Green Finance and Sustainable Development: International Evidence

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ABSTRACT: The research investigates the relationship between green finance and sustainable industrialization based on 268 countries from the period 2001- 2024 via statistical regression models. The findings show the positively impact of green finance on sustainable industrialization. Overall, the findings confirm that green finance is a vital tool for promoting sustainable industrialization and supporting long-term sustainable development at the global level by aligning financial resources with environmental objectives. The findings provide valuable guidance for policymakers and financial institutions seeking to advance sustainable industrial development at the global level by supporting more informed policy formulation, stronger regulatory frameworks, and better-targeted investment choices that balance economic growth with environmental sustainability.

KEYWORDS: Green Finance, Sustainable Industrialization, Panel Data Analysis

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Introduction

Today, almost all countries face the problem of protecting the environment while also growing their economies. The development of industries has served to enhance employment, earnings and living conditions in the global society. The expansion, however, largely relies on fossil fuels, the intense utilization of natural resources and old fashioned technologies. This has led to an increase in pollution and global warming has become a significant concern worldwide. This scenario brings up the question of whether industrial development is sustainable in the long-run. According to that green finance refers environment friendly investment and practices which is essential element for sustainable economic development and carbon neutrality(Bhatnagar et al, 2022).

This issue is found in every country even it is developing or non-developing. It is hard to see that many countries cannot grow their industries without polluting the environment. Due to this fact, sustainable industrialization has gained a significant objective in the world. Sustainable industrialization refers to increasing industries in a manner that will not harm the environment but will help in economic development through efficient use of resources. Akhtar

et al., (2022) note that the challenges that hinder the attainment of sustainable industrial growth in countries include poor coordination of economic and environmental policies, poor institutions, and inadequate technology.

The lack of financial resources is also one of the reasons that contribute to this issue. According to the explanation's presented by the Zhang et al., (2025), not all industries have the necessary funds to invest into clean technologies and energy-efficient production methods. Despite the fact that this is a number of countries worldwide are finding it difficult to ensure adequate investment that will result in sustainable industrial growth. This has consequently resulted in the industries still employing the use of polluting techniques and low innovativeness.

In order to address these issues, scholars and policy makers have paid attention to green finance as a potential solution. Green finance is financial aid of environmentally-friendly projects, including clean energy, pollution control, recycling, and green industries (Zhang and Wang, 2021). It features financial products such as green loans, green bonds and environmental investment fund that serve the purpose of channeling money to projects that consume less resources and generate less pollution. Green finance engages to promoting the innovation process and adoption of cleaner technologies.

The significance of green finance plays a crucial role in achieving global development goals. According to the Yadav et al., (2024), green finance represents one of the instruments of achieving the Sustainable development goals (SDGs), in certain, SDG 7 (clean energy), SDG 9 (industry and innovation), and SDG 13 (climate action). These targets emphasize the importance of industrialization that is sustainable to the economy and safeguarding the environment.

Thus, this study will analyze the impact of green finance and sustainable industrialism in countries. The aim of the research to learn about the green financial tools and their role in ensuring that industrial growth is performed in environmentally friendly ways and also to effectively provide guidance to policymakers who desire to attain economic growth without negatively impacting on the environment.

Marouf and Sassi (2025) concluded that the impact of green finance in supporting sustainable industrialization greatly in Asia and South America, but in Africa it is less because of the lack of green infrastructure and institutional ability. These results indicate that it is necessary to have specific financial policies and better governance to ensure that the advantage of green finance in sustainable industrialization are leveraged to the maximum. On the same note, the article by Al-Masri, R., (2025) investigates the effects of green finance, economic complexity, and renewable energy on achieving sustainable development goals using sample 1990 to 2023 in the Asian countries. The green finance has a great benefit in regard to sustainability, as revealed in this study. In addition, Xinyue wang study on the role of green finance in reshaping china industrial landscape. The positive effects are manifested in the study that utilizes data between periods 2008 and 2020 and the empirical test of relationship between green finance and industrial structure was conducted through the use of grey correlation. Nonetheless, the current research by Saqib mehmood proposed to map the economic sustainability by use of green finance and financial developments. The analysis is done by panel quantile regression and robustness analysis using annual data 1998-2022. The results are heterogeneous and mixed.

Literature review

Green Finance

As stated by Marouf and Sassi (2024) green finance serves as a financial mechanism and an investment that contributes to the environmentally sustainable operations and industrial undertakings. It finances clean energy, pollution control, and industrial green transformation thus connecting the financial sector with sustainable development task

Sustainable Industrialization

Sustainable industrialization based on UNIDO SDG 9 concept The mechanism of industrialization leading to innovation, resource efficiency, and environmental sustainability without undermining future productivity.

Theoretical Perspective

Endogenous Growth Theory offers an important basis on both Sustainable Development Theory and Green Finance Theory, in that it applies the environmental consideration, technological technology, and long-term resource management as the key drivers of economic growth instead of the traditional perspective of growth as an exogenous or purely capital-driven process.

Link to Green Finance Theory:

The idea of sustainable finance Theory is the mobilization of funds into environmentally friendly projects and is focused on becoming financially aligned to environmental goals (e.g. renewable energy, energy efficiency, pollution reduction). Green finance relies on the Endogenous Growth Theory by describing how these investments contribute to the economic growth, which is long term and sustainable.

Green Finance and Sustainable Industrialization

Wang (2023) examines how green finance and the evolution of china's regional industrial structure based on the data between 2008 and 2020 and the gray correlation method. The results prove that environmental finance sport a great positive role in stimulating the optimization and modernization of the Chinese industrial system. On the same note, Agyemang (2024) also analyzes the connection between carbon emissions, green finance, and eco-innovation within the same period, 1990-2020 through the lens of a panel data set. The findings shows that green finance is positively associated with eco-innovation as they are related to the reduction of carbon emissions and enhancing environmental performance. Equally, Al-Masri (2025) examines how economic complexity index, sustainable finance and renewable energy affect the promotion of sustainable development in Asian nations between 1990 and 2023. These findings affirm that green finance support greatly to the increase in sustainability and serves a crucial purpose in the supporting of low-carbon growth. In the article, In addition, Xing (2023) also discusses how the impact of green finance on industrial upgrading structures between 2012 and 2020 using TOPSIS, and the findings show that the significance of green finance on optimizing the structure of industries in different regions is positive but heterogeneous. Mehmood (2024) however analyzes the relationship between environmental finance and economic sustainability based on panel quantile regression and robustness analysis between 1998 and 2022 data. According to this study, the effects of sustainable finance on sustainability are heterogeneous and mixed, which suggests that the impact of green finance can be different in the case of different economic settings. Equally, Baştürk (2024) looks at how green finance has affected the carbon emission in 48 countries between 2017 and 2022. They apply the generalized method of moments (GMM) system approach. They have found that there is a major negative association between the issuance of green bonds and carbon emissions. They conclude that every 1 percent growth in the issuance of green bonds can decrease carbon emission by 0.012 percent. The study by Zhang et al. (2021) examines the correlation between government spending and green economic performance in nations contributing in the Belt and Road Initiative (BRI). By utilizing data envelopment analysis and system GMM techniques on panel data over the period of 2008 to 2018, the research reveals that government spending has a profound influence on green economic performance, particularly when allocated towards human capital development and renewable energy initiatives. The authors propose policy recommendations to facilitate the achievement of green development goals in BRI countries, including incentivizing private investment in green infrastructure projects. Although the study's focus on BRI

countries may limit its generalizability to other regions, and the methodologies employed may not fully capture the intricacies of the relationship, the research provides valuable insights and practical implications for policymakers seeking to promote sustainable economic growth. Another study on China discusses the role of eco finance on carbon emissions based on the period from 2005-2019, which shows a negative and nonlinear relationship, with green finance benefit at the subsequent levels of investment. There is equivalent analysis of nonlinear outcomes of green finance on carbon emissions in 20 Asia-Pacific countries between 2000-2023 using panel threshold regression model (Chi and Iqbal, 2025). Their analysis shows that there is a critical investment level of 2.5 percentage of the GDP such that below the critical level, the connection of green finance on reducing emissions becomes insignificant and above the critical level, the result is strongly positive.

Literature Gap

The majority of the past research on green finance and sustainability was oriented predominantly at the developing countries, where the environmental and financial issues are more critical. This literature makes us get to know how green finance aids in sustainable development, however, due to the local nature of their study, they can only be generalized to the country they are conducted and not to the rest of the world with different economic and institutional frameworks. Secondly, numerous researches have examined the role of green investment environmental performance or economic development, but have not placed much emphasis on sustainable industrialization as an independent consequence at the international level. Thus, the world has little evidence on how the idea of green finance can promote sustainable industrialization in various nations around the world.

Hypothesis

H1: green finance has significantly positive effect on sustainable industrialization

Methodology

To investigate the relationship between green finance and sustainable industrialization, this study uses panel data of 268 countries with the period from 2001 to 2024. Focus on a smaller sample of 56 developing countries from the period 2000 to 2021. The current study uses a larger country coverage and a long time period, which allow for a more clear and comprehensive analysis of sustainable industrialization across all countries including both developed and developing economies. After collecting data from different sources we apply quantitative research for analysis of variables. For analysis of variables we use different statistical techniques like descriptive statistics, correlation, OLS, random and fixed effect models.

Measurements of Variables

There are six variables GF (green finance), SI (sustainable industrialization), TO (trade openness), GDP (gross domestic product), FDI (foreign direct investment), ICT (information communication technology). We measure these variables and collecting data from secondary sources.

Operationalization of Variables

Variable	Definitions
Green finance	Green finance signifies to financial investments and activities that support environmentally friendly and sustainable projects, such as renewable energy and green technologies.

Variable	Definitions
Sustainable industrialization	Sustainable industrialization means developing industries in a way that supports economic growth while ensuring long term sustainability and protecting environment.
Trade openness	Trade openness measures a country's level of integration with the global economy and is commonly defined as the ratio of total trade to GDP.
gross domestic product	Gross domestic product represents the total value of goods and services produced within a country and is used as an indicator of economic growth.
Foreign direct investment	Foreign direct investment refers to long-term investment by foreign entities in domestic firms, contributing to capital formation and technology transfer.
Information communication technology	ICT includes digital technologies such as the internet and mobile networks that support communication, innovation, and productivity.

Baseline Equation

This model is for the relationship among green finance and sustainable industrialization and control variables include trade openness, gross domestic product GDP, foreign direct investment FDI and ICT.

$SI = \beta o + \beta 1GF + \beta 2TO + \beta 3GDP + \beta 4\ FDI + \beta 5ICT + \varepsilon$

SI = sustainable industrialization

GF = green finance

TO = trade openness

GDP = gross domestic product

FDI = foreign direct investment

ICT = information communication technology

The aim of this research is to find out the relationship between green finance and sustainable industrialization. Regression analysis will be employed to assess the impact of control variables on SI. The regression coefficient will show the direction and nature of the variables between GF and SI. The study uses data to check whether green finance has a positive or negative impact on sustainable industrialization.

Sample Data

We collect data period from 2001to 2024 in globally countries including developing and non-developing to explore their relationship between green finance and sustainable industrialization.

Data Source

We collected secondary data which are already used by different trusted organization. We collect data from WDI (World Development Indicator) and WGI world governance indicator.

Data Analysis Techniques

We use different data techniques for analysis of variables, but according to our research we use three basic techniques for analyzing the impact within green finance and sustainable industrialization GF and SI. Here we are used different three techniques for analysis of variables which are descriptive statistics, correlation and regression analysis (OLS, fixed and random effect) after applying these techniques, we examine that there is a positively significant relationship between green finance and sustainable industrialization with other control variables.

Data Analysis

Descriptive Analysis

Interpretation

The summary statistics are reported in table 1. The mean value of SI is 0.27 having ranges of 0.000 to 0.609766 and standard deviation of 0.087877 in all the developing and non-developing countries this mean value are generally similar in most countries. The mean value of Green finance is 15.37 having range 0.00 to 23.995 and standard deviation is 6.2553 this shows that green finance is much more developed in some countries, while many countries still have very limited green financial resources. This trend is similarly to Jawadi et al., (2025), who also found differences in green finance across different region. The average value of top is 4.35 with range 1.643 to 6.761 and SD is 0.4690 and doesn't vary much across countries. Richer and faster-growing countries have more resources to invest in social and green development, which is also highlighted in Jawadi et al., (2025). Foreign direct investment has a high average value of 20.62 with the range of 0.000 to 28.7656 and SD is 5.5435. Finally, ICT has an average value of 3.24 with the range of 0.000 to 4.6,51 with clear differences across countries. This finding is uniform with Jawadi et al. (2025), who emphasized the importance of ICT for sustainable and industrial development.

Figure 1

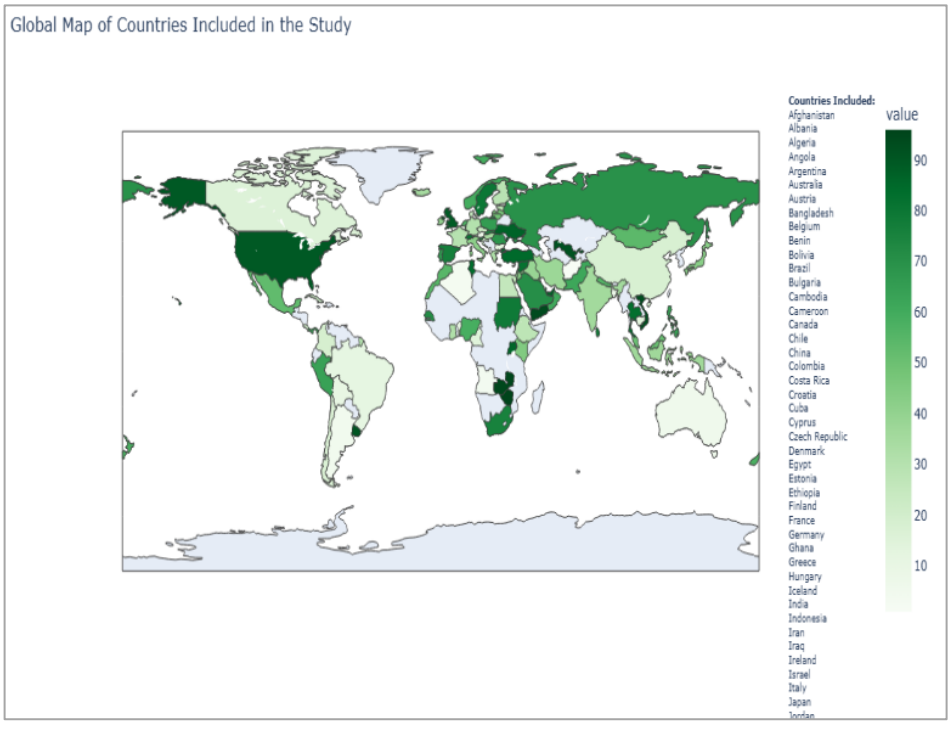


Table 1

Descriptive Statistics

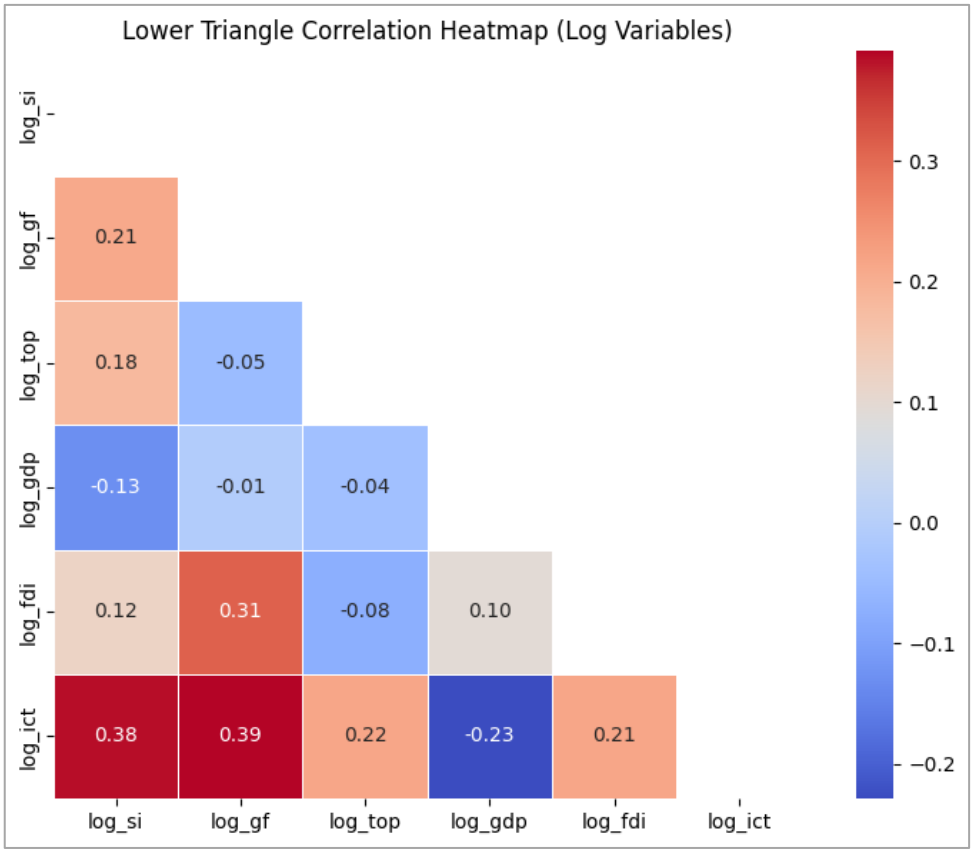
	N	Mean	Std. Dev.	Min	Median	Max
log_si	6432.0	0.269696	0.087877	0.000000	0.273773	0.609766
log_gf	6432.0	15.365682	6.255348	0.000000	17.926302	23.995287
log_top	6432.0	4.349735	0.469073	1.634628	4.379964	6.761799
log_gdp	6432.0	1.337990	0.756512	0.000000	1.492568	4.523277
log_fdi	6432.0	20.622906	5.543596	0.000000	21.348720	28.765644
log_ict	6432.0	3.242157	1.174291	0.000000	3.592871	4.615121

Correlation

Interpretation

Figure shows the correlation matrix within the study variables. The findings reveal that sustainable industrialization has a low positive correlation with green finance with a correlation coefficient of 0.21 and trade openness is 0.18, showing that countries with higher levels of green finance and greater openness to trade tend to experience slightly better sustainable industrialization. Sustainable industrialization is negatively correlated with GDP having value is -0.13 suggesting that higher income levels do not necessarily guarantee sustainable industrial development. In contrast, sustainable industrialization shows a moderate positive correlation with information and communication technology. Green finance has a moderate positive association with foreign direct investment and ICT which is 0.31 and 0.39, indicating that countries with stronger digital development and higher FDI inflows tend to have more developed green finance systems, while its relationship with GDP and trade openness remains weak. Trade openness shows a weak positive correlation with ICT and weak negative correlations with GDP and FDI. Economic growth is negatively correlated with ICT, while FDI shows a weak positive relationship with both GDP and ICT.

Figure 2



Regression Analysis

Interpretation

Table 3 provides the results of OLS, fixed effects and random effects regression analysis of the effect of various factors on sustainable industrialization (SI). The outcomes reveal that green finance (GF) has positive regression coefficient in all the three models. The factor of the green finance in OLS is 0.001 meaning that an increase in the magnitude of green finance by one unit will result in a one-unit increase in sustainable industrialization. However, the relationship becomes statistically insignificant when the model is fixed effects and random effects, showing that the influence of green finance is weak when the effect is controlled by country-specific effects. On the control variables,

foreign direct investment (FDI) has a beneficial and significant impact on sustainable industrialization in all of the models. It means that increased FDI inflows are associated with sustainable industrialization. The negative and significant effect of (GDP) is realized in the OLS model and the coefficient changes to positive and significant in the fixed and random effects models. The coefficient of (ICT) is supportive and highly significant in all the three models. This implies that sustainable industrialization is highly encouraged by innovations in ICT. Equally, trade openness (TOP) is a statistically significant and positive variable that affects sustainable industrialization in all the models indicating that more open economies are more likely to realize high rates of sustainable industrialization. In general, the findings show that FDI, ICT and trade openness are major factors responsible in sustainable industrialization and that the green finance has a favorable influence but not strong in all specifications. The ability of the results to be consistent across OLS and the fixed effects and random effects models helps in enhancing reliability of the results.

Table 3

Regression Analysis Regression Results: OLS, Fixed Effects and Random Effects

	Dependent variable: log_si		
	OLS	Fixed Effects	Random Effects
	(1)	(2)	(3)
Const	0.073***	0.206***	0.203***
	(0.011)	(0.007)	(0.008)
log_fdi	0.001***	0.0002**	0.000**
	(0.000)	(0.000)	(0.000)
log_gdp	-0.007***	0.001**	0.001**
	(0.001)	(0.000)	(0.000)
log_gf	0.001***	0.000	0.000
	(0.000)	(0.000)	(0.000)
log_ict	0.023***	0.005***	0.005***
	(0.001)	(0.000)	(0.000)
log_top	0.023***	0.010***	0.010***
	(0.002)	(0.001)	(0.001)
Observations	6432	6432	6432
N. of groups		268	268
R^2	0.170	0.068	0.068
Adjusted R^2	0.169		
Residual Std. Error	0.080 (df=6426)	0.004 (df=6159)	0.004 (df=6426)
F Statistic	262.671*** (df=5; 6426)	90.202*** (df=273; 6159)	93.872*** (df=6; 6426)
Note:	*p<0.1; **p<0.05; ***p<0.01		

Conclusion

The primary focus of the research is to examine the link within green finance and sustainable industrialization across nations within the period from 2001 to 2024. The paper also discusses the question of whether green financial systems development contributes to sustainable industrial development by facilitating the green industrial activities. It also examines the effects of the chosen control variables to sustainable industrialization such as foreign direct investment, gross domestic product, trade openness and information communication technology. Besides, the analysis presents the outcome of the global data to examine whether the correlation between green finance and sustainable industrialization the outcome demonstrates that the green finance is a significant factor in promoting environmentally-friendly industrial practices and long-term sustainable development at the international level.

The outcome of the research show that the consequences of green finance on sustainable industrialization is positive and significant in countries. It implies that the more the countries are green-financed, the more climate friendly and sustainable the industrial development of the countries. The outcomes show that sustainable finance enhance to the industry adopting cleaner technologies, lowering pollution of the environment, and enhancing efficiency of resources without halting economic growth. Another conclusion of the analysis is that the success of green finance varies depending on financial systems and institutional capacity of different countries. Nations that have stronger financial and regulatory systems enjoy the advantages of green finance more than countries with less developed green financial systems. In general, the outcome reveals that green finance is a significant instrument of sustainable industrialization and attaining a long-term sustainable development on the international level.

The results of this paper suggest that green finance may be a viable instrument of sustainable industrialization in all nations. Governments need to come up with favorable green financial policies and enhance regulation systems to promote investment in clean and green industrial operations. Another significant stakeholder is financial institutions that increase eco-friendly investment products including green bonds and green loans to encourage sustainable industries. In the case of industries, green finance can also be adopted to minimize environmental harm and promote growth and competitiveness in the long term. In general, the research points out that the enhancement of green finance systems may assist in addressing the sustainable development because of the association among economic growth and ecological protection at the global scale.

The first limitation of this study is that, analysis is done using secondary data, which might not be able to give full aspects of green finance and sustainable industrialization between diverse countries. Second, the research is based on available indicators of green finance, which do not represent all types of green financial activities in all countries. Though the research concentrates on the global nations, it does not investigate country based or industry based but rather it should have taken a closer look at the effect of the green finance on the sustainable industrialization.

The current study can be developed further in the future in a number of ways. To begin with, the future research can undertake sector-level research to examine the impact of green finance on sustainable industrialization in certain industries. Second, country-specific data will help researchers gain a better insight into how the national policy, institutional quality, and financial system can be employed to determine the effectiveness of green finance. Third, the further researches can introduce more variables, including the aspects of innovation, the use of renewable energy, and the environmental laws, to present a more detailed analysis. Lastly, comparative analysis of the developed and developing nations would possibly give more information about how the contribution of green finance towards advocacy of sustainable industrialization vary in various economic situations.

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