

Sensitivity of Green Finance to Environmental Sustainability

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This study investigates the impact of green finance on environmental sustainability across 136 countries spanning eight regions from 1960 to 2023. By employing robust regression models, including interaction terms to account for varying regional contexts, the research provides two key findings. First, green finance has a generally positive effect on environmental sustainability in the European Union and Western Europe, Eastern Europe and Central Asia, East Asia and the Pacific, North America, and South Asia. However, it shows a negative impact in Latin America and the Caribbean, the Middle East and North Africa, and Sub-Saharan Africa. Second, inflation moderates the effect of green finance on environmental sustainability, with its influence varying across different regions. This study contributes novel insights by revealing how green finance's effectiveness is contingent on regional economic conditions and inflationary pressures, offering a nuanced understanding of its role in promoting environmental sustainability globally.

Keyword - *Environmental sustainability, Green bond, Green finance, Inflation.*

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Introduction

Sustainable development advocates for a shift in social structure and mindset that accelerates economic growth by committing to reducing social injustice, extreme poverty, and inequality in society (Jelili Amuda, 2021). According to Ye et al. (2023), sustainable economic development is defined as economic growth with the protection of the environment and the promotion of human well-being as its main objectives. Within the growth narrative, there has been much discussion on the importance of economic expansion for lowering rates of poverty, increasing environmental sustainability, and reducing income inequality (Murshed, 2022). However, counterarguments have been made about how unsustainable economic expansion may eventually have a negative impact on the environment and society (Murshed, 2022). Furthermore, sustaining a stable rate of economic growth is critical because it increases the state's capacity to distribute public goods and raises the spending power of the relevant population. It is conceivable that in both situations, greater economic growth will raise the living standards of the affected populations (Murshed, 2022). Sustainable economic development might decrease future emissions and is associated with increasing urbanization, which leads to better fire-fighting and fuel fragmentation (Park et al., 2023). Therefore, there is a strong belief that the numerous macroeconomic challenges that arise during the development phases can ultimately be neutralized by attaining sustainable economic growth (Murshed, 2022). In this sense, one of the three main tenets of the 2030 Sustainable Development Goals (SDG) agenda established by the UN is the achievement of sustainable economic growth (Murshed, 2022). Consequently, the SDG agreement's signature has pushed global economies to discover pertinent avenues that would promote the sustainable expansion of the economy overall (Murshed, 2022).

Green finance has drawn a lot of attention in recent literature due to the growing number of international efforts being made to combat climate change. Significant

accomplishments by international organisations and national governments, the adoption of the Paris Climate Agreement and the United Nations Sustainable Development Goals demonstrate a renewed commitment to environmental sustainability. A joint project of the Global Environment Facility (GEF) and the Asian Development Bank (ADB) is climate change finance. The ADB's carbon market programs in Asia, ADB's technical support for the establishment of the China National Emission Trading System, and the GEF's support for China's green finance reform are notable initiatives in this regard (Tiwari et al., 2020). With the attention drawn to environmental sustainability, particularly the recent Intergovernmental Panel on Climate Change (IPCC) report on attaining carbon emissions that are net zero by 2050, governments and corporations have focused on attaining environmentally sustainable development (Tiwari et al., 2020). Countries are determined to achieve the green finance objective by funding renewable energy projects, eco-friendly constructions, forest restoration, and facilitating green corporate behavior.

Previous research indicates that green finance tends to impact the environment and sustainable development in various ways, such as impacting the stock and commodity markets (Naeem et al., 2022), lowering the ecological footprint (Khan et al., 2022), encouraging the production of blue hydrogen (Webb et al., 2023), improving corporate green innovation (Jia et al., 2023), and assisting businesses in making the transition to a greener business (Chi & Yang, 2023; Zhao et al., 2023), supporting high-quality energy development (Xu et al., 2023), fostering sustainable economic growth (Nenavath & Mishra, 2023), and influencing central bank mandates (Dikau & Volz, 2021).

From 2011 to 2019, Khan et al. (2022) examined the effects of green finance on ecological footprints in 26 Asian economies, demonstrating that green finance appeared to be environmentally friendly and decreased ecological footprints. From an Asian point of view, supporting the early stages of the scaling up of green hydrogen production would be the most economical use of green finance, particularly when the

investment environment might not accurately reflect medium- to longer-term prospects (Webb et al., 2023). The study conducted by Jia et al. (2023) investigated the impact of green finance reform on corporate green innovation in China between 2012 and 2020. The findings indicated a notable improvement in corporate green innovation subsequent to the implementation of green finance reform. From September 2010 to July 2021, Naeem et al. (2022) examined the return and volatility connectedness of the established US industry stock and commodity markets as well as the growing green asset market. They found that time-varying return and volatility connectedness had significant crisis jumps. In the green and commodity markets, asset volatility is more common than return volatility, and certain financial and economic uncertainty indicators indicate that the large-scale market volatility of commodities has positive effects. The role of green finance development in China's high-quality energy development (HED) was examined by Xu et al. (2023) between 2007 and 2013. Their findings indicated that the effect of green finance becomes more noticeable once it surpasses a threshold value and that its spatial spillover boundary is 1750 km. The government can use these findings as a guide to create more green finance policies that will lead to the development of high-quality energy. Nenavath and Mishra (2023) looked at how financial technology and green finance affected sustainable economic growth between 2010 and 2021. They found that green finance greatly influences the development of environmental quality protection, financial efficacy, and finance structure.

The impact of green finance on environmental sustainability is evident; however, research on this impact has primarily focused on developed countries. Additionally, the moderating role of national inflation on this impact has not been thoroughly addressed in existing studies. As inflation becomes a global issue, understanding how it affects the relationship between green finance and sustainable development is crucial. The lack of research on this factor creates a significant gap, particularly in developing and emerging regions where inflation rates tend to be higher and exert a

stronger influence on the economy and financial policies.

This study aims to identify and analyze the relationship between green finance and environmental sustainability across eight different regions of the world. These regions include the European Union and Western Europe, Eastern Europe and Central Asia, East Asia and the Pacific, Latin America and the Caribbean, the Middle East and North Africa, North America, South Asia, and Sub-Saharan Africa. The study will explore the influencing factors and specific characteristics of each region, providing tailored policy recommendations to enhance sustainable development.

Additionally, the research aims to uncover the moderating role of national inflation on the impact of green finance on environmental sustainability across these global regions. This will help offer more effective policy recommendations tailored to the economic conditions and inflationary situations of each region, contributing to a more comprehensive approach to sustainable development.

Literature Review

Green Finance and Environmental Sustainability

Green finance has significantly influenced environmental sensitivity by channeling investments towards projects and initiatives that prioritize ecological preservation and sustainability. By funding renewable energy projects, eco-friendly construction, and forest restoration, green finance helps reduce greenhouse gas emissions and promotes cleaner production methods (Zhang et al., 2024). This financial approach encourages businesses to innovate and adopt sustainable practices, thus lowering their ecological footprints. Additionally, green finance supports the development of green technologies, such as blue hydrogen and energy-efficient systems, which further enhance environmental protection efforts (Wei et al., 2024). Through these targeted investments, green finance not only mitigates the adverse effects of industrial activities on the environment but also fosters a culture of sustainability and environmental consciousness within the corporate sector and beyond. Therefore, we develop the following hypothesis 1:

H1: Green finance has a positive impact on environmental sustainability across different regions.

Green Finance, Inflation and Environmental Sustainability

Inflation, representing the rate at which the general level of prices for goods and services rises, can influence the effectiveness and efficiency of green finance initiatives in several ways (Lin & Wang, 2013). High inflation can erode the real value of financial investments, including those directed towards green projects. When inflation rates are high, the purchasing power of allocated funds diminishes, potentially reducing the scale and impact of green finance initiatives. This may result in fewer resources being available for renewable energy projects, eco-friendly constructions, and other sustainability-oriented investments, thereby hindering their effectiveness in achieving environmental goals (Zhao et al., 2024). Moreover, inflation can affect the cost structure of green technologies and sustainable practices. Rising costs of materials, labor, and other inputs due to inflation can increase the overall expenses of green projects, making them less economically viable. This can discourage both public and private sector investments in green finance, as the perceived financial returns may not justify the increased costs associated with inflationary pressures (Wang et al., 2019). On the other hand, inflation can impact consumer behavior and corporate strategies, which in turn affects environmental sustainability. During periods of high inflation, consumers may prioritize essential spending over eco-friendly products and services, leading to reduced demand for sustainable goods. Similarly, companies facing inflationary pressures might cut back on their sustainability initiatives to maintain profitability, thereby weakening the positive impact of green finance on environmental sustainability (Jia, 2022). Therefore, we develop hypothesis 2 as follows:

H2: Inflation moderates the impact of green finance on environmental sustainability across different regions.

Other Factors and Environmental Sustainability

Previous studies have shown that while green finance plays a crucial role in promoting sustainable practices and reducing environmental degradation, other determinants such as unemployment, trade openness, population, inflation, and FDI also significantly impact environmental sustainability (Gupta & Dutta, 2021; Oanh, Van, and Dinh, 2023; Hamid et al., 2020).

High levels of unemployment can have both direct and indirect effects on environmental sustainability. On one hand, unemployment may reduce the financial capacity of individuals and governments to invest in sustainable technologies and practices. On the other hand, high unemployment rates can lead to increased exploitation of natural resources as a means of livelihood, potentially causing environmental degradation (Oanh, Van, and Dinh, 2023; Gupta & Dutta, 2021; Salam & Xu, 2021).

The degree of trade openness influences environmental sustainability through various channels. Increased trade openness can lead to the transfer of environmentally friendly technologies and practices, promoting sustainability. However, it can also result in the "pollution haven" effect, where countries with lax environmental regulations attract polluting industries, thereby negatively impacting environmental sustainability (Oanh, Van, and Dinh, 2023; Salam & Xu, 2021).

Population growth exerts significant pressure on environmental resources. Higher population levels increase the demand for food, water, energy, and other resources, leading to greater environmental stress. Rapid urbanization associated with population growth can also result in habitat destruction, pollution, and increased waste generation, challenging efforts towards environmental sustainability (Oanh, Van, and Dinh, 2023). As discussed earlier, inflation affects the real value of investments in green projects and the cost structure of sustainable practices. High inflation can erode the purchasing power of funds allocated for environmental initiatives and increase the costs of

implementing green technologies, thereby reducing their effectiveness in promoting sustainability (Wang et al., 2019).

FDI can be a double-edged sword in the context of environmental sustainability. On one side, FDI brings in capital, technology, and expertise that can enhance environmental management and promote sustainable practices. On the other side, without stringent environmental regulations, FDI can lead to environmental degradation as multinational corporations may exploit natural resources unsustainably to maximize profits (Hamid et al., 2020).

Research Methods

Research Design

The study utilized an econometric technique known as panel data regression. In evaluating the effects of green finance and environmental sustainability, variables such as environmental sustainability (ES), green bond (GB), unemployment (UE), trade openness (TO), population (PP), inflation (INF), foreign direct investment (FDI) were included.

To test H1 and H2, we employ Model 1 and 2 as follows:

$$ES_{i,t} = \beta_0 + \beta_1 \times GB_{i,t} + \beta_2 \times UE_{i,t} + \beta_3 \times TO_{i,t} + \beta_4 \times PP_{i,t} + \beta_5 \times INF_{i,t} + \beta_6 \times FDI_{i,t} + \varepsilon_{i,t} \quad (1)$$

$$ES_{i,t} = \beta_0 + \beta_1 \times GB_{i,t} + \beta_2 \times UE_{i,t} + \beta_3 \times TO_{i,t} + \beta_4 \times PP_{i,t} + \beta_5 \times INF_{i,t} + \beta_6 \times FDI_{i,t} \\ + \beta_7 \times INF_{i,t} \times GB_{i,t} + \varepsilon_{i,t} \quad (2)$$

In Model 1, we regress the independent variables ($GB_{i,t}$) with the dependent variables ($ES_{i,t}$), incorporating control variables ($UE_{i,t}$, $TO_{i,t}$, $PP_{i,t}$, $INF_{i,t}$, $FDI_{i,t}$). In Model 2, we include interaction terms $INF_{i,t} \times GB_{i,t}$ in the regression.

Measuring Environmental Sustainability

We measure environmental sustainability ($ES_{i,t}$) as a dependent variable is followed by the method of (Sohag et al., 2019b). (Sohag et al., 2019b) define environmental sustainability as the efficient use of renewable resources after deducting the damage

caused by greenhouse gas emissions, natural resource exploitation, and other negative externalities. We obtain data from the World Bank. The data is then transformed using the natural logarithm to minimize errors.

$$ES_{i,t} = \ln (\text{Renewable resource use}_{i,t} - \text{Greenhouse gas emission}_{i,t} \\ - \text{Natural resource exploitation}_{i,t} \\ - \text{Other negative externalities}_{i,t})$$

Measuring Green Finance

We follow Cui et al. (2024) to use green bond issuances by country $[(GB)]_{(i,t)}$ as an independent variable to measure green finance, which is collected from Asian Development Bank.

Measuring Control Variables

We follow (Oanh, Van, and Dinh 2023) and (Hamid et al. 2020) to add control variables unemployment rate ($UE_{i,t}$), trade openness ($TO_{i,t}$), population ($PP_{i,t}$), inflation ($INF_{i,t}$), and foreign direct investment ($FDI_{i,t}$). Unemployment rate is measured by the number of unemployed people divided by a country's labor force. Trade openness is measured by the ratio of total import and export of goods and services by GDP. Population growth rate is measured by the annual population growth rate. Inflation rate is measured by the CPI rate of a country at a specific time (Oanh, Van, and Dinh 2023). We use (Hamid et al. 2020) to calculate yearly FDI inflows to nation i in year t . All data is collected from the World Bank.

Measuring the Moderating Variable

In this study, the Inflation variable is used as a moderating variable. The inflation rate (INF) is calculated based on the percentage change in the Consumer Price Index (CPI) using the following formula:

$$INF_{i,t} = \frac{CPI_{i,t} - CPI_{i,t-1}}{CPI_{i,t-1}} \times 100$$

Where:

- $INF_{i,t}$ is the inflation rate of country i in year t ;
 $CPI_{i,t}$ is the Consumer Price Index of country i in year t ;
 $CPI_{i,t-1}$ is the Consumer Price Index of country i in year $t - 1$.

Findings of the Study

Table 1 presents the descriptive statistics for the main variables in the model. The Environmental Sustainability (ES) variable, with 13,950 observations, has a mean of 23.64 and a standard deviation of 3.14, indicating a relatively narrow range of environmental sustainability scores across the sampled regions. The minimum and maximum values for ES are 15.30 and 32.24, respectively. Green bond (GB) data, with 17,024 observations, shows a mean value of 1.16 and a standard deviation of 2.09, with values ranging from 0 to a high of 99.43. This indicates a substantial variation in the issuance of green bonds among different regions.

Table 1: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
ES	13,950	23.64	3.14	15.30	32.24
GB	13,950	1.16	2.09	0.00	99.43
UE	13,950	7.84	5.53	0.10	38.80
TO	13,950	76.73	56.10	0.02	863.20
PP	13,950	15.71	3.06	7.88	22.80
INF	13,950	44.23	281.63	(17.64)	11,749.64
FDI	13,950	19.10	3.50	2.30	28.77

ES: Environmental Sustainability; GB: Green bond; UE: Unemployment; TO: Trade openness; PP: Population; INF: Inflation; FDI: Foreign direct investment

Baseline Regressions

Table 2 presents the Variance Inflation Factors (VIF) for the variables used in the study to assess multicollinearity. The VIF values for PP, FDI, TO, UE, GB, and INF are 2.29, 1.87, 1.32, 1.04, 1.02, and 1.01, respectively. The mean VIF is 1.42. These results indicate that multicollinearity is not a concern in this study, as all VIF values are well below the common threshold of 5. The relatively low VIF values suggest that the

explanatory variables are not highly correlated and can be reliably used in the regression analysis.

Table 2. VIF

Variable	VIF	1/VIF
PP	2.29	0.437254
FDI	1.87	0.535138
TO	1.32	0.757611
UE	1.04	0.960082
GB	1.02	0.985182
INF	1.01	0.995017
Mean VIF	1.42	

ES: Environmental Sustainability; GB: Green bond; UE: Unemployment; TO: Trade openness; PP: Population; INF: Inflation; FDI: Foreign direct investment

Table 3 displays the Pearson correlation coefficients among the variables studied. GB positively correlate with ES, indicating that higher green bond issuance is associated with improved environmental sustainability. UE negatively correlates with ES, suggesting that higher unemployment rates are linked to lower environmental sustainability. TO negatively correlates with ES, indicating that greater trade openness is associated with lower environmental sustainability. PP strongly positively correlates with ES, showing that larger populations tend to be associated with better environmental sustainability outcomes. INF weakly negatively correlates with ES, implying a slight negative impact of inflation on environmental sustainability, though the correlation is very weak. FDI strongly positively correlates with ES, indicating that higher levels of FDI are significantly associated with improvements in environmental sustainability. These findings provide insights into the complex interplay of economic factors affecting environmental sustainability.

Table 3: Pearson Correlation

	ES	GB	UE	TO	PP	INF	FDI
ES	1.0000						
GB	0.1204	1.0000					
	0.0000						
UE	-0.1031	-0.0530	1.0000				
	0.0000	0.0000					
TO	-0.2129	-0.0117	0.1292	1.0000			
	0.0000	0.1271	0.0000				
PP	0.8292	0.0903	-0.1439	-0.4109	1.0000		
	0.0000	0.0000	0.0000	0.0000			
INF	-0.0155	0.0046	-0.0324	-0.0107	0.0065	1.0000	
	0.0571	0.5450	0.0000	0.1624	0.3996		
FDI	0.8461	0.1183	-0.0495	-0.1071	0.6377	-0.0442	1.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	

ES: Environmental Sustainability; GB: Green bond; UE: Unemployment; TO: Trade openness; PP: Population; INF: Inflation; FDI: Foreign direct investment

Table 4 presents the regression analysis results for Model 1, which examines the impact of green finance and other factors on Environmental Sustainability (ES) using Ordinary Least Squares (OLS), Fixed Effects Model (FEM), Random Effects Model (REM), and Generalized Least Squares (GLS). The GLS model is the most suitable model as suggested by both the Likelihood ratio and Hausman tests (Achim, 2017; Tabsh, 2015; Talukdar, 2012; Yusuf, 2003). We applied F-test, Breusch-Pagan test, Wooldridge test to ensure that the model does not have autocorrelation and serial correlation problems (Bahl et al., 2019). The coefficient of GB is positive and significant (0.0257***), indicating that increased issuance of green bonds is associated with improved environmental sustainability.

The coefficients for the control variables reveal various impacts on Environmental Sustainability (ES). UE has a positive and significant coefficient (0.0124***), suggesting that higher unemployment rates are associated with improved environmental sustainability, though this result is somewhat unexpected and may

warrant further scrutiny. TO shows a positive and significant effect (0.00108***), indicating that increased trade openness contributes to better environmental sustainability. PP exhibits a strong positive and significant coefficient (0.532***), demonstrating that larger populations are associated with enhanced environmental sustainability outcomes. INF has a positive and significant coefficient (0.000201***), suggesting a slight but meaningful positive impact on environmental sustainability. FDI also shows a strong positive and significant effect (0.495***), highlighting its substantial role in improving environmental sustainability. These results underscore the varying degrees to which these control variables influence environmental sustainability.

Table 4: Regression for Model 1

ES	OLS	FEM	REM	GLS
GB	0.0263***	0.0171***	0.0170***	0.0257***
	(5.77)	(4.82)	(4.74)	(6.48)
UE	0.00854***	-0.0196***	-0.0148***	0.0124***
	(4.51)	(-5.72)	(-4.49)	(9.40)
TO	0.00158***	0.00526***	0.00525***	0.00108***
	(6.97)	(17.12)	(17.35)	(5.79)
PP	0.530***	0.968***	0.857***	0.532***
	(105.44)	(72.32)	(74.20)	(139.20)
INF	0.0000719	0.000128**	0.000139***	0.000201***
	(1.60)	(3.29)	(3.56)	(6.39)
FDI	0.476***	0.353***	0.366***	0.495***
	(118.98)	(89.54)	(94.02)	(160.42)
_cons	5.739***	1.032***	2.591***	5.242***
	(77.14)	(5.37)	(14.92)	(102.65)
N	13,950	13,950	13,950	13,950

t statistics in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

ES: Environmental Sustainability; GB: Green bond; UE: Unemployment; TO: Trade openness; PP: Population; INF: Inflation; FDI: Foreign direct investment

Table 5 presents the regression results for Model 2, which incorporates the interaction term between inflation and green bonds (INF x GB) to examine the nuanced effects of green finance on environmental sustainability. In the GLS model, the coefficient for

GB remains positive and significant (0.0228***), reinforcing the finding that increased green bond issuance is positively associated with improved environmental sustainability. The interaction term (INF x GB) also shows a positive and significant coefficient (0.000449***), suggesting that the impact of green bonds on environmental sustainability is enhanced in the presence of higher inflation. This indicates a synergistic effect where inflation moderates the positive relationship between green bonds and environmental outcomes. For the control variables, UE maintains a significant positive effect, TO remains positively associated with ES, PP continues to have a strong positive impact, and FDI shows a significant positive relationship. In contrast, INF shows a negative and significant coefficient (-0.000221***), indicating a slight adverse effect on environmental sustainability, which contrasts with the positive correlation observed in Table 4. These results highlight the complex interplay between green finance, inflation, and environmental sustainability, emphasizing the importance of considering interaction effects in the analysis.

Table 5: Regression for Model 2

ES	OLS	FEM	REM	GLS
GB	0.0208***	0.0174***	0.0171***	0.0228***
	(4.54)	(4.88)	(4.77)	(5.72)
INF x GB	0.000510***	-0.0000881	-0.0000522	0.000449***
	(9.00)	(-1.05)	(-0.63)	(9.34)
UE	0.0102***	-0.0198***	-0.0149***	0.0133***
	(5.39)	(-5.78)	(-4.52)	(10.04)
TO	0.00155***	0.00526***	0.00525***	0.00116***
	(6.89)	(17.14)	(17.35)	(6.19)
PP	0.535***	0.968***	0.856***	0.535***
	(106.10)	(72.24)	(74.13)	(140.37)
INF	-0.000463***	0.000205*	0.000185*	-0.000221***
	(-6.22)	(2.47)	(2.25)	(-3.67)
FDI	0.475***	0.353***	0.366***	0.493***
	(118.84)	(89.52)	(94.03)	(159.67)
_cons	5.683***	1.044***	2.610***	5.216***
	(76.33)	(5.42)	(15.02)	(102.93)
N	13,950	13,950	13,950	13,950

t statistics in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

ES: Environmental Sustainability; GB: Green bond; UE: Unemployment; TO: Trade openness; PP: Population; INF: Inflation; FDI: Foreign direct investment

Table 6 displays the regression results for Model 2 across eight different regions, revealing that the correlation of GB with ES is notably varied across regions.

In region 1 (European Union and Western Europe), region 2 (Eastern Europe and Central Asia), region 3 (East Asia and Pacific), region 6 (North America) and region 7 (South Asia), GB exhibits a robust positive correlation with ES, indicating that green bonds significantly enhance environmental sustainability in these regions. In contrast, region 4 (Latin America and the Caribbean), region 5 (Middle East and North Africa) and region 8 (Sub-Saharan Africa) show negative correlations, suggesting that green finance may be less effective in these areas due to factors such as lower investment in green initiatives or less developed financial markets for green bonds.

For Inflation (INF), the correlation with ES is generally negative, reflecting the overall global trend seen in Table 5. However, in region 2 (Eastern Europe and Central Asia), region 4 (Latin America and the Caribbean), region 5 (Middle East and North Africa) and region 8 (Sub-Saharan Africa), inflation has a more substantial negative effect on ES compared to other regions, possibly due to higher inflation rates creating economic instability that undermines environmental policies.

The interaction term INF x GB reveals significant regional variations. In region 2 (Eastern Europe and Central Asia), region 4 (Latin America and the Caribbean), region 5 (Middle East and North Africa) and region 8 (Sub-Saharan Africa), the positive interaction suggests that green bonds have a positive impact on ES when inflation is high. This could indicate that in these regions, inflation drives more investment into green bonds as part of broader economic adjustments. Conversely, in region 1 (European Union and Western Europe), region 3 (East Asia and Pacific), region 6 (North America) and region 7 (South Asia), the interaction term is either insignificant

or negative, pointing to the complexity of how inflation and green finance interact in these regions, possibly due to less mature financial systems or different economic conditions affecting the impact of green finance.

Table 6. Regression for Model 2 Across Eight Regions

ES	Model 1	Model 2	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8
G B	0.0257 ***	0.0228 ***	0.0207 27***	0.1009 095**	0.0229 498**	- 0.0864 106***	- 0.2221 342***	0.0203 651**	0.0917 428**	- 0.0438 834**
	(6.48)	(5.72)	(3.87)	(3.26)	(3.35)	(4.03)	(7.38)	(2.07)	(2.73)	(2.52)
U E	0.0124 ***	0.0133 ***	0.0032 072ns	0.0047 196ns	0.0073 573ns	0.0035 797ns	- 0.0919 757***	- 0.0554 986**	0.0182 678**	0.0402 673***
	(9.40)	(10.04)	(0.71)	(1.52)	(1.11)	(0.84)	(22.38)	(3.13)	(2.91)	(14.44)
T O	0.0010 8***	0.0011 6***	0.0073 331***	- 0.0095 802***	- 0.0008 902**	0.0047 585***	0.0054 114***	0.0129 361**	0.0031 56ns	0.0021 301***
	(5.79)	(6.19)	(15.51)	(12.74)	(-2.45)	(8.75)	(10.26)	(3.38)	(1.92)	(3.67)
PP	0.532* **	0.535* **	0.7711 909***	0.6215 911***	0.4459 652***	0.5774 071***	0.8565 311***	0.8508 104***	0.6296 461***	0.7818 051***
	(139.2 0)	(140.3 7)	(48.00)	(42.58)	(33.87)	(55.67)	(38.91)	(16.12)	(32.88)	(71.01)
IN F	0.0002 01***	0.0002 21***	0.0011 386ns	0.0003 985***	0.0036 17ns	0.0016 16***	0.0032 779***	0.0125 462**	0.0014 9ns	0.0013 797***
	(6.39)	(-3.67)	(0.90)	(4.14)	(1.30)	(4.47)	(3.62)	(2.08)	(1.54)	(4.21)
F DI	0.495* **	0.493* **	0.3427 686***	0.4025 268***	0.5261 4***	0.5047 683***	0.2470 626***	0.4289 53***	0.3571 493***	0.2935 922***
	(160.4 2)	(159.6 7)	(32.39)	(34.46)	(47.83)	(59.63)	(24.87)	(16.75)	(31.45)	(41.94)
IN F x G B		0.0004 49***	- 0.0008 793ns	0.0005 312***	- 0.0025 355ns	0.0019 88***	0.0015 282***	- 0.0025 44ns	- 0.0094 74**	0.0014 425**
		(9.34)	(1.10)	(7.30)	(1.86)	(4.62)	(4.13)	(1.23)	(2.93)	(3.33)
_c on s	5.242* **	5.216* **	4.9608 39***	6.4426 12***	6.1592 15***	4.3740 17***	6.2075 ***	2.2985 85***	6.0286 65***	4.0819 76***
	(102.6 5)	(102.9 3)	(22.15)	(28.47)	(48.59)	(27.15)	(20.68)	(3.57)	(23.46)	(30.21)
N	13,950	13,950	1,700	1,367	1,984	2,413	1,193	247	591	2,577

t statistics in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

ES: Environmental Sustainability; GB: Green bond; UE: Unemployment; TO: Trade openness; PP: Population; INF: Inflation; FDI: Foreign direct investment

Region 1: European Union and Western Europe; Region 2: Eastern Europe and Central Asia; Region 3: East Asia and Pacific; Region 4: Latin America and Caribbean; Region 5: Middle East and North Africa; Region 6: North America; Region 7: South Asia; Region 8: Sub-Saharan Africa

Discussion and Recommendation

This study explores the impact of green finance on environmental sustainability (ES) across various regions, while considering the moderating role of inflation. The findings are summarized in Table 7 and reveal nuanced regional differences in the relationships between green finance, inflation, and ES. Firstly, green finance generally has a positive impact on ES, as supported by the results in region 1 (European Union and Western Europe), region 2 (Eastern Europe and Central Asia), region 3 (East Asia and Pacific), region 6 (North America) and region 7 (South Asia). This finding aligns with previous studies by Zhang et al. (2024) and Wei et al. (2024), which emphasized the role of green finance in enhancing environmental sustainability. However, the study found a negative impact in region 4 (Latin America and the Caribbean), region 5 (Middle East and North Africa) and region 8 (Sub-Saharan Africa). This divergence could be attributed to varying levels of green finance implementation, regional economic conditions, or institutional effectiveness in these areas.

Secondly, inflation moderates the impact of green finance on ES. This hypothesis is supported in regions 2 (Eastern Europe and Central Asia), 4 (Latin America and Caribbean), 5 (Middle East and North Africa), 7 (South Asia), and 8 (Sub-Saharan Africa), consistent with the work of Wang et al. (2019), Jia (2022), and Zhao et al. (2024). The moderation effect of inflation varies, indicating that its impact on the relationship between green finance and ES is not uniform across regions. The results generally align with previous studies, which suggest a positive relationship between green finance and ES. However, the negative correlations found in certain regions highlight that the impact of green finance is not universally beneficial and can be influenced by regional factors. The differing results for inflation's moderating role indicate that economic conditions and policies vary in their effectiveness across regions, reflecting the complex interplay between economic variables and environmental outcomes. Moreover, in regions 1 (European Union and Western

Europe), 3 (East Asia and Pacific), and 6 (North America), we did not find statistically significant evidence for the moderating role of inflation on the impact of green finance on environmental sustainability. There are several potential reasons for this. First, these regions generally have more stable and lower inflation rates compared to developing regions, which may reduce the variability in how inflation interacts with green finance. In such environments, green finance initiatives may be more insulated from short-term economic fluctuations, allowing their positive impacts on environmental sustainability to remain relatively consistent, irrespective of inflationary pressures. Second, these regions typically have well-established financial systems and stronger regulatory frameworks, which could diminish the influence of inflation on green finance. The maturity of these financial markets might allow green finance to operate more efficiently and effectively, without being heavily affected by inflationary dynamics. Lastly, the higher level of technological innovation and investments in clean energy in these regions could play a role in mitigating the effects of inflation. Green finance in these areas might be directed toward projects that are more resilient to economic pressures, such as those backed by government support or long-term policy commitments, which reduce the moderating influence of inflation.

Based on the discussion of the results above, we propose recommendations for different regions to enhance environmental sustainability. Specifically, for regions 1 (European Union and Western Europe), 2 (Eastern Europe and Central Asia), 3 (East Asia and Pacific), 6 (North America), and 7 (South Asia), which have seen positive contributions from green finance to environmental sustainability (ES), policymakers should continue to support and enhance green finance initiatives. Strengthening green finance frameworks in these regions will help maintain and potentially amplify these positive outcomes. In contrast, regions 4 (Latin America and Caribbean), 5 (Middle East and North Africa), and 8 (Sub-Saharan Africa) have experienced negative impacts from green finance. For these regions, it is essential to address underlying issues such as institutional weaknesses and inadequate implementation of green finance policies.

Adapting green finance strategies to fit local contexts and improving governance and regulatory frameworks could alleviate these adverse effects. Additionally, since inflation moderates the impact of green finance across various regions, policymakers must consider the economic context when designing and implementing green finance policies. Adjustments may be needed to account for inflationary pressures and their diverse impacts on different regions.

Based on the discussion of the results above, we propose recommendations for different regions to enhance environmental sustainability. Specifically, for regions 1 (European Union and Western Europe), 2 (Eastern Europe and Central Asia), 3 (East Asia and Pacific), 6 (North America), and 7 (South Asia), which have seen positive contributions from green finance to environmental sustainability (ES), policymakers should continue to support and enhance green finance initiatives. Strengthening green finance frameworks in these regions will help maintain and potentially amplify these positive outcomes. In contrast, regions 4 (Latin America and Caribbean), 5 (Middle East and North Africa), and 8 (Sub-Saharan Africa) have experienced negative impacts from green finance. For these regions, it is essential to address underlying issues such as institutional weaknesses and inadequate implementation of green finance policies. Adapting green finance strategies to fit local contexts and improving governance and regulatory frameworks could alleviate these adverse effects. Additionally, since inflation moderates the impact of green finance across various regions, policymakers must consider the economic context when designing and implementing green finance policies. Adjustments may be needed to account for inflationary pressures and their diverse impacts on different regions.

This study has several limitations, including reliance on aggregate data, which may obscure sector-specific dynamics. Future research should leverage more detailed and disaggregated data to better understand the relationships between green finance, inflation, and ES at more granular levels, such as sectoral or firm-specific analyses.

Conclusion

This study provides valuable insights into the relationship between green finance and environmental sustainability across various regions, as well as the moderating role of inflation in this dynamic. The findings indicate that green finance has a generally positive impact on environmental sustainability in regions 1 (European Union and Western Europe), 2 (Eastern Europe and Central Asia), 3 (East Asia and Pacific), 6 (North America), and 7 (South Asia). However, a notable exception exists in regions 4 (Latin America and the Caribbean), 5 (Middle East and North Africa), and 8 (Sub-Saharan Africa), where the relationship is found to be negative.

Additionally, the study confirms that inflation moderates the impact of green finance on environmental sustainability in regions 2 (Eastern Europe and Central Asia), 4 (Latin America and Caribbean), 5 (Middle East and North Africa), 7 (South Asia), and 8 (Sub-Saharan Africa). This suggests that the effectiveness of green finance initiatives is influenced by the prevailing economic conditions, with inflation potentially altering the expected benefits of these initiatives.

Table 7 summary the research's results:

Table 7: Summary of Results

Hypothesis	Reference	Expected Sign	Result
H1: Green finance have a positive impact on environmental sustainability across different regions.	(Zhang et al., 2024; Wei et al., 2024)	+	Support in region 1, 2, 3, 6 and 7 Negative in region 4, 5 and 8
H2: Inflation moderates the impact of green finance on environmental sustainability across different regions.	(Wang et al., 2019; Jia, 2022; Zhao et al., 2024)	Moderate	Support in region 2, 4, 5, 7 and 8

The contrasting results highlight the complexity of the interplay between economic variables and environmental outcomes, emphasizing the need for region-specific

strategies to enhance the effectiveness of green finance. Policymakers should consider the unique economic contexts and challenges faced by each region when developing and implementing green finance initiatives.

The study contributes to the understanding of how green finance can be leveraged to promote environmental sustainability while also acknowledging the critical role that inflation plays in shaping these relationships. Further research is encouraged to explore these dynamics in greater depth, particularly in regions where the impact of green finance appears less beneficial.

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