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Green Finance Mechanisms for Sustainable Development: Evidence from Panel Data

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Abstract: The nexus between environmental degradation, green finance, and sustainable development has been analyzed in a number of studies. Despite attempts by different studies to fill the gap in the existing literature, they have all failed to do so. This study further extends the existing literature by applying robust techniques such as the system-GMM method and applying various proxies to measure green finance, which other studies have failed to examine. For this purpose, we employ panel data for the period of 1985–2021. Our findings support our hypothesis: while green funding tends to have a positive effect on sustainable development, environmental degradation has exactly the opposite effect. These findings are supported by a wide range of statistical methods, including the system-GMM technique. Our work underlines the major contribution bound to be made by green resources toward legislative frameworks in an attempt to aid the effort of reducing the negative impact of environmental degradation and building a sustainable development path.

Keywords: green finance; environmental degradation; sustainable development; panel data

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1. Introduction

The increasing concern over climate change, environmental degradation, and the depletion of natural resources has brought sustainable development to the forefront of global policy discussions. Sustainable development, as defined by the United Nations, refers to the ability to meet the needs of the present without compromising the ability of future generations to meet their own needs [1]. The global transition towards sustainability requires the alignment of economic, social, and environmental goals, which has led to the rise of green finance as a pivotal mechanism in achieving these objectives. Green finance, which refers to financial investments that support environmental sustainability and a reduction in environmental risks, is an essential tool for ensuring that capital is directed towards initiatives that foster sustainable development [2]. However, the relationship between green finance, environmental degradation, and sustainable development remains a complex and under-explored area, particularly in developing economies such as the E7 countries.

The E7 countries—comprising Brazil, China, India, Indonesia, Mexico, Russia, and Turkey—play a crucial role in the global environmental landscape. These emerging economies are characterized by rapid industrial growth, which, while driving significant economic development, also leads to higher levels of environmental degradation [3]. At the same time, these countries are increasingly recognizing the importance of green finance in transitioning to a low-carbon economy and mitigating the adverse effects of their rapid growth. Despite the increasing implementation of green finance instruments, including green bonds, green loans, and other sustainable investment products, the effectiveness of these mechanisms in balancing economic growth with environmental sustainability

in E7 countries is still a subject of ongoing debate [4]. This study aims to fill this gap by providing a comprehensive analysis of how green finance mechanisms interact with environmental degradation to influence sustainable development, focusing explicitly on the E7 nations.

The existing literature on sustainable development has extensively explored the individual components of environmental degradation, economic growth, and green finance, but few studies have integrated these elements to examine their combined effects on sustainability. For instance, research has shown that green finance plays a significant role in driving renewable energy investments, reducing carbon emissions, and fostering corporate social responsibility. However, the interaction between green finance and environmental degradation in emerging economies remains understudied, particularly with regard to the mechanisms through which green finance can mitigate the environmental impact of industrialization and rapid economic growth. By analyzing this interaction in the context of the E7 economies, this study seeks to provide a more comprehensive understanding of the dynamics at play in achieving sustainable development.

The existing literature has made significant progress in examining the relationship between green finance, environmental degradation, and sustainable development. However, past studies have often focused on isolated aspects such as the impact of green finance on renewable energy investments or the role of environmental regulations in mitigating carbon emissions, without considering the combined effect of these variables on sustainability [4]. Additionally, much of the prior research has concentrated on developed economies, overlooking the unique dynamics present in emerging markets like the E7 countries, where economic growth and environmental degradation are tightly intertwined [3]. Moreover, few studies have employed comprehensive proxies for green finance, limiting understanding of its full impact on sustainable development. This study aims to address these gaps by providing a holistic analysis that integrates multiple facets of green finance and environmental degradation in the context of emerging economies.

This study draws on key insights from recent works on optimizing energy hubs and sustainable development. Zhong et al. [5] propose a low-carbon operation model for energy hubs, integrating distributionally robust optimization (DRO) with a Stackelberg game approach to address uncertainties in renewable generation and improve the solution efficiency of energy hubs. Meanwhile, Hariram et al. [6] introduce the socio-economic theory of sustainalism, offering a holistic framework for the achievement of sustainable development by prioritizing quality of life, social equity, and environmental well-being. These approaches provide valuable contributions to the growing discourse on sustainability and energy optimization.

This study makes five key contributions to the existing literature on sustainable development. Firstly, it adopts a holistic approach by combining the effects of green finance and environmental degradation on sustainable development. This is particularly relevant as most existing studies tend to focus on one of these aspects, either green finance or environmental degradation, without considering their joint impact. By examining these two factors together, this research provides a more nuanced understanding of how they interact to shape sustainability outcomes in emerging economies.

Secondly, this study focuses specifically on the E7 countries, which are among the largest contributors to global greenhouse gas emissions and have a critical role to play in addressing global environmental challenges. Despite their environmental and economic significance, the E7 countries have not been adequately explored in the context of green finance and sustainable development, as much of the existing literature focuses on developed countries or global aggregates. By focusing on these key players, this study offers valuable insights into how emerging economies can balance economic growth with environmental sustainability through green finance initiatives.

Thirdly, this study employs robust econometric techniques, specifically the system generalized method of moments (GMM) with panel fixed effects. This approach addresses potential issues of endogeneity and unobserved heterogeneity, ensuring the reliability

and precision of the results. The GMM method has been widely used in recent studies to control for endogeneity and omitted variable biases in panel data analysis. By using this methodology, this study enhances the credibility of its findings, offering a solid empirical foundation for its policy recommendations.

Fourthly, this study uses multiple proxies to measure green finance, including green credit, green securities, and green investments. Previous studies have often used a single proxy for green finance, such as green bonds [3], which may not fully capture the range of financial instruments available to support environmental sustainability. By using a broader set of proxies, this research provides a more comprehensive view of the various green finance mechanisms that can be leveraged to achieve sustainable development. This multi-dimensional approach to measuring green finance helps in better understanding its impact on environmental and economic outcomes.

Finally, this study contributes to the broader debate on how emerging economies can transition towards a sustainable development model. The findings of this study will have significant implications for policymakers in E7 countries as they seek to design and implement green finance policies that support sustainable development while addressing the pressing issue of environmental degradation. By highlighting the importance of green finance as a tool for mitigating environmental risks and promoting sustainable growth, this research aims to inform the development of more effective policies and practices in the field of sustainable finance.

In conclusion, this study provides a comprehensive analysis of the interaction between green finance and environmental degradation and their combined effect on sustainable development, with a particular focus on the E7 countries. By adopting a robust econometric approach and using multiple proxies for green finance, this research offers valuable insights into the role of green finance in achieving sustainability goals. The findings of this study are expected to contribute to the ongoing discourse on how emerging economies can leverage green finance to address the challenges posed by environmental degradation while promoting sustainable development.

Our analysis focuses on E7 countries for a number of reasons. This research targets Brazil, Russia, India, China, South Africa, Mexico, and Turkey because they drive the two important areas of international finance and ecological policy. Besides, some of these countries are among the biggest and most advanced nations and contribute a great share of the world's gross domestic product. Their financial activities and legislative decisions have a sharp effect on global markets and the environment as well [7,8].

The wealth of the large nations in the E7 countries makes them some of the largest contributors to global greenhouse gas emissions. Therefore, their roles in environmental degradation and green growth are relatively larger than those of other countries. Understanding the changing aspects among these states is crucial to assessing the effectiveness of approaches which aim to use green finance and environmental policy measures to align environmental impacts with economic progress.

Further, the E7 states are very regularly at the forefront of creating revolutionary green finance initiatives and ecological legislation. Their technical capability, institutional robustness, and financial wherewithal provide a strong platform on which one could build strategies for sustainable development. The present research deals with the industrialized E7 countries, which possess multifaceted systems of finance and law, in order to probe the way in which sustainable development functions. The E7 serve as an important case study for both emerging countries who aim at achieving financial growth while preserving environmental sustainability and established ones. A thorough grasp of the tactics utilized by the E7 nations provides a perceptive appraisal of the difficulties they encounter, which may direct national and global plans to bolster global sustainability initiatives.

The rest of this paper is structured as follows. Section 2 covers a literature review concerning environmental degradation, green finance, and sustainable development. Section 3 describes the sources of data, variables, proxies, and methodology used in this study.

Section 4 presents the empirical results and discussion. Finally, Section 5 concludes this paper with some policy implications, limitations, and future research directions.

2. Literature Review

2.1. Theoretical Literature

The concept of green finance has its theoretical roots in the broader framework of sustainable finance, which seeks to align financial markets with environmental, social, and governance (ESG) criteria. Green finance specifically refers to the mobilization of funds for environmentally sustainable projects, including renewable energy, energy efficiency, waste management, and pollution reduction initiatives [9]. The theory of green finance is closely linked to the "double dividend hypothesis," which argues that environmental taxes and green investments can yield two benefits: reducing environmental damage while simultaneously boosting economic efficiency [10]. Within this framework, green finance is seen as a mechanism that channels resources away from environmentally harmful activities and towards those that support sustainability, thereby helping to mitigate the adverse effects of climate change and environmental degradation.

At the macroeconomic level, green finance plays a crucial role in promoting sustainable development by facilitating the transition towards low-carbon economies. The theoretical foundations of this relationship are often tied to the environmental Kuznets curve (EKC) hypothesis, which posits an inverted-U relationship between economic growth and environmental degradation [11]. According to this theory, as economies develop, pollution initially rises but eventually declines as a country reaches a higher level of income and can invest more in environmental protection. Green finance accelerates this transition by funding green technologies and infrastructure, thus shifting economies toward cleaner growth models earlier in their development [12]. This theoretical framework underscores the importance of financial instruments such as green bonds, green loans, and green investments in reducing the carbon footprint of economic activities, particularly in emerging economies such as the E7 countries, where rapid industrialization poses significant environmental challenges.

Additionally, the theory of financial development and environmental quality highlights the role that well-functioning financial markets play in achieving sustainable outcomes. According to this perspective, financial markets facilitate the allocation of resources towards projects that enhance environmental quality by lowering the cost of capital for environmentally friendly investments [13]. The availability of green finance instruments creates financial incentives for companies and governments to engage in sustainable practices, which can mitigate the environmental degradation associated with economic growth. For emerging economies, like the E7 countries, integrating green finance with sustainable development policies becomes even more critical, as these nations face the dual pressures of maintaining economic growth while curbing environmental degradation [2]. This study builds on these theoretical foundations by investigating how green finance mechanisms, particularly in the context of the E7 countries, can balance economic growth with environmental sustainability to achieve sustainable development.

2.2. Empirical Literaure

The role of green finance in promoting sustainable development has been increasingly recognized in the literature, particularly as emerging economies seek to their balance economic growth with environmental protection. Green finance refers to the allocation of financial resources to environmentally sustainable projects, including renewable energy, energy efficiency, and climate change mitigation initiatives [14,15]. In recent years, the E7 countries, comprising some of the world's largest emerging economies, have made significant strides in incorporating green finance mechanisms to address the environmental challenges posed by rapid industrialization and urbanization [16,17]. Studies show that green finance can act as a catalyst for sustainable development by providing the necessary funding for green technologies, infrastructure, and practices that reduce environmental degradation while fostering economic growth [11,18]. For instance, Zhou et al. [19] found

that, in emerging economies, green finance has played a critical role in accelerating the transition to renewable energy and reducing carbon emissions.

One of the primary channels through which green finance influences sustainable development is by funding renewable energy projects, which are essential for reducing reliance on fossil fuels and lowering greenhouse gas emissions. A growing body of research supports the positive relationship between green finance and renewable energy investments in emerging markets. For example, literature demonstrated that green bonds, a key instrument in green finance, have been particularly effective in financing large-scale renewable energy projects in the E7 countries. These bonds provide governments and corporations with the necessary capital to invest in solar, wind, and hydroelectric power, thereby supporting a transition to cleaner energy sources and reducing the environmental impact of economic activities. Furthermore, green finance facilitates investments in energy-efficient technologies that can significantly lower the carbon footprints of industries, further contributing to sustainable development [20]. As such, green finance has been shown to have a direct and favorable impact on environmental sustainability in emerging economies.

In addition to supporting environmental sustainability, green finance also plays a critical role in fostering economic resilience in E7 countries. Several studies highlight that, by encouraging investments in environmentally friendly projects, green finance can help create new markets, jobs, and industries that contribute to long-term economic stability [21]. For instance, Zhang et al. [22] argued that green finance mechanisms such as green credit and green investments not only help mitigate environmental risks but also stimulate economic growth by attracting private sector investments in sustainable development initiatives. This relationship is particularly important for E7 countries, where rapid economic expansion often comes at the cost of environmental degradation. By integrating green finance into their development strategies, these nations can pursue a more balanced growth model that prioritizes both economic prosperity and environmental sustainability. This dual benefit underscores the favorable influence of green finance on sustainable development in emerging economies.

Moreover, empirical studies have consistently shown that green finance contributes to achieving sustainability goals by addressing the environmental challenges faced by developing economies. Other studies emphasized the role of green credit policies in China, one of the E7 countries, in curbing pollution and promoting the efficient use of resources. These policies incentivize businesses to adopt sustainable practices by offering lower interest rates and financial incentives for environmentally friendly projects. Similarly, Dong et al. [12] found that green finance initiatives in Brazil and India have significantly contributed to reducing carbon emissions and improving air quality. These findings highlight that green finance mechanisms are not only effective in tackling environmental challenges but also serve as a vital tool for promoting sustainable development. As the E7 countries continue to face mounting environmental pressures, the adoption and expansion of green finance mechanisms will likely play an increasingly important role in shaping their sustainable development trajectories.

Hypothesis 1 (H1). *Green finance favorably influences sustainable development in E7 countries.*

There is much literature on the issue of pollution and its relation to sustainable development. Ecological regulations become important when it is not possible to reduce emissions through sustainability efforts alone. Lee et al. [23] comment that putting greener technology into practice along with creating an ecological evaluation mechanism will help Asia move toward an economic structure that is carbon-free. Even though the development assessment approach is often used in the energy sector, it may also be used to analyze the efficiency of the performance of the sustainability index in other fields. Ulucak and Kassouri [24] comment that rules regarding environmental degeneration have contributed consistently to the conservation of the environment worldwide. The achievement of the emission reduction goals of some countries underlines the significance of environmental

legislation in curbing carbon dioxide emissions. Carbon dioxide emissions are influenced by many country-specific factors, as deduced by a study on sustainable development in SAARC countries that was conducted by Shekhawat et al. [25]. Due to favorable environmental conditions and lower poverty rates, carbon dioxide emissions have been reduced in most countries. In relation, Peng & Deng [26] described the perceptible gap between both social progress and economic growth and environmental protection by using the entropy technique. They established a total of 35 performance indices to monitor the progress of basic development in urban infrastructure alongside that of low-carbon urban areas. From this analysis, they realized that there was a striking lack of social and economic development that considered the protection of the environment within the threshold of sustainability.

Recent works have also put forward new routes of theorization to explain the interlinkages between environmental deterioration and sustainable development. The work by Zambon et al. [13] while discussing the influence of land degradation on the issues of sustainable growth, propounded the applicability of entropy indices in quantifying the susceptibility of land in farming regions of Italy. This research found that degradation-prone sites typically have high spatial variation in land sensibility, which very often acts as an obstacle to achieving sustainable development. Their study goes as far as to suggest that, because of sustainability, the process of environmental degradation may be stopped. Ahmad et al. [10] explored the influence of technical innovation on environmental degradation and sustainable development in China. They mention that technical innovation has greatly contributed to sustainable development by increasing financial growth and lessening carbon dioxide emissions. The latter element, therefore, places innovation herein as having a dual role in promoting environmental sustainability and enhancing financial growth.

Bashir et al. [2] again, more profoundly linked the consumption of natural resources, energy transition, and environmental deterioration under a cloud of geopolitical dangers. This study found that financial expansion and the use of natural resources resulted in environmental degradation, while financial expansion and energy transition caused improvement in the environment. Therefore, the above studies suggested that a cautious handling of energy and natural resource policies would be required in the pursuit of attaining sustainable growth. Other researchers studied the nexus of issues of environmental degradation and green financing, and their impact on sustainable growth in emerging economies. They determined a positive relationship between green financing and sustainable growth, and a negative relationship between ecological deterioration and sustainable growth. Consequently, it is correct to say that these factors improve sustainability by shielding it from negative impacts.

Jie et al. [27] analyzed the effects of renewable energy use, natural assets, fintech, and financial integration on carbon dioxide emissions in Central Asian countries. Their results evidence that some factors play a significant role in environmental sustainability, especially in financial integration and renewable energy. Ecological sustainability was assessed by Wang et al. [9] through an improved index of environmental degradation for China, North Korea, and Russia. Their work was complemented by two more studies indicating that the ecological degradation in these territories is very serious, and that it is mostly due to forestland reduction and the increase in cropland. Conclusions from our results indicate that, in order to pursue sustainable development, it is necessary to establish regulations which will accomplish a balance between protection of the environment and economic profits. We therefore formulate our second hypothesis as follows:

Hypothesis 2 (H2). *Environmental degradation unfavorably influences sustainable development in E7 countries*.

The reviewed literature indicates that green finance acts as an important factor in sustainable development and the further reduction of environmental degradation. In this respect, the financial sector is supposed to contribute to financial needs and facilitate a reduction in credit risks in response to sustainable business activities, hence fostering finan-

cial stability in concert with ecological objectives. Further, while portraying the relationship between wealth and environmental quality, the U-shaped environmental Kuznets curve epitomizes the passage of countries from financial growth to sustainable development as they develop. This is further promoted by environmentally friendly regulations, in turn, along with the macroeconomic conditions created by the Paris Agreement, which promotes green financing towards sustainable development in a manner befitting investor protection and strong financial regulation. In this respect, context-specific strategies are required given the regional variation in the above green financing initiatives. Our study extends the literature on the nexus between sustainable development, environmental deterioration, and green finance in the E7 countries. The introductory section of this report has highlighted the most important contributions of our study. To that extent, green finance and environmental regulation in the developed world make sustainable development feasible.

3. Data and Methodology

This paper uses an unbalanced panel dataset of the E7 countries and focuses on the development of an interface between sustainable development and green finance with respect to environmental degradation. We collected a dataset from various reliable sources such as national financial statements, the WDI by the World Bank, and other relevant economic data records using annual data from 1985 to 2021. We define our hypotheses, applying both the panel fixed-effects technique and SYS-GMM, then check the robustness and strength of our results by considering the endogeneity problem. The static and dynamic panel predictions are evaluated using Stata 12.

Further, some main control variables in the given research may represent environmental deterioration and green finance, whereas the explained variable is brought about by sustainable development. A proxy which was considered to represent sustainable development is the net savings per capita, obtained by the division of the adjusted net savings by the total population. The EKC obtains the net national savings plus the education expenditure, adjusted for the depletion of forest and mineral resources and damage caused by carbon dioxide and other greenhouse gases. As Kamoun et al. [28] clarified, this measure was chosen because it is the one which is most complete when considering the sustainability dimension, whether it used for the education, economic, or ecological dimensions.

Accordingly, green finance is proxied through measures in green credit, green securities, and green investment. The share of green credit to total credit is obtained from the national banking data of each country. The issuance of green securities is proxied through the share of green investment and total securities issues. On the contrary, financial market statistics provide the public expenditure on environmental protection, which is part of the total government expenditure. These indicators have been chosen because it can be seen how they reflect the commitment of the financial sector to green and sustainable development. We use carbon dioxide as the indicator of environmental degradation because it strongly contributes to global warming and health in the environment.

There are so many control variables in our research, such as the TO (traditional openness), TNR (natural resource abundance), FDI (foreign direct investment), and GDP (economic growth). The measure of economic growth in our study is the growth rate of the GDP, since, in the latter case, the reverse effect exerts a simultaneous influence on green finance and environmental degradation. FDI has such vast effects on financial growth and environmental policy that it served as an important independent factor in our regressions. Two parameters, trade openness and abundance in natural resources, are used to reflect their huge influence on sustainable development within the framework's definition. Independent factors are needed to isolate the exact effects of environmental degradation and green finance on sustainable development. We log-transform the data into their natural logarithmic form by using the natural logarithm.

For analytical reasons, we utilize the following equation on the basis of the variables listed in Table 1.

$$ANS_{m,n} = \varphi + \omega_1(GC)_{m,n} + \omega_2(GS)_{m,n} + \omega_3(GIN)_{m,n} + \omega_4(CO_2)_{m,n} + \omega_5(GDP)_{m,n} + \omega_6(FDI)_{m,n} + \omega_7(TNR)_{m,n} + \omega_8(TO)_{m,n} + \delta_{m,n} \quad (1)$$

Table 1. Statistics of descriptive assessment and multicollinearity assessment.

Variables	Mean	St. Dev.	Min	Max	No. of Obs.	1/VIF	VIF
TO	6.44	4.392	2.365	18.376	182	2.235	2.002
TNR	12.506	8.119	3.069	30.652	182	1.706	2.792
FDI	8.413	9.975	2.589	19.365	182	1.782	2.605
GDP	11.606	8.606	3.325	27.652	182	2.21	2.023
CO_2	30.609	3.606	4.652	66.369	182	1.706	2.792
GIN	9.606	4.707	3.362	19.652	182	1.74	2.706
GS	10.385	3.607	2.652	22.625	182	2.131	2.095
GC	7.584	4.312	1.3251	14.623	182	1.624	3.066
EPU	209.329	21.243	71.384	301.309	181	2.362	
IPI	7.658	6.362	1.438	9	182	2.635	

Note: Table 1 uses the average, standard deviation, minimum, maximum, and number of observations to provide the statistics of descriptive assessment. Furthermore, multicollinearity is calculated in Table 1 using the values of 1/VIF and VIF.

In the above equation, the explained variable is the ANS, that is the adjusted net savings. GC, GS, and GIN refer to the independent variables that are green credit, green securities, and green investments, respectively. Carbon dioxide is used as a proxy for environmental degradation. TO, TNR, FDI, and GDP allude to trade openness, natural resource abundance, foreign direct investment, and economic growth, respectively. δ_(m,n) represents the constant term, while φ represents the error term.

Techniques 1, 2, 3, and 4 are estimated by employing Equations (1A), (1B), (1C), and (1D), respectively.

$$ANS_{m,n} = \varphi + \omega_1(GC)_{m,n} + \omega_2(GDP)_{m,n} + \omega_3(FDI)_{m,n} + \omega_4(TNR)_{m,n} + \omega_5(TO)_{m,n} + \delta_{m,n} \quad (1A)$$

$$ANS_{m,n} = \varphi + \omega_1(GS)_{m,n} + \omega_2(GDP)_{m,n} + \omega_3(FDI)_{m,n} + \omega_4(TNR)_{m,n} + \omega_5(TO)_{m,n} + \delta_{m,n} \quad (1B)$$

$$ANS_{m,n} = \varphi + \omega_1(GIN)_{m,n} + \omega_2(GDP)_{m,n} + \omega_3(FDI)_{m,n} + \omega_4(TNR)_{m,n} + \omega_5(TO)_{m,n} + \delta_{m,n} \quad (1C)$$

$$ANS_{m,n} = \varphi + \omega_1(CO_2)_{m,n} + \omega_2(GDP)_{m,n} + \omega_3(FDI)_{m,n} + \omega_4(TNR)_{m,n} + \omega_5(TO)_{m,n} + \delta_{m,n} \quad (1D)$$

To evaluate the outcomes of our study, we employ different statistical methods to analyze the data, including correlation evaluation, assessment of the multicollinearity assessment, descriptive assessment, and dynamic and static panel techniques. We utilize a correlation matrix to determine the relationships between the variables mentioned above. Descriptive statistics are similarly used to summarize the basic properties of the data. The sample correlation coefficient is a measure that tells us about the degree and the direction of the linear relationship between two variables. The range is from +1 to −1.

In this study, we apply panel regression evaluation to investigate the relationship between green finance, sustainable development, and environmental degradation. There are two main estimation methods used in panel data: fixed-effects and random effect frameworks. The fixed-effects approach is regarded as suitable to test the hypotheses in our study according to the Hausman test results. Also, we employ the system-generalized method of moments to ensure that the outcomes derived from this research are valid and robust. According to González [29], autoregressive features for the dependent variable,

omitted variables on firm-specific factors, and endogeneity which affects explanatory variables are suitably handled by the GMM method.

To this end, we add the variable PA (Paris Agreement) to our equations in order to see whether the effect of green finance and environmental degradation on sustainable development changes as a result of the agreement in 2015. Concretely, we add a dummy for the PA that is valued at zero prior to 2015 and one from 2015 onwards. Equations (2A)–(2D) all take this variable as a relation term with our main control variables. We can assess how the implementation of the Paris Agreement influences the relationship of green finance (proxied by green investments, green securities, and green credit) and environmental degradation (proxied by carbon dioxide emissions) with sustainable development, since their respective interaction terms (CO2PA, GINPA, GSPA, and GCPA) are present. These are represented mathematically as follows:

$$ANS_{m,n} = \varphi + \omega_1(GC)_{m,n} + \omega_2(GC * PA)_{m,n} + \omega_3(PA)_{m,n} + \omega_4(GDP)_{m,n} + \omega_5(FDI)_{m,n} + \omega_6(TNR)_{m,n} + \omega_5(TO)_{m,n} + \delta_{m,n} \quad (2A)$$

$$ANS_{m,n} = \varphi + \omega_1(GS)_{m,n} + \omega_2(GS * PA)_{m,n} + \omega_3(PA)_{m,n} + \omega_4(GDP)_{m,n} + \omega_5(FDI)_{m,n} + \omega_6(TNR)_{m,n} + \omega_5(TO)_{m,n} + \delta_{m,n} \quad (2B)$$

$$ANS_{m,n} = \varphi + \omega_1(GIN)_{m,n} + \omega_2(GIN * PA)_{m,n} + \omega_3(PA)_{m,n} + \omega_4(GDP)_{m,n} + \omega_5(FDI)_{m,n} + \omega_6(TNR)_{m,n} + \omega_5(TO)_{m,n} + \delta_{m,n} \quad (2C)$$

$$ANS_{m,n} = \varphi + \omega_1(CO_2)_{m,n} + \omega_2(CO_2 * PA)_{m,n} + \omega_3(PA)_{m,n} + \omega_4(GDP)_{m,n} + \omega_5(FDI)_{m,n} + \omega_6(TNR)_{m,n} + \omega_5(TO)_{m,n} + \delta_{m,n} \quad (2D)$$

Furthermore, we present the following equations, where IPI denotes the investor protection index, to show how the investor protection index affects the interaction between sustainable development, green finance, and environmental degradation.

$$ANS_{m,n} = \varphi + \omega_1(GC)_{m,n} + \omega_2(GC * IPI)_{m,n} + \omega_3(IPI)_{m,n} + \omega_4(GDP)_{m,n} + \omega_5(FDI)_{m,n} + \omega_6(TNR)_{m,n} + \omega_5(TO)_{m,n} + \delta_{m,n} \quad (3A)$$

$$ANS_{m,n} = \varphi + \omega_1(GC)_{m,n} + \omega_2(GS * IPI)_{m,n} + \omega_3(IPI)_{m,n} + \omega_4(GDP)_{m,n} + \omega_5(FDI)_{m,n} + \omega_6(TNR)_{m,n} + \omega_5(TO)_{m,n} + \delta_{m,n} \quad (3B)$$

$$ANS_{m,n} = \varphi + \omega_1(GIN)_{m,n} + \omega_2(GIN * IPI)_{m,n} + \omega_3(IPI)_{m,n} + \omega_4(GDP)_{m,n} + \omega_5(FDI)_{m,n} + \omega_6(TNR)_{m,n} + \omega_5(TO)_{m,n} + \delta_{m,n} \quad (3C)$$

$$ANS_{m,n} = \varphi + \omega_1(CO_2)_{m,n} + \omega_2(CO_2 * IPI)_{m,n} + \omega_3(IPI)_{m,n} + \omega_4(GDP)_{m,n} + \omega_5(FDI)_{m,n} + \omega_6(TNR)_{m,n} + \omega_5(TO)_{m,n} + \delta_{m,n} \quad (3D)$$

Lastly, we propose the following equations, where EPU stands for economic policy uncertainty, to show how this affects the link between sustainable development, environmental degradation, and green finance.

$$ANS_{m,n} = \varphi + \omega_1(GC)_{m,n} + \omega_2(GC * EPU)_{m,n} + \omega_3(EPU)_{m,n} + \omega_4(GDP)_{m,n} + \omega_5(FDI)_{m,n} + \omega_6(TNR)_{m,n} + \omega_5(TO)_{m,n} + \delta_{m,n} \quad (4A)$$

$$ANS_{m,n} = \varphi + \omega_1(GS)_{m,n} + \omega_2(GS * EPU)_{m,n} + \omega_3(EPU)_{m,n} + \omega_4(GDP)_{m,n} + \omega_5(FDI)_{m,n} + \omega_6(TNR)_{m,n} + \omega_5(TO)_{m,n} + \delta_{m,n} \quad (4B)$$

$$ANS_{m,n} = \varphi + \omega_1(GIN)_{m,n} + \omega_2(GIN * EPU)_{m,n} + \omega_3(EPU)_{m,n} + \omega_4(GDP)_{m,n} + \omega_5(FDI)_{m,n} + \omega_6(TNR)_{m,n} + \omega_5(TO)_{m,n} + \delta_{m,n} \quad (4C)$$

$$ANS_{m,n} = \varphi + \omega_1(CO_2)_{m,n} + \omega_2(CO_2 * EPU)_{m,n} + \omega_3(EPU)_{m,n} + \omega_4(GDP)_{m,n} + \omega_5(FDI)_{m,n} + \omega_6(TNR)_{m,n} + \omega_5(TO)_{m,n} + \delta_{m,n} \quad (4D)$$

In all of the equations used herein, the extensive use of datasets covering the E7 countries between 1985 and 2021, apart the use of from powerful econometric methods like panel fixed-effects and the system-generalized method of moments (SYS-GMM), would mitigate all possible endogeneity concerns. More importantly, to check how green finance and environmental degradation influenced sustainable development before and after the 2015 agreement, we consider the interaction parameters of the dummy variable of the Paris Agreement and green finance on one hand, and between the PA and environmental degradation on the other.

In an effort to better understand how the economic policy uncertainty (EPU) and investor protection index (IPI) may affect the connection between sustainable development, environmental degradation, and green finance, we additionally include terms of interaction for each. This three-way approach will ensure that the dynamic relationship existing among the variables is fully analyzed to obtain knowledge about how efficiently conservation measures and green investments can promote sustainable development in the face of policy stability related to the shifting protection of investors.

4. Findings and Discussion

As seen from Table 1, the descriptive analysis indicates that the majority of the variables, save for the GDP and FDI, whose standard deviations are reasonably larger at 8.606 and 9.975, respectively, are small and, hence, have values that combine well with minimal deviation across the set. This infers that, while the GDP and FDI face higher unpredictability across the E7 nations, the other measures remain relatively stable. The high average value for carbon dioxide (CO_2) means great degradation to the environment, while the high average value for natural resource abundance (TNR) indicates the availability of natural assets in these countries. These results are also confirmed by the outcomes of the multicollinearity test, as there are no issues of multicollinearity problems, making the regression estimates valid. This is evidenced by VIF values below 2 and values of 1/VIF above 0.5.

Table 2 presents the correlation matrix of the variables under study. This table shows that the variables are not collinear, indicating a wide scope of controlled variables; the highest correlation coefficient is between GS and GIN, being approximately 0.679. This value falls within the cutoff value of 0.70. Such low correlations between variables enhance the soundness of the assessment and reduce the likelihood that multicollinearity may affect the findings of the regression. In other words, the early assessments support the suitability of the data for subsequent statistical assessment, offering a sound basis for research on the relationship between sustainable development, green finance, and environmental degradation in the E7 member states.

The results obtained using the time-fixed-effects method are displayed in Table 3, where we analyze the effect of environmental degradation and green finance on sustainable development in the E7 countries. All the proxies for green finance are represented in Table 3: green credit (GC) in sample 1, green securities (GS) in sample 2, and green investment (GIN) in sample 3. To quantify the value of the effect of environmental degradation on sustainable development, carbon dioxide is also included in sample 4. In each form, we

also add a set of control variables: trade openness (TO), natural resource abundance (TNR), GDP growth, and foreign direct investment (FDI).

Table 2. Correlation matrix.

	EPU	IPI	TO	TNR	FDI	GDP	CO_2	GIN	GS	GC
EPU	1									
IPI	0.782	1								
TO	0.343	0.346	1							
TNR	0.364	0.257	0.185	1						
FDI	0.874	0.387	0.404	0.42	1					
GDP	0.394	0.38	0.227	0.73	0.21	1				
CO_2	−0.58	−0.34	−0.38	−0.02	−0.06	−0.04	1			
GIN	1.085	0.353	0.205	0.448	0.413	−0.08	−0.32	1		
GS	0.976	0.88	0.218	0.169	0.658	−0.05	−0.43	0.679	1	
GC	0.347	0.67	0.212	0.218	0.227	−0.031	−0.06	0.21	0.207	1

This table provides the correlation matrix for our variables of interest.

Table 3. Time-fixed-effects panel model.

Variables	Sample 1	Sample 2	Sample 3	Sample 4
TO	0.637 (0.683)	0.876 ** (2.11)	0.321 * (1.674)	0.867 * (1.672)
TNR	0.721 ** (2.23)	0.212 * (1.515)	−0.957 (−0.658)	0.896 * (1.657)
FDI	0.821 ** (1.394)	0.765 *** (7.498)	0.210 ** (2.13)	0.917 *** (4.291)
GDP	0.948 ** (2.01)	0.745 ** (2.17)	0.964 (0.754)	0.733 *** (3.132)
CO_2	–	–	–	−0.434 *** (−5.329)
GIN	–	–	0.829 *** (9.392)	–
GS	–	0.816 *** (4.291)	–	–
GC	0.598 *** (5.120)	–	–	–
C	0.746 *** (6.392)	−0.309 ** (−2.09)	−0.675 (−0.493)	−0.456 *** (−4.292)
R-squared	0.834	0.856	0.812	0.801
Adj. R-squared	0.895	0.845	0.824	0.813
F-statistic	19.987 *** (0.005)	32.495 *** (0.008)	35.593 *** (0.002)	41.394 *** (0.006)
Country Fixed Effect	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Hausman test (*p*-values)	0.021	0.039	0.030	0.029

Note: this table provides the results based on the time fixed-effects model. In this table, three models were used: the first used green credit, the second used green securities, and the third used green investment. The independent variables for green credit, green securities, and green investment are denoted by the proxies GC, GS, and GIN, respectively. The explained variable ANS stands for adjusted net savings. The environmental degradation is determined by carbon dioxide. The control variables are GDP, FDI, TNR, and TO. The significance level at 1 percent, 5 percent, and 10 percent is indicated by ***, **, *.

The positive and significant GC coefficient value for sample 1 is 0.598, indicating that an increase in green credit positively influences sustainable development. The same applies to sample 2, where GS shows a positive and significant impact, with a coefficient of 0.875. In sample 3, the coefficient of 0.829 for GIN indicates that green investment also significantly boosts sustainable development. Green finance procedures have a positive influence because financial resources are directed towards ecologically friendly ventures, which in turn promote sustainable practices and help slow down environmental degradation. Our new findings confirm our previous conclusions and align with the studies of [1,3,4], among others, which also revealed a positive relationship between sustainable development and green finance.

In this respect, sample 4 shows a negative and significant relationship between carbon dioxide emissions and sustainable development, with a coefficient of -0.434. This aligns with financial theory, which suggests that environmental degradation undermines sustainability by increasing emissions, depleting natural resources, disrupting social cohesion, and destabilizing financial stability. High levels of carbon dioxide typically signal intensified industrial activities that worsen climate change and cause environmental harm, ultimately hindering sustainable development. This finding is consistent with that of Rehman et al. [30], who also found that carbon dioxide emissions specifically threaten sustainable development and ecological conservation.

In addition, the independent variables help to explain underlying mechanisms: trade openness (TO), natural resource abundance (TNR), GDP growth, and FDI generally show substantial and favorable coefficients throughout the models. It can be concluded that these independent variables positively contribute to sustainable development by promoting sustainable behaviors, the use of technology, and the growth of financial assets. An expanded economy and FDI increase a nation's financial and technical capacity, while abundant natural assets provide essential resources. Trade openness allows developing nations to share sustainable practices and technology. These findings align with those of Ben Cheikh & Ben Zaied [31], Ziolo et al. [32], and Shobande and Enemona [33], who found that trade concerns, resource management, financial development, and foreign investments are key determinants of sustainability. The robustness of the estimations is supported by the high adjusted R-squared values (all above 0.70), showing that a significant portion of the variance in sustainable development is explained. As well, the adoption of fixed-effects frameworks is validated by the substantial Hausman analysis results. Finally, we obtain the results using the entity fixed-effects model. These results are present in Table 4. These results are also consistent with the results shown in Table 3.

Table 4. Entity fixed-effects panel model.

Variables	Sample 1	Sample 2	Sample 3	Sample 4
TO	0.651 (0.451)	0.746 ** (2.11)	0.374 * (1.854)	0.867 * (1.672)
TNR	0.451 ** (2.45)	0.412 * (1.715)	−0.857 (−0.788)	0.896 * (1.657)
FDI	0.471 ** (2.394)	0.845 *** (7.754)	0.352 ** (2.41)	0.845 *** (4.851)
GDP	0.854 ** (2.74)	0.875 ** (2.74)	0.564 (0.874)	0.743 *** (3.748)
CO_2	–	–	–	−0.534 *** (−5.549)
GIN	–	–	0.745 *** (9.854)	–
GS	–	0.745 *** (4.845)	–	–

Table 4. *Cont.*

Variables	Sample 1	Sample 2	Sample 3	Sample 4
GC	0.451 *** (5.4510)	–	–	–
C	0.451 ** (6.392)	−0.419 ** (−2.19)	−0.142 (−0.542)	−0.456 *** (−4.292)
R-squared	0.745	0.654	0.812	0.801
Adj. R-squared	0.742	0.721	0.824	0.813
F-statistic	19.945 *** (0.005)	32.495 *** (0.008)	35.593 *** (0.002)	41.394 *** (0.006)
Country Fixed Effect	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Hausman test (*p*-values)	0.021	0.039	0.030	0.029

Note: this table provides the results based on the entity fixed-effects model. The rest of the variables are described in Table 3. The significance level at 1 percent, 5 percent, and 10 percent is indicated by ***, **, *.

In the end, we utilize the dynamic panel SYS-GMM approach to check the robustness of our empirical results. The results of the SYS-GMM technique are presented in Table 5, where the independent variables for samples 1, 2, and 3 are green credit (GC), green securities (GS), and green investments (GIN), respectively. Green finance is positively related to sustainable development, as shown by the significant coefficients for the three indicators at the 1% level. These data support our previous conclusions derived from the panel fixed-effects approach.

Table 5. Dynamic panel GMM two-step assessment.

Variables	Sample 1	Sample 2	Sample 3	Sample 4
TO	0.453 (0.645)	0.874 * (2.123)	0.326 * (2.098)	0.764 * (2.234)
TNR	0.974 *** (4.322)	0.323 * (2.009)	−0.967 (−0.561)	0.215 * (1.562)
FDI	0.432 ** (2.193)	0.921 ** (2.183)	0.876 *** (9.273)	0.893 *** (5.382)
GDP	0.546 * (2.173)	0.756 ** (2.098)	0.874 (0.657)	0.557 * (2.183)
CO_2	–	–	–	−2.193 *** (−5.382)
GIN	–	–	0.218 *** (4.292)	–
GS	–	0.593 *** (9.348)	–	–
GC	2.193 *** (3.192)	–	–	–
C	0.758 *** (5.392)	−0.746 *** (−4.239)	−0.462 (−0.465)	−0.465 *** (−5.329)
L1.	2.193 *** (8.391)	0.938 ** (2.110)	2.193 * (2.009)	1.384 * (1.948)
L2.	2.193 ** (2.008)	−2.193 *** (−9.484)	2.842 *** (10.939)	−2.183 *** (−10.398)
Year Fixed	Yes	Yes	Yes	Yes

Table 5. *Cont.*

Variables	Sample 1	Sample 2	Sample 3	Sample 4
AR1 (*p*-value)	1.382	1.637	1.546	1.263
p-value	0.561	0.939	0.897	0.462
AR2 (*p*-value)	1.546	1.354	1.432	1.642
Sargan	7.831	8.492	9.598	8.382
Country Fixed	Yes	Yes	Yes	Yes

Note: three models were used: the first used green credit, the second used green securities, and the third used green investment. The independent variables for green credit, green securities, and green investment are denoted by the proxies GC, GS, and GIN, respectively. The explained variable ANS stands for adjusted net savings. The environmental degradation is determined by carbon dioxide. The control variables are GDP, FDI, TNR, and TO. The significance level at 1 percent, 5 percent, and 10 percent is indicated by ***, **, *.

Also, sample 4 from Table 5 tests the impact of environmental degradation on sustainable development and shows that carbon dioxide emissions significantly negatively influence it. This finding confirms our previous analysis using the fixed-effects model. The inverse relationship between carbon dioxide emissions and sustainable development indicates that environmental degradation has a significant negative impact on society; therefore, governments can achieve sustainable development through policies aimed at reducing emissions. In all models, the explanatory variables—trade openness, GDP, FDI, and natural resource abundance—consistently show significance and a positive relationship with sustainable development.

The SYS-GMM estimation of the dynamic panel generally encourages the adoption of green finance regulations to attain sustainability by promoting investment in eco-friendly projects through green resources, investments, and loans. Liu et al. [4] and Ping et al. [34] found a significant relationship between the development of renewable energy projects, environmental conservation, and the attainment of sustainability through sustainable financing and investment preservation.

Further details on how economic policy uncertainty influences the relationship between sustainable development, environmental degradation, and green finance are presented in Table 6. Most green finance indicators show positive and significant relationships with economic policy uncertainty, indicating that green finance performs better in countries with high levels of policy uncertainty. This result might initially seem counterintuitive, but it can be explained by the fact that, during recessions, both investors and governments tend to favor longer-term, less volatile investments, with green finance being seen as a more stable option.

Table 6. Panel fixed-effects approach to assess the influence of EPU (economic policy uncertainty).

Variables	Model 1	Model 2	Model 3	Model 4
TO	0.949 (0.675)	0.938 *** (3.123)	0.298 * (1.779)	0.928 * (1.675)
TNR	0.565 ** (2.173)	0.847 ** (2.091)	−0.546 (−0.847)	0.609 * (1.637)
FDI	0.763 *** (3.964)	0.657 *** (3.101)	3.827 ** (1.938)	0.958 *** (4.382)
GDP	0.746 ** (2.182)	0.748 * (1.785)	0.775 (0.576)	0.857 *** (3.595)
EPU	2.193 *** (5.392)	2.853 *** (6.382)	2.172 *** (5.842)	−2.008 ** (−1.982)
CO_2	–	–	–	−0.872 *** (−9.348)

Table 6. *Cont.*

Variables	Model 1	Model 2	Model 3	Model 4
CO_2*EPU	–	–	–	−0.632 *** (−4.291)
GIN	–	–	0.817 *** (7.246)	–
GIN*EPU	–	–	2.119 *** (8.328)	–
GS	–	0.837 *** (5.201)	–	–
GS*EPU	–	0.758 *** (9.482)	–	–
GC	0.872 *** (7.403)	–	–	–
GC*EPU	0.845 *** (6.135)	–	–	–
C	0.512 *** (6.392)	−0.821 * (−1.758)	−0.833 (−0.654)	−0.465 *** (−4.328)
R-squared	0.881	0.884	0.892	0.912
Adj. R-squared	0.834	0.814	0.871	0.817
F-statistic	21.032 *** (0.007)	23.583 *** (0.004)	20.493 *** (0.005)	20.49 *** (0.005)
Country Fixed Effect	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Hausman test (*p*-values)	0.031	0.038	0.009	0.051

Note: this table is comparable to Table 2, with the exception that every nation's economic policy uncertainty (EPU) is now included. It serves as the framework's control variable in each of the four samples. Furthermore, we employ its relationship term to ascertain if safeguarding investors has altered the relationship between green finance (GIN, GS, GC) and environmental degradation (carbon dioxide) with respect to sustainable development. The remaining variables in this table have the same definitions as before. The significance level at 1 percent, 5 percent, and 10 percent is indicated by ***, **, *.

On the other hand, the significant negative coefficient of CO_2*EPU suggests that environmental degradation worsens with economic policy uncertainty. This is likely due to regulatory loopholes and the inconsistent application of environmental policies, which increase emissions and harm the environment. These results emphasize the importance of predictable and stable financial regulations in reducing the negative effects of environmental degradation through green finance initiatives.

Table 7 examines green finance and the interaction terms between the investor protection index and both sustainable development and environmental degradation. Stronger investor protection enhances the positive role of green finance in achieving sustainable development, as indicated by the significant positive coefficients for the interaction terms GINIPI, GSIPI, and GCIPI. This outcome makes sense, as robust investor protections create a secure investment environment, leading to increased funding for green initiatives. When investors feel secure, they are more likely to invest in long-term, sustainable projects that once seemed risky. Strong investor protection also mitigates the negative impact of environmental degradation on sustainable development, as shown by the positive coefficient of CO2IPI. This may be because effective regulatory and legal frameworks ensure the enforcement of environmental standards, penalizing violations and reducing harmful emissions through sustainable practices.

Table 7. Panel fixed-effects approach to assess the influence of IPI (investor protection index).

Variables	Sample 1	Sample 2	Sample 3	Sample 4
TO	0.847 (0.657)	0.645 *** (3.292)	0.219 * (1.756)	0.756 * (1.657)
TNR	0.529 ** (2.103)	0.874 ** (2.193)	−0.948 (−0.834)	0.756 * (1.782)
FDI	0.657 ** (1.987)	0.563 ** (1.877)	3.192 ** (2.342)	0.821 *** (4.291)
GDP	0.645 ** (1.948)	0.528 * (1.561)	0.523 (0.756)	0.847 *** (3.201)
IPI	2.492 *** (5.271)	2.953 *** (6.493)	2.011 *** (5.392)	2.876 ** (1.938)
CO_2	–	–	–	− 0.867 *** (− 9.493)
CO_2*IPI	–	–	–	0.693 *** (4.292)
GIN	–	–	0.563 *** (7.492)	–
GS*IPI	–	–	2.103 *** (8.043)	–
GS	–	0.736 *** (5.392)	–	–
GS*IPI	–	0.948 *** (9.439)	–	–
GC	0.635 *** (7.493)	–	–	–
GC*IPI	0.551 *** (6.392)	–	–	–
C	0.932 *** (6.391)	−0.763 * (−1.645)	−0.798 (−0.758)	−0.453 *** (−4.276)
R-squared	0.832	0.832	0.896	0.839
Adj. R-squared	0.813	0.785	0.848	0.803
F-statistic	21.482 *** (0.006)	21.943 *** (0.004)	21.573 *** (0.003)	31.394 *** (0.005)
Year Fixed Effect	Yes	Yes	Yes	Yes
Country Fixed Effect	Yes	Yes	Yes	Yes
Hausman test (*p*-values)	0.031	0.021	0.009	0.051

Note: the table above is comparable to Table 2, with the exception that every nation's investor protection index (IPI) is now included. It serves as the model's control variable in each of the four samples. Furthermore, we utilize its relationship term to ascertain if investor protection has altered the relationship between green finance (GIN, GS, GC) and environmental degradation (carbon dioxide) with respect to sustainable development. The remaining variables in this table have the same definitions as before. The significance level at 1 percent, 5 percent, and 10 percent is indicated by ***, **, *.

Table 8 examines the relationship between the 2015 Paris Agreement, sustainable development, environmental degradation, and green finance. From the estimation results, it can be inferred that the interaction terms for the green finance indicators and the Paris Agreement (GINPA, GCPA, and GSPA) are positively significant. This indicates that the 2015 Paris Agreement has enhanced the impact of green finance on sustainable development. Additionally, the interaction term for environmental degradation (CO2PA) is positive and significant, showing that the Paris Agreement has mitigated the negative effect of carbon

dioxide on sustainable development. These results suggest that the Paris Agreement has encouraged emission reductions and the adoption of more environmentally friendly technologies. On a global scale, these findings affirm the crucial role that international agreements play in strengthening commitment to sustainable development.

Table 8. Panel fixed-effects approach to assess the influence of the 2015 Paris Agreement (PA).

Variables	Sample 1	Sample 2	Sample 3	Sample 4
TO	0.785 (0.665)	0.847 ** (1.984)	0.214 * (1.674)	0.891 * (1.657)
TNR	0.756 ** (2.192)	0.382 * (1.574)	−0.847 (−0.563)	0.758 * (1.675)
FDI	0.543 ** (1.984)	0.573 *** (9.594)	3.291 ** (1.904)	0.842 *** (4.291)
GDP	0.572 ** (2.103)	0.873 ** (2.112)	0.847 (0.465)	0.843 *** (3.209)
PA	2.193 *** (4.291)	2.193 *** (6.439)	2.193 *** (5.292)	2.001 ** (1.987)
CO_2	–	–	–	−0.945 *** (−8.439)
CO_2*PA	–	–	–	0.329 *** (4.320)
GIN	–	–	0.573 *** (9.393)	–
GIN*PA	–	–	2.194 *** (7.393)	–
GS	–	0.875 *** (4.853)	–	–
GS*PA	–	0.539 *** (6.493)	–	–
GC	0.675 *** (6.392)	–	–	–
GC*PA	0.543 *** (5.292)	–	–	–
C	0.548 *** (6.493)	−0.475 ** (−2.198)	−0.875 (−0.563)	−0.476 *** (−4.292)
R-squared	0.958	0.983	0.847	0.918
Adj. R-squared	0.847	0.901	0.812	0.899
F-statistic	21.394 *** (0.005)	21.304 *** (0.003)	20.941 *** (0.002)	19.393 *** (0.005)
Country Fixed Effect	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Hausman test (*p*-values)	0.021	0.019	0.009	0.039

Note: Tables 2 and 4 are comparable, with the exception that the Paris Agreement of 2015 is represented by a new dummy variable (PA). It has a value of 1 as of 2015 and 0 before that year. Utilizing its connection term, we ascertain if the 2015 Paris Agreement has altered the relationship between environmental degradation (carbon dioxide) and green finance (GIN, GS, GC) with respect to sustainable development. The remaining variables in the table have the same definitions as before. The significance level at 1 percent, 5 percent, and 10 percent is indicated by ***, **, *.

In Table 9, we have quantified the impact of the COVID-19 pandemic on the relationship between green finance, carbon emissions, and sustainable development. The results show that the pandemic had a significant positive effect on the interaction between green

finance indicators (green credit, green securities, and green investment) and sustainable development, as reflected by the positive and significant coefficients for the interaction terms. Additionally, the interaction between COVID-19 and carbon emissions is also significant, suggesting that the pandemic influenced the reduction in emissions, likely due to decreased industrial activity. These findings highlight the important role of green finance in fostering sustainable development during times of public crises, such as COVID-19, by promoting investments in eco-friendly projects and technologies.

Table 9. Panel fixed-effects approach to assess the effect of COVID-19.

Variables	Sample 1	Sample 2	Sample 3	Sample 4
TO	0.785 (0.854)	0.857 ** (2.454)	0.278 * (1.895)	0.874 * (1.784)
TNR	0.874 ** (2.782)	0.382 * (1.744)	−0.747 (−0.843)	0.895 * (1.784)
FDI	0.754 ** (1.844)	0.574 *** (9.784)	3.745 ** (1.454)	0.745 *** (4.841)
GDP	0.572 ** (2.103)	0.847 ** (2.542)	0.896 (0.745)	0.784 *** (3.745)
COVID	2.843 *** (4.291)	2.843 *** (6.439)	2.413 *** (5.745)	2.745 ** (1.987)
CO_2	–	–	–	−0.945 *** (−8.439)
CO_2*COVID	–	–	–	0.329 *** (4.320)
GIN	–	–	0.573 *** (9.393)	–
GIN*COVID	–	–	2.194 *** (7.393)	–
GS	–	0.875 *** (4.853)	–	–
GS*COVID	–	0.539 *** (6.493)	–	–
GC	0.675 *** (6.392)	–	–	–
GC*COVID	0.543 *** (5.292)	–	–	–
C	0.548 *** (6.493)	−0.475 ** (−2.198)	−0.875 (−0.563)	−0.476 *** (−4.292)
R-squared	0.958	0.983	0.847	0.918
Adj. R-squared	0.847	0.901	0.812	0.899
F-statistic	21.394 *** (0.005)	21.304 *** (0.003)	20.941 *** (0.002)	19.393 *** (0.005)
Country Fixed Effect	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Hausman test (*p*-values)	0.021	0.019	0.009	0.039

The significance level at 1 percent, 5 percent, and 10 percent is indicated by ***, **, *.

5. Conclusions and Policy Recommendations

It is vital that financial systems supporting ecologically friendly endeavors and mitigating the negative impacts of environmental degradation should be researched in light

of accelerating concerns about climate change and environmental sustainability across the globe. In our research, the E7 countries offer an interesting background as they are significant contributors to international carbon dioxide levels and have strong economies. Therefore, this paper explores how green finance, through its tools like green investment, green securities, and green credit, promotes sustainable development to help build effective policies and measures that support the attainment of long-term sustainability in both the economy and the environment.

Our purpose is to observe the correlation between environmental degradation and green finance in relation to sustainable development. We have tested the hypothesis that, while environmental degradation negatively influences sustainable development, green finance has a positive effect. Additionally, we examine whether the 2015 Paris Agreement, the investor protection index, and economic policy uncertainty influence the relationship between green finance, environmental degradation, and sustainable development. We apply the panel fixed-effects method to test these hypotheses and use the SYS-GMM approach to verify the robustness of our results.

Precisely, we find that green finance significantly promotes sustainable development when assessed through green investments, green securities, and green credit. This is evident from the positive and highly significant coefficients for GIN, GS, and GC. Conversely, our study shows that environmental degradation, represented by carbon dioxide, significantly undermines sustainable development. The same results are confirmed using the SYS-GMM method, validating our conclusions. Environmental degradation negatively impacts sustainable development due to the depletion of natural resources and rising pollution levels, which also lead to social fragmentation and harm prosperity. Elevated carbon dioxide emissions indicate manufacturing activities that exacerbate climate change and damage ecologies, further hindering sustainable development. Lastly, our research highlights that the positive effects of green finance on sustainable development are strengthened by the 2015 Paris Agreement, the investor protection index, and the uncertainty of financial regulation.

The implications of these findings extend to green finance approaches that are favorable to sustainable development. Policymakers in the E7 countries need to prioritize environmentally conscious initiatives by committing resources and expanding funding through green financial systems. Economically sustainable growth without environmental degradation could be supported by fostering green securities, green credit, and green investments. These findings highlight the need for multifaceted economic and ecological policies that simultaneously support sustainability goals. The immediate creation and implementation of relevant environmental regulations should be motivated by the significant negative impact of carbon dioxide emissions on sustainable development. Legislators must focus on reducing carbon dioxide emissions by pairing enhanced energy conservation efforts with stricter regulations and incentives to shift towards renewable energy sources. Tackling environmental degradation is essential to ensuring sustainable economic growth and improving the standard of living for future generations.

Although our analysis of the data herein is quite valuable, some values are missing in the dataset which could be useful for a comparative analysis of different indicators of sustainable development and green finance. Future research could explore other measures of green finance, such as green bonds, green loans, or other financing options that promote environmental sustainability. Additionally, incorporating indicators like biodiversity loss and water contamination would expand the study of ecological impacts, strengthen the conclusions of our research, and provide a clearer understanding of how environmental degradation affects sustainable development. Moreover, this study could be further enriched by including non-E7 nations.

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