical evidence provided by Töbelmann & Wendler (2020) and Chien et al. (2023).

The study further confirms that urbanization, trade openness, government size, and renewable energy consumption contribute positively to sustainable development. In contrast, GDP growth driven by extensive expansion, foreign direct investment (FDI), population growth, and reliance on natural resources exert negative effects on SD in the sampled countries.

5. Conclusion and suggestion

This study provides robust empirical evidence on the roles of income inequality and GPR in shaping SD. The findings demonstrate that income inequality (INEQ) negatively affects SD with a posterior probability of 100%, confirming that unequal income distribution not only undermines human capital accumulation and institutional quality but also weakens social consensus for environmental policies. Conversely, geopolitical risk (GPR) exerts a positive effect on SD within the sample. This may reflect a short-term economic–environmental adjustment effect, whereby conflicts reduce growth, investment, and energy consumption, thereby improving certain environmental indicators. However, this positive effect is not sustainable in the presence of high income inequality. The negative interaction coefficient (INEQ×GPR), with a posterior probability of 99.96%, indicates that inequality significantly weakens the positive impact of GPR on SD. In highly unequal societies, adaptive capacity in response to geopolitical shocks is more limited. Moreover, green innovation, urbanization, trade openness, government size, and renewable energy consumption enhance SD, whereas extensive GDP growth, FDI inflows, population growth, and dependence on natural resources have detrimental effects.

These findings yield several important policy implications. First, countries should prioritize policies aimed at reducing income inequality through progressive taxation reforms, expanded social protection systems, and increased investment in education and healthcare for low-income groups. Narrowing income disparities not only enhances social equity but also strengthens institutional foundations and resilience to external shocks.

Second, in the context of rising GPR, governments should shift from reactive responses to proactive adaptation strategies, including trade diversification, energy security enhancement, and the strengthening of strategic reserves. However, to sustain long-term positive outcomes, such strategies must be accompanied by improvements in income distribution to avoid diminishing adjustment effectiveness.

Third, promoting green innovation should become a central pillar of development strategies. Governments should increase R&D investment, encourage firms to adopt clean technologies, expand carbon credit markets, and establish green financing mechanisms. This transformation would facilitate the transition from “brown” to “green” growth, enhance long-term productivity, and reduce environmental pressures.

Fourth, economic growth models should be reoriented toward intensive, quality-based development rather than reliance on resource extraction, resource-intensive FDI, and simple output expansion. FDI attraction policies should prioritize high-technology, environmentally friendly projects with strong domestic linkages.

Finally, expanding renewable energy, improving the quality of urbanization, and enhancing governance effectiveness will help reinforce the economic, social, and environmental pillars of SD.

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