Green Finance and Sustainable Development: Exploring Dynamic Causal Links and Global Implications

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Abstract. This research investigates the potential causal relationship among sustainable development and green finance on a world level, using data from 2011 to 2023. In this study, the researcher utilized the bootstrap rolling-window Granger causal relationship test to investigate the contributions of different stakeholders to sustainable development by participating in green finance initiatives. The results of the analysis demonstrate that green finance has a positive impact on sustainable development across different time periods. While green finance represents a crucial financing mechanism for advancing sustainable development goals, its direct influence on SD remains unproven. Additionally, this analysis identifies distinct causal relationships in different sub periods, emphasizing the importance of context-specific causality. Moreover, in specific contexts, the direction of causality holds significant implications. Therefore, we propose that governments and international organizations play a pivotal role in guiding high-quality green investments and implementing risk mitigation strategies within the established system framework. Furthermore, enhancing the standards for categorizing green finance, developing comprehensive evaluation systems, and promoting transparent information disclosure related to GF can foster greater contributions by countries to sustainable development initiatives.

1 Introduction

Social and environmental problems have resulted from the pursuit of economic expansion and industrial development [3]. The climate and environment face growing challenges as a result of the depletion of natural resources and the release of harmful emissions from industrial operations [24]. Extreme weather events and the disappearance of biodiversity are some of the key changes brought about by rising temperatures in environmental systems and human life [7]. Sustainable development, as articulated by the WCED, aims to fulfil current needs without compromising the capacity of future generations to fulfil their own [4].

This necessitates addressing negative externalities associated with energy use and fostering energy sustainability [12]. The progress toward these goals has been slower than anticipated. To achieve the SDGs, substantial investments, estimated at $5 to 7 trillion annually, are required from all sectors of society [10]. The Paris Agreement emphasizes the need for persistent financing and significant global investments. In this context, green finance, championed by China, has gained widespread attention as a potent tool to address environmental concerns while promoting sustainable development [42]. Government action required to protect environment by investing in green finance projects [33].

The Significance of Green Finance

Green finance has garnered global recognition for several key reasons. Firstly, it aligns with the imperative of sustainable development, becoming a central focus in international financial circles. Eco-financed products adoption on "One Planet Summit" in Paris in 2017, supported by global central banks and financial industry leaders, exemplifies its growing prominence. The Green Climate Fund's commitment to supporting green projects that can reduce global greenhouse gas emissions by 1.4 billion tonnes underscores its pivotal role in financing sustainability initiatives. Secondly, green finance prioritizes the societal benefits derived from a healthier environment. It places a strong emphasis on how economic activity and ecological wellbeing can coexist peacefully, ultimately promoting long-term development in society. The "green" component of green finance is demonstrated by the distribution of social capital to a variety of industries, including corporate governance, renewable energy, green building, climate resilience, and environmental preservation [33,41]. Thirdly, there are now a variety of green financial products. They encompass green bonds, green investments, green insurance, carbon finance, and anticipate the emergence of new products. Green bonds, well-known for their risk reduction features and attractiveness to socially conscious investors, have become increasingly important in the realm of climate change and strategies for financing sustainable development. [8,32].
Despite recognized potential of green finance in advancing sustainable development, clear evidence of its global efficacy remains elusive. This study undertakes empirical analysis to explore the intricate connection among green finance as well as sustainable development, providing policy-level insights to further the SD agenda. It is widely acknowledged that Green finance plays a crucial role in advancing sustainable development because of its unique attributes.

Global Attention: Green finance has garnered global attention and support. For instance, global central banks and financial institutions endorsed eco-financed products at the "One Planet Summit" in Paris, emphasizing its significance in combating climate change. Global central banks and key players in the financial industry worldwide have wholeheartedly embraced the adoption of eco-financed products. They are championing the cause of green projects aimed at reducing global greenhouse gas emissions by an impressive 1.5 billion tonnes. Playing a pivotal role in financing these vital green initiatives is the Green Climate Fund.

In a significant commitment, the Spanish government pledged in November 2021 to increase its contribution to the Green Climate Fund by 60%. This boost in funding is intended to provide essential support to underdeveloped nations in their efforts to combat the challenges posed by climate change. Green finance lays a lot of emphasis on enhancing society's quality of life. It aims for the harmonious cohabitation of economic activity and ecological wellbeing, ultimately promoting long-term societal progress. A vast array of financial instruments is included in the category of "green finance," such as carbon finance, green bonds, green investments, and green insurance. The efficient distribution of funds to initiatives aimed at mitigating and adapting to climate change is made possible by this diversity.

This article comprehensively assesses the dynamic causality among green finance as well as sustainable development from 2011 to 2023 using a subsample rolling window test. The empirical findings show that these two variables are related causally in particular sub periods, highlighting the significance of creating a complete green financial system to promote sustainable development. It thoroughly examines the manner in which green finance affects sustainable development on a worldwide basis, illuminating the challenges encountered during this process. It examines the two-way causal relationship between green financing and sustainable development, revealing that green finance positively impact sustainable development, the reverse relationship yields mixed results in different timeframes. By examining the various effects of various entities on sustainable development through green financing, it offers policy recommendations. To efficiently direct green money, governments can implement laws pertaining to industry, finance, environmental protection, and other high-level plans.

This study emphasizes the value of programmatic papers, information disclosure requirements, classification schemes, and green finance product innovation in promoting sustainable development. This work fills a significant research vacuum by using the bootstrap rolling-window causal association test to take into account any potential time-varying aspects of the causal relationship among green finance as well as sustainable development.

In conclusion, green finance represents a critical component in the pursuit of sustainable development in an era marked by climate change, environmental degradation, and financial crises. Understanding the multifaceted dynamics of its relationship with sustainable development is essential for guiding policy decisions and fostering a sustainable future for all.

This research is organised as follows: Part 2 reviews the literature; Part 3 delves into the idea of the relationship between sustainability and green finance; Part 4 describes the technique, covering data sources, parameter stability, and subsample rolling window tests; and concludes with a descriptive analysis. Part 5 discusses the empirical results, and Part 6 offers policy implications to advance the Sustainable Development Goals.

2 Materials and Methods

Several studies have undertaken the exploration of how sustainable development influences green finance (GF). The findings from this body of research shed light on the dynamic interplay between these two crucial elements of global sustainability:

According to [39], the role of GF is amplified by a variety of government ecological regulatory laws, corporate green initiatives, and improved supervision. This emphasizes how crucially important corporate behaviour and governmental rules have been in forming the landscape of green financing.

[29] discern the significant influence of environment as well as social responsibility in fostering and sustaining the green bond market. Their findings emphasize the importance of ethical and social considerations in driving green finance initiatives. [27] underscore the integration of ESG (Environmental, Social, and Governance) factors in the realm of sustainable development, serving as catalysts for the expansion of environmentally sustainable financial initiatives. This demonstrates the convergence of sustainability principles with financial decision-making. [23] provide evidence of the increasing demand for green bonds driven by ESG considerations, which, in turn, bolster investor confidence. This highlights the pivotal role of governance, social and environmental factors in shaping investor preferences. ESG factors are given more weight in investors’ decision-making processes, as shown by [5], which has an impact on the issuing of green bonds. This highlights the growing importance of ethical and sustainable criteria in investment decisions. [17] argue that clean energy rising demand acts as a significant driver for increased investment in green finance. This emphasizes the close connection between sustainable development goals, particularly in the realm of clean energy, and the growth of green finance. [40] provide empirical evidence suggesting that green finance benefits from environmental regulations, fostering external financing in both the short and long term. This underscores the regulatory framework's role in promoting
green finance as an essential component of sustainable development strategies. Collectively, these studies illustrate the multifaceted ways in which sustainable development principles, encompassing ecological, social, and governance considerations, influence and shape the landscape of green finance. Numerous researches have underscored the pivotal role of green bonds in financing and advancing the global Sustainable Development Goals (SDGs). These studies collectively emphasize the profound impact of green bonds on environmental sustainability and their significance as a financial instrument in addressing critical global challenges:

[8] provide evidence that a substantial portion of current environmental investments can be financed for the benefit of future generations, with green bonds emerging as a potent financial tool to combat climate-related issues. Their findings underscore the long-term sustainability of green bond investments. According to [25], green bond trades have produced favourable environmental externalities that are consistent with the goals of putting renewable energy plans into practise. This demonstrates how green bonds have beneficial environmental benefits that go beyond their main purpose of funding. [28] highlight the interdependence of the clean energy and green bond markets by establishing a significant causal relationship between returns on the Wilder Hill Clean Energy Index and bond prices. This link emphasises how important green bonds are to investments in sustainable energy.

According to [1] the rising environmental consciousness among investors is spurring heightened investments in green bonds. This trend, they suggest, provides borrowers with access to financing at lower costs, incentivizing sustainable projects.

[18,19] emphasize the utilization of green bonds for environmental projects and recognize them as instrumental innovations in the field of green finance over the past decade. These studies underline the role of green bonds in channelling capital toward environmentally beneficial initiatives.

As per [11], sovereign green bonds represent an efficient approach to addressing environmental crises and mitigating issues related to ecosystem securitization. This emphasises how important green bonds are in solving urgent environmental issues.

[32] observe that, in tandem with the growing issuance of green bonds, there is growing apprehension about the viability of green bonds as a funding mechanism for environmental enhancements. Their findings reflect the growing interest in green bonds as an avenue for environmental financing.

[20] said that, green bonds, loans, and other financial instruments are useful for allocating cash to programs that address environmental issues and the climate catastrophe. This highlights the function of green bonds in aiding sustainability and climate change activities.

[15] illuminate the potential spill over effects of excessive volatility in the clean energy market on the market of green bond. Their research underscores the interconnectivity of these markets and the importance of monitoring their dynamics. While previous studies have predominantly explored causal connection in one direction, from green finance to sustainable development, this research highlights the need to consider the reciprocal relationship between these two domains. Factors such as risk reduction, increased green productivity, and reduced carbon emissions resulting from green finance can ultimately impact sustainable development. Although numerous researches have indicated that green money has a favourable impact on sustainable development, there remains debate on the environmental benefits, emphasizing the importance of continued investigation [29]. Moreover, this study recognizes the influence of ecological regulation, ESG factors, and clean energy needs on green finance, contributing to a more comprehensive understanding of the interconnectedness of these variables. Importantly, it introduces a robust empirical methodology, employing the bootstrap subsample rolling-window causation test, to capture time-varying causal links and structural breaks in the relationship between green finance and sustainability. This approach enables a more nuanced exploration of the factors influencing green finance and the reciprocal influence of sustainable development on green finance. Ultimately, it provides valuable insights for investors, policymakers, and climate action initiatives, helping market participants make informed decisions in pursuit of sustainability goals.

3. The theoretical framework

The theoretical framework of this study revolves around the symbiotic relationship between green finance and sustainability, examining how various market players and factors influence this relationship and contribute to sustainable development. Key perspectives include government, financial institutions, firms, and consumers, each playing a distinctive role in promoting green finance and its impact on sustainability.

Government Perspective:

Governments are recognized as pivotal drivers in promoting green finance. They stimulate green production by employing publicity campaigns and providing incentives and financial support for green finance endeavours [21]. Their actions have far-reaching consequences, impacting economic growth, employment rates, and resource allocation. Government policies and fiscal measures shape corporate investment decisions, influencing the direction of enterprises towards sustainability. The level of fiscal certainty and energy-related policies can significantly affect the innovation investments of enterprises in sectors like renewable energy [38]. Moreover, price-based policies such as gasoline taxes, when implemented effectively, can incentivize pollution reduction [12]. Conversely, inactive disincentives like taxes and levies that are placed on conventional manufacturing firms can spur industrial transformation and support ecological and social sustainability.

Financial Institutions Perspective:

Financial institutions serve as essential intermediaries facilitating green production by providing green financial services. Their engagement in offering such services not only yields direct benefits (e.g., fees from innovative products and
intermediation fees) but also indirect benefits (e.g., increased market share, enhanced competitiveness, and improved social visibility) [25]. While providing green financial services may entail increased credit risk ratios and costs, policies designed to promote green projects provide a protective framework for financial institutions, reinforcing their commitment to green financial services.

Firms Perspective:
Businesses play a key role in the shift to sustainable development and green production. Their investing choices are heavily influenced by green finance, which promotes the development of initiatives that have positive environmental effects including green energy and climate improvement. When determining whether to choose green manufacturing, businesses take into account a wide range of issues, such as financial repercussions, government laws, and the cost of executing green projects [9]. In instances where traditional production methods result in pollution compensation costs to consumers, firms are more inclined to choose green production as the economically viable option [14]. Green production entails additional costs, including technological innovation, equipment upgrades, and financial investments, but it also brings intermediate benefits such as future prospects and societal recognition. When enterprises manage to reduce the overall costs associated with green production, they strike a balance between economic prosperity and environmental sustainability.

Consumers Perspective:
Consumers’ choices and preferences are integral to the success of green finance as well as sustainable development. The increasing prevalence of sustainable consumption concepts and heightened awareness of eco-friendly products have led consumers to opt for green consumption [6]. Consumer choices are influenced by the utility they derive from green products [42]. When green products offer superior utility and align with consumers' values, they are more likely to be selected. In cases where consumers lean towards green products but firms continue to rely on non-green production methods, consumers may demand pollution compensation. This compensation represents a portion of the income diverted from non-green production. Consequently, consumers may gravitate towards green consumer goods, accelerating the transformation of enterprises towards sustainability and ultimately achieving a harmonious balance between economic interests and environmental well-being.

In sum, this theoretical framework elucidates the multi-faceted interactions and interdependencies among government policies, financial institutions, enterprises, and consumer choices, all contributing to the advancement of green finance and sustainable development. It underscores the importance of aligning these perspectives to foster a more sustainable and ecologically responsible economic landscape. Current study is based upon secondary data. Using a subsample rolling window test, current study evaluates the dynamic causation between green funding and sustainable development spanning the years 2011 to 2023.  In 2011, the global Sustainable Development Conference centred its theme on the concept of the green economy within the framework of sustainable development. This pivotal event marked the beginning of a concerted effort by policymakers in various countries to explore the potential of financial tools in driving economic growth while simultaneously promoting sustainability objectives. Subsequently, green finance emerged as a rapidly evolving field, accompanied by the gradual maturation of green finance policy frameworks.

Over time, internationally recognized standards for green finance, particularly in the realm of bonds, have taken shape. One notable example is the Climate Bonds Standard introduced by the Climate Bonds Initiative in 2011. These standards provided a structured and widely accepted framework for assessing the environmental impact and sustainability credentials of financial instruments. Following the pivotal year of 2012, there was a remarkable surge in both publications and citations related to green finance, indicative of the growing academic interest and attention bestowed upon this field [37]. "Scholarly research, as exemplified by the works of [18, 29] and [22], began to represent the concepts of green finance and social sustainability through specific indices. Notably, (GBI) Global Green Bond Index represented green finance, while the Environmental, Social, and Governance Index (ESGI) represented social sustainability. These indices were sourced from the S&P Dow Jones Indices website and were transformed by taking the natural logarithms to mitigate latent non stationarity. In addition to these key indices, several control variables were incorporated into research endeavours. These variables included the Crude Oil Price (COP), the World Uncertainty Index (WDI), and the US Equity Market Volatility Index (EMV). These variables, drawn from studies such as [31, 35], were carefully selected due to their significant relevance to sustainable development and their potential impact on the dynamics of green finance. This period of burgeoning interest and evolving standards marked a critical juncture in the development of green finance as a driving force behind sustainable development. It highlighted the growing recognition of the potential of financial tools in shaping a more sustainable and ecologically responsible global economy".

3 Results and Discussion

Time series stability is a fundamental requirement when employing the traditional Granger causality test. When the prerequisites for this test are not met, the time series data is likely to deviate from the expected asymptotic distribution. This deviation can limit the accuracy of estimating the vector autoregression (VAR) model, as suggested by Toda and Phillips in their work from 1993 and 1994. [28] have presented an alternative approach using a residual-based bootstrap (RB) technique to enhance the statistical power and significance levels of critical values in such situations.

In the context of the current rolling-window causality test, additional control variables have been introduced. These variables include the price of crude oil (COP), the world uncertainty index (WDI), and the US equity market volatility index (EMV).

Table.1 Descriptive statistics
Table 1 presents the results of descriptive statistics. The average values of ESGI, GBI, COP, WDI, and EMV indicate that these sequences exhibit distinct clustering around the levels of 152.79, 137.19, 71.79, 26,679.55, and 20.49, respectively. Furthermore, the skewness values of ESGI, GBI, COP, WDI, and EMV are notably right-skewed, with values of 142.49, 134.35, 65.47, 23,989.49, and 16.89, respectively. This right-skewness suggests that these variables have a longer right tail in their distributions. Additionally, the kurtosis parameter values of ESGI, GBI, WDI, and EMV exceed 3, indicating leptokurtic distributions characterized by heavier tails and more outliers. However, the kurtosis of COP is 1.989, implying a platykurtic distribution with thinner tails compared to the others. Furthermore, the Jarque–Bera statistic confirmed that these variables significantly deviate from normal distribution assumptions at the 1% level, further highlighting the non-normal distribution of these variables.

Table 2 Unit root test

<table>
<thead>
<tr>
<th></th>
<th>LM unit root test</th>
<th>ZA unit root test</th>
<th>Fourier unit root test</th>
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<tbody>
<tr>
<td>GBI</td>
<td>-5.38</td>
<td>-3.89</td>
<td>-34.98</td>
</tr>
<tr>
<td>ESGI</td>
<td>-4.78</td>
<td>-2.78</td>
<td>-57.98</td>
</tr>
</tbody>
</table>

Table 3 Grange causality Test

<table>
<thead>
<tr>
<th></th>
<th>Statistics</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESGI does not Granger cause GBI</td>
<td>0.500</td>
<td>0.489</td>
</tr>
<tr>
<td>GBI does not Granger cause ESGI</td>
<td>5.018</td>
<td>0.33</td>
</tr>
</tbody>
</table>

Table 4 Parameter stability test

<table>
<thead>
<tr>
<th>Test</th>
<th>ESGI</th>
<th>GBI</th>
<th>VAR</th>
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<tbody>
<tr>
<td></td>
<td>Statistics</td>
<td>P-Value</td>
<td>Statistics</td>
</tr>
<tr>
<td>Sup-F</td>
<td>14.89</td>
<td>0.027</td>
<td>54.89</td>
</tr>
<tr>
<td>Ave-F</td>
<td>3.02</td>
<td>0.589</td>
<td>23.37</td>
</tr>
<tr>
<td>Exp-F</td>
<td>3.899</td>
<td>0.071</td>
<td>23.89</td>
</tr>
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Table 2 provides the outcomes of unit root tests, demonstrating that ESGI was statistically significant at the 5% level in the ZA unit root test, whereas all other variables exhibited significance at the 1% level. This implies that both GBI and ESGI are stationary at level 1 (0).
To investigate the causal relationship between ESGI and GBI, a bivariate VAR model was constructed using these variables for the entire dataset. The optimal lag period, determined by the Schwarz Information Criterion (SIC), was found to be 1. The results of this analysis, presented in Table 3, indicate that GBI Granger causes ESGI, but the reverse causality is not observed. It is worth noting that traditional Granger causality tests assume parameter stability and can only capture a single causal link within the entire sample period. However, when there are structural breaks, both internal and external, parameters may not remain stable. As a result, the causation among ESGI and GBI may change over time, as discussed by [2].

To account for this time-varying causation, the study employed the Sup-F test, assuming that parameters do not change abruptly, as well as the Ave-F and Exp-F tests, which assume that parameters evolve gradually over time. The results, as presented in Table 4, suggest that the hypothesis of unchanged parameters was not robust, except for the Ave-F test for ESGI. This implies that the traditional full-sample Granger causation test using bootstrap methods may not be practically applicable.

To address this issue, the study utilized the bootstrap subsample rolling-window causation test to investigate the time-varying causation connection GBI and ESGI. In conclusion, the standard causality test captures a single linear causal link between ESGI and GBI, which is not entirely realistic and leads to incorrect conclusions. Additionally, the Sup-F, Ave-F, and Exp-F tests demonstrate that the parameters in the VAR system are unstable. Therefore, in order to identify the time-varying mutual causal relationship between ESGI and GBI, we employed the bootstrap subsample rolling-window causality test in our study. This study comes to the novel result that, over specific time periods, ESGI and GBI were found to be oscillating in the same direction, illustrating the positive impacts of green finance (GF) on the societal environment and the sustainability of regulatory measures. The findings were corroborated by the interaction theory between green finance and sustainability, suggesting that GBI had some influence. On the other hand, this study's findings regarding the causal connection among environmental society as well as green finance regulation are inconsistent. For a brief period, ESGI will have a positive impact on GBI, demonstrating the reputational and risk-reduction benefits of ESG performance. This viewpoint is no longer relevant in other contexts, primarily due to the way that early ESG adoption impacts different kinds of risks, inadequate standardisation as well as transparency, and the slowness of changes in policy. Consequently, the influence on green bonds diverges due to the maturity of ESG during the implementation process.

4 Conclusion

In conclusion, the dynamic causal connections among green financing (GF) and sustainability were explored using a bootstrap rolling window test. The analysis of parameter stability revealed that the relationship between GBI and ESGI is not consistently stable in the short term, accounting for structural changes throughout the entire time series.

To establish that GBI affects ESGI in specific time periods, the study employed the subsample rolling-window causation method, aligning with the theoretical framework. Additionally, it was observed that ESGI has both positive and negative effects on GBI. The positive impact signifies how the pursuit of sustainability by many nations has spurred the development of new financial instruments. Conversely, the negative influence suggests that promoting sustainability does not always guarantee the growth of the green finance market.

This study centres on comprehending the individual behaviours of diverse stakeholders that impact the connection between green finance (GF) and sustainable development (SD). The objective is to offer governments valuable insights for leveraging green finance to promote sustainable development. Understanding the mechanisms by which ESGI and GBI interact holds significant policy implications. To ensure the attainment of sustainable development objectives, governments can establish effective monitoring mechanisms, which can reduce perceived risks and enhance expected rewards, thereby incentivizing private investments in sustainable development with trustworthy and transparent regulations.

Furthermore, a thorough evaluation of the effects of GF can help determine its contribution to sustainability and climate goals, offering investors policy incentives and direction for climate action. It is essential to enhance the efficiency of green finance projects, and international environmental and climate authorities should reinforce requirements related to information disclosure. To bolster investor, trust in the financial market, comprehensive market data and accurate, appropriate indicators are crucial.

Establishing a business-conducive atmosphere, supported by a strong economic framework encompassing a well-organized tax system, transparent trade policies, and steady exchange rates, is essential for drawing in top-tier domestic and international investors. A robust flow of market information and transparent, rational indicators are indispensable for enhancing investor trust in the financial market."

However, this study has some limitations and suggests potential avenues for future research. Firstly, due to methodological constraints and incomplete data across regions, the study could not provide a country-specific analysis or targeted implementation strategies. It is advised that distinct research be carried out in various sorts of nations to investigate the formation of "GF systems within their particular contexts. Additionally, this study mostly ignored social issues in favour of environmental ones. Future research should consider incorporating social event factors into the analysis.
5. References


