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# GREEN BONDS AND CARBON EMISSIONS: THE EUROPEAN UNION CASE

## ABSTRACT

**Purpose:** The growing popularity of green bonds has sparked an ongoing debate about their real impact on the environment. The idea behind green bonds is that they provide environmental benefits, such as a reduction in carbon emissions, by financing environmentally friendly projects. The aim of this paper is to examine the relationship between green bond issuance and CO<sub>2</sub> emissions in the EU-27 from 2013 to 2017 to determine the validity of this theory.

**Methodology:** Data on green Eurobonds issued in the EU-27 and CO<sub>2</sub> emissions in the EU-27 were collected from 2013 to 2017 using the Refinitiv Eikon database. Descriptive statistics and linear correlation were used to investigate the association between green Eurobonds issued and CO<sub>2</sub> emissions per capita in the EU-27.

**Results:** The study found that while green bond issuance increased dramatically, from EUR 5 billion in 2013 to EUR 75 billion in 2017, there was only a small decrease in total and per capita CO<sub>2</sub> emissions of 3.7% and 4.6%, respectively. Moreover, no significant relationship was found between them.

**Conclusions:** The results suggest that while an increase in green bond issuance indicates a trend toward more sustainable investments, it does not necessarily lead to a proportional decrease in CO<sub>2</sub> emissions. Therefore, further research is needed to better understand the association between green bond issuance and carbon emissions and to identify the underlying factors that may influence this relationship.

**Keywords:** Low-carbon economy, CO<sub>2</sub> emissions, green bonds, green financing, greenwashing

## 1. Introduction

Greenhouse gases (GHGs) emitted from human activities are the primary cause of global warming (IPCC, 2018), with carbon dioxide (CO<sub>2</sub>) being the most significant contributor accounting for 74.4% of total emissions (Ritchie et al., 2022). In order to keep a global increase in temperature to 2°C above pre-industrial levels, the Paris Agreement (UN-

FCC, 2019) was signed in 2015. It aims to finance low-carbon and climate-resilient growth, which requires substantial environmentally responsible investments. One of the tools for financing climate resilience is through green bonds.

Green (climate) bonds are a financial mechanism that enables climate change alleviation and the transition to a low-carbon economy (Benlemlih et al.,

2022; Hung, 2021; Gianfrate & Peri, 2019). Green bonds can affect greenhouse gas (GHG) emissions at the company level through two main mechanisms; firstly, by funding projects that decrease emissions such as lower energy consumption or the development of cleaner products, and secondly, by encouraging firms to improve their environmental practices.

To this end, the development and adoption of green financial instruments have proven necessary to support the achievement of climate goals. Although the green bond market has developed in recent years (Climate Bond Initiative, 2022; Flammer, 2021; Cheong & Choi, 2020; Tolliver et al., 2019), especially after the endorsement of the Paris Agreement (UNFCC, 2015), it is not yet sufficient to finance all the needs for implementing environmental investments (Faure et al., 2020). Nonetheless, green bonds are emerging as a popular and even dominant form of financing green projects, particularly in China, the United States, and Europe (Statista, 2022), in addition to green loans and green equity (Flammer, 2021).

In 2021, more than \$517 billion worth of green bonds were issued, a 50% increase from the previous year (Climate Bonds Initiative, 2022). Green bonds are no longer just attracting financial development institutions and public sector issuers, but also private sector and private issuers seeking financing for their green projects (Demary & Neligan, 2018; Weber & Saravade, 2019). Although green bonds were less widely accepted in the early days of green bond market development due to higher perceived risk compared to ordinary corporate bonds and were therefore higher-priced (Lütken, 2014), views on green bonds have changed today as green strategies and the green bond market have evolved. Their characteristics such as long maturity, low cost, acceptable risk due to policy support, and usually high issuer credit quality (Wang & Chu, 2022; Azhgaliyeva et al., 2020; Sachs et al., 2019a; Sachs et al., 2019b), make them attractive to both potential investors and issuers. Moreover, they represent a model that contributes to an intergenerational solution to a common problem by transferring some of the costs of green projects implemented today to the generations that will benefit from their implemen-

tation (Sartzetakis, 2021; Orlov et al., 2017; Flaherty et al., 2016; Gevorkyan et al., 2016).

Along with efforts to achieve the United Nations Sustainable Development Goals (SDGs) (United Nations, 2015) and the Paris Agreement (UNFCC, 2015) through various measures, including the development of financing mechanisms for low-carbon, climate-resilient global development, this financial instrument is acquiring an important role in financial markets. However, the question is whether and to what extent green benefits are associated with the increasing issuance of green financial instruments. Given the increasing importance of this issue, studies have been conducted on the role and contribution of green financial mechanisms in reaching the goals of the Paris Agreement, leading to different conclusions regarding a link between green financial instruments and CO<sub>2</sub> emission reductions.

This paper aims to complement existing research on green finance by analysing the correlation between green bond issuance and CO<sub>2</sub> emissions in the European Union, which is useful information for policy makers and energy policy analysts (Marín-Rodríguez et al., 2022). The study aims to establish the extent to which the rising issuance of green Eurobonds is related to actual environmental benefits. To the best of our knowledge, there are no studies that investigate this relationship in the context of green bonds issued by the EU member states. The literature on the environmental impact of green financial instruments, specifically green bonds, is limited and this study aims to fill this gap in the research. The study intends to provide insights into the effectiveness of green bonds as a tool for promoting sustainable development and reducing carbon emissions in the EU.

The paper is structured in the following way: following the introduction, the second section provides an overview of the association between the issuance of green bonds and carbon emissions and highlights key findings from previous studies. The third section details the sample and methods used. The fourth section presents the results of the study on the relation between green bonds and carbon emissions, and the final section concludes the paper.

## 2. Conceptual background with literature review

Research on the association between green bonds and carbon emissions has yielded varied results, with some studies suggesting a possible positive association between the two (Chang et al., 2022; Fatica & Panzica, 2021; Schmittmann & Chua, 2021; Shen et al., 2021; Tolliver et al., 2019), and others finding mixed or inconclusive results (Benlemlih et al., 2022; Kant, 2021; Ehlers et al., 2020). One theory is that green bond issuance could lead to a reduction in carbon emissions by financing projects that decrease emissions, such as renewable energy projects or energy efficiency projects. Additionally, green bond issuance could also incentivize firms to improve their environmental performance, which could lead to a reduction in carbon emissions.

Benlemlih et al. (2022) examined the association between green bond issuance and carbon emissions and environmental performance using a sample of 534 bonds issued by 213 companies and found mixed results from regression analysis, with no significant reduction in carbon emissions among green bond issuers, but a decrease in CO<sub>2</sub> emissions over time. Meo & Abd Karim (2022) examined the association between green finance (using green bonds as a proxy) and carbon emissions using quantile-on-quantile regression (QQR) on a sample of countries leading in green finance in the period from November 2008 to June 2019 and found an overall negative impact of green finance on CO<sub>2</sub> emissions, but this relationship varied at different quantiles. Shen et al. (2021) applied cross-sectionally augmented autoregressive distributed lags (CS-ARDL) using panel data of 30 provinces in China over the period 1995-2017 and found a negative association between green investment and carbon emissions. Sinha et al. (2021) studied the effects of green bond financing on environmental and social sustainability by analysing the S&P 500 Global Green Bond Index and the S&P 500 Environmental and Social Responsibility Index from October 2010 to July 2020, combining advanced quantile modelling methods. They discovered that this type of financing is starting to have a detrimental impact on environmental and social responsibility, though initially it had a positive impact. Fatica & Panzica (2021) investigated the relationship between green

bond issuances and issuers' environmental performance of nonfinancial companies up to 2019 and found that green bond issuers have recorded a decrease in carbon emissions. Kant (2021) examined the relationship between green bonds and carbon emissions using a sample of 200 corporate green bonds from December 2015 to December 2019 and found no statistically significant association between analysed variables. Schmittmann & Chua (2021) examined carbon emissions intensity in 2019 for 148 green bond issuers in the S&P Global 1200 Index and found that these companies have lower carbon emissions in terms of revenue and assets than green bonds non-issuing companies. In addition, those companies have higher environmental rating scores.

Older studies such as Ehlers et al. (2020) examined carbon intensity of companies that issued green bonds and compared them to other companies. They found no clear evidence that green bond issuance is associated with a decrease in carbon intensity over time at the firm level. The study found that, on average, carbon intensity declined in the two years following green bond issuance, but later increased. Tolliver et al. (2019) examined the contribution of green bonds to the Sustainable Development Goals (SDGs) by examining the relationship between green bonds and GHG emissions. Using a sample of 53 green bond issues from 96 countries from 2008 to 2017, the authors found that projects financed with green bonds led to a reduction in GHG emissions of about 108 million metric tonnes of CO<sub>2</sub> equivalent.

Green bond issuance intended to finance environmentally friendly projects can lead to "greenwashing" if companies use green bond issuance primarily to enhance their reputation without making significant changes to their environmental practices. Transparency in the disclosure of projects by green bond issuers is crucial to mitigate the risk of greenwashing. Schneeweiß (2019) found that only a small number of issuers, 186 out of 429, disclosed any information about their projects. He proposed that comprehensive documentation of all projects, the allocation of projects to individual bonds, and the disclosure of the amount invested in each project are crucial to address this issue. This finding is consistent with the conclusions of Sartzetakis

(2021). In addition, Tuhkanen & Vulturius (2020) found that many green bond issuers do not align their bonds with their climate targets and do not take an extensive approach to the transition to carbon neutrality. They also discovered deficiencies in post-issuance reporting, suggesting that issuers were not sufficiently pressured by investors, regulators, or society to increase transparency and reduce the risk of greenwashing. This is consistent with the findings of Kalesnik et al. (2022), who claim that investor reporting of carbon emissions is inadequate and based only on self-assessments, which are overestimated by at least 2.4 times. Subsequently, researchers emphasize the importance of certification (green verification) of financial instruments (Migliorelli, 2020; Bachelet et al., 2019), as well as external auditors and public monitoring (Lu, 2021).

The studies reviewed suggest that the relationship between green bond issuance and carbon emissions is complex and multifaceted. One key takeaway from this research is that the impact of green bond issuance on carbon emissions may not be immediate or straightforward. For example, Sinha et al. (2021) found that while green bond financing had a positive impact on environmental and social sustainability in the short term, its influence began to weaken in the long term, which is consistent with Ehlers et al. (2020). Similarly, Meo & Abd Karim (2022) found that the relationship between green finance and carbon emissions varied at different quantiles.

Given the complexity of the relationship between green bond issuance and carbon emissions, it is important to gain a deeper understanding of this

relationship. In the methodology section, we will outline the approach used in this study to examine the association between green bond issuance and CO<sub>2</sub> emissions in the EU-27 from 2013 to 2017.

### 3. Methodology

In this study, data on green Eurobonds issued in the EU-27 and CO<sub>2</sub> emissions per capita in the EU-27 were collected from 2013 to 2017 using the Refinitiv Eikon database. The data were extracted in June and July 2022. The selected time frame of 2013 to 2017 was chosen due to the limited availability of green Eurobond emissions data before 2013 and a high number of missing data per country. Additionally, 2013 was the year in which corporate issuers and government-supported entities entered the market (Weber & Saravade, 2019). Eurobonds were chosen as the subject of the research study because they are the most prevalent in the listing of green bonds on the Euronext exchange (according to Statista (2022), they account for 85% of the total value of green bonds listed on the Euronext exchange).

At the time of data extraction, CO<sub>2</sub> emissions data for all member states up to 2017 were published in the Refinitiv Eikon database. Data for CO<sub>2</sub> emissions per capita were calculated using Eurostat data on the population of each country. Table 1 presents data on green Eurobond issuance in various European Union member states from 2013 to 2019. It includes total green bond issuance for each year in each country, as well as cumulative total issuance for the period 2013 to 2017, plus 2013 to 2019 for comparison.

**Table 1 EU green bonds issuances by country in the period 2013 to 2019 (in 000 000 EUR)**

	2013	2014	2015	2016	2017	2018	2019	SUM 2013- 2017	SUM 2013- 2019
Finland	108	482	594	1,866	42,127	600	3,374	45,178	49,151
Luxembourg	3,304	5,644	2,915	5,507	6,960	6,967	8,025	24,331	39,323
Germany	300	3,341	5,715	3,921	7,080	5,690	19,797	20,357	45,844
Netherlands	0	1,250	3,763	5,627	8,751	8,858	21,158	19,391	49,406
France	1,946	5,573	6,158	5,568	0	6,616	27,496	19,246	53,358
Sweden	170	1,240	1,420	2,727	3,707	6,323	10,956	9,264	26,543
Spain	0	530	0	790	2,786	3,190	7,446	4,106	14,742
Italy	0	513	0	375	1,693	2,005	5,851	2,581	10,437
Denmark	0	0	547	0	1,370	750	10,915	1,918	13,583
Poland	0	0	0	750	0	1,000	2,197	750	3,947
Austria	0	0	0	0	303	0	0	303	303
Lithuania	0	0	0	0	300	368	0	300	668
Belgium	0	0	0	55	112	10,930	0	167	11,097
Latvia	0	0	100	25	20	0	0	145	145
Estonia	0	0	50	0	0	0	0	50	50
Czech Republic	0	0	0	0	41	0	0	41	41
Ireland	0	0	0	0	0	6,849	1,200	0	8,049
Portugal	0	0	0	0	0	0	1,110	0	1,110
Greece	0	0	0	0	0	0	150	0	150
Slovenia	0	0	0	0	0	75	0	0	75
Hungary	0	0	0	0	0	0	0	0	0
Romania	0	0	0	0	0	0	0	0	0
Slovakia	0	0	0	0	0	0	0	0	0
Bulgaria	0	0	0	0	0	0	0	0	0
Cyprus	0	0	0	0	0	0	0	0	0
Croatia	0	0	0	0	0	0	0	0	0
Malta	0	0	0	0	0	0	0	0	0
<b>EU (27)</b>	<b>5,828</b>	<b>18,574</b>	<b>21,263</b>	<b>27,211</b>	<b>75,250</b>	<b>60,222</b>	<b>119,674</b>	<b>148,127</b>	<b>328,022</b>
<b>Annual change</b>		<b>+219%</b>	<b>+14%</b>	<b>+28%</b>	<b>+177%</b>	<b>-20%</b>	<b>+99%</b>	-	-

Source: Authors' work (calculations based on the Refinitiv database)

The table illustrates that in 2017, Finland had the highest green bond issuance at 42,127, followed by Luxembourg and Germany. The total green bond issuance for the EU-27 increased from 5,828 million EUR in 2013 to 75,250 million EUR in 2017, and then to 119,674 million EUR in 2019. The green

Eurobond market experienced strong growth from 2013 to 2017, followed by a decline in 2018 (-20%), but after that it continued to grow in 2019, almost doubling the values from the previous year. This demonstrates that the rise of the green Eurobond market is not just a temporary trend. From 2014 to

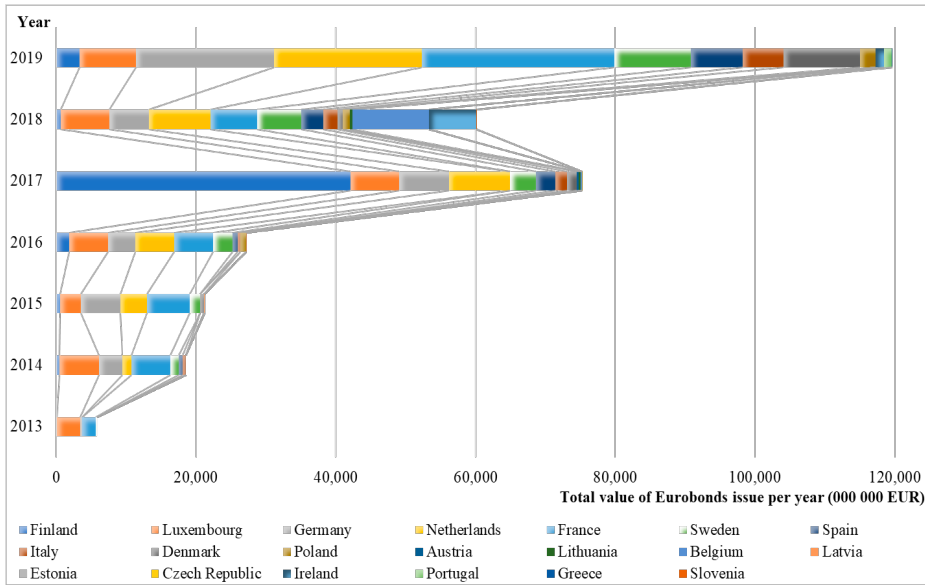
2021, approximately 35% of total green bond proceeds in Europe were invested in the energy sector, followed by housing with a 28% share and transport with 18%. A similar trend can be observed on the global market level, where the value of green bonds issued worldwide increased from USD 37 billion to USD 269 billion from 2014 to 2019, almost doubling by 2021, with Europe's share at 45.3% in 2019 and 52% in 2021, followed by Pacific Asia with 25% in both years observed (Statista, 2022).

Due to limited data availability, as shown in Table 1, which is the main limitation of this study, descriptive statistics and linear correlation were used to investigate the association between green Eurobonds issued and CO2 emissions per capita in the EU-27. Data analysis was performed using the SPSS PC+ statistical software package and Microsoft Office Excel.

#### 4. Results

The results of the analysis show a significant increase in the issuance of green Eurobonds in the European Union during the period from 2013 to 2017. This trend continued in 2019, with the exception of a slight dip in 2018. A total of 20 EU member states issued green Eurobonds during the analysed period, with three countries that had issued bonds prior to 2013 and four countries that have not issued any green Eurobonds at all (Bulgaria, Cyprus, Malta, and Croatia). Figure 1 illustrates green Eurobond issuance per country during the period from 2013 to 2019. These data provide an extensive review of the trend of green bond issuance in the European Union and highlights the countries that have been actively issuing green bonds to support low-carbon and climate-resilient global development in financial markets.

Figure 1 Value of EU-27 green Eurobond issues in the period from 2013 to 2019 (in 000 000 EUR)

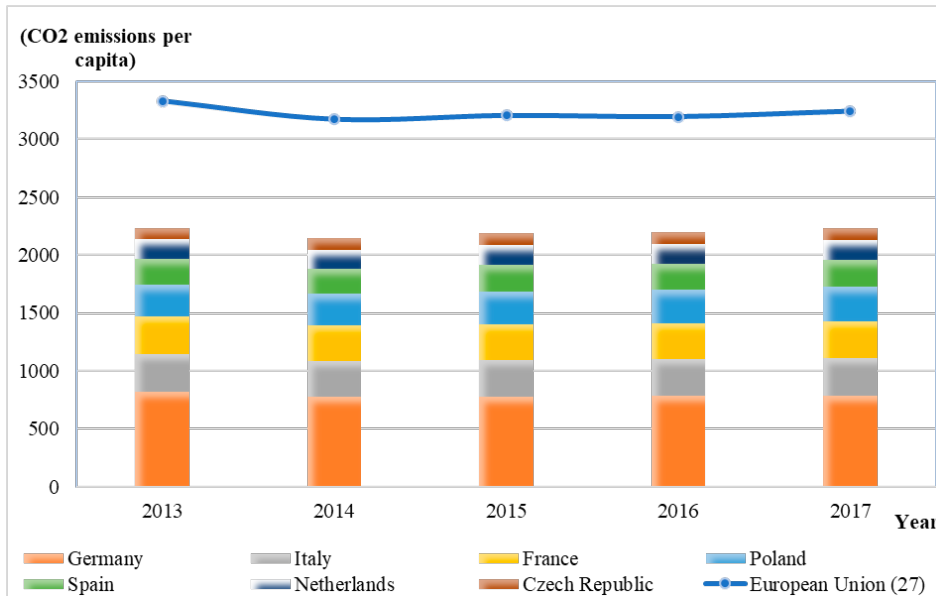


Source: Authors' work (calculations based on the Refinitiv database)

From the analysis of Figure 1, it is apparent that the issuance of green Eurobonds varies among European Union member states. During the period from 2013 to 2017, the largest issuers were Finland, Luxembourg and Germany, whereas in the more recent period from 2013 to 2019, the largest issuers were France, the Netherlands and Finland in terms of the value of the issues. The data also suggest that a few countries such as Finland, Germany, Sweden and Finland have been issuing green Eurobonds on an

annual basis, while other countries have larger or smaller intervals between new releases.

On the other hand, Figure 2 illustrates the trends and provides a comparative analysis of CO2 emissions per capita for the EU-27 and major contributors to CO2 emissions in the EU-27 in the period from 2013 to 2017. The data in the figure also enable us to understand how the trends of green bond issuance and CO2 emissions per capita in the EU-27 are correlated during the observed period.

**Figure 2 CO2 emissions per capita for the EU-27 and the largest contributors to EU-27 CO2 emissions**

Source: Authors' work (calculations based on the Refinitiv database)

The analysis of EU-27 CO2 emissions per capita over the observed period from 2013 to 2017 reveals a lack of significant decrease in emissions. The trends over this period, as indicated by the percentage change in emissions, were -4.7%, 1.02%, -0.31%, and 1.45%, respectively, resulting in a total decrease of only 2.64% from 2013 to 2017.

Concurrently, there has been a significant increase in the annual value of green Eurobonds issues over this period. In particular, the annual value of these bonds increased by approximately 13 times in 2017 compared to 2013, and by 20.5 times in 2019 compared to the base year of 2013. Table 2 presents the results of the descriptive statistics analysis of the data on green Eurobonds issues and CO2 per capita.

**Table 2 Descriptive statistics**

	N	Minimum	Maximum	Mean	Std. Deviation
Green Eurobonds (EU-27)	48	20,000,000	42,127,391,662	3,329,002,586.04	6,313,460,011.353
CO2 per capita (EU-27)	80	3.60	19.18	8.1434	3.47871
Valid N (listwise)	48				

Source: Authors' work

The data show a large standard deviation in the annual value of green Eurobonds issued among countries and in years. Finland had the highest annual value at 42 billion EUR in 2017, while Latvia had the lowest annual value at 20 million EUR in 2017 (excluding countries that did not issue green Eurobonds during the observed period).

To determine the correlation between the annual value of green Eurobond issues and CO2 emissions per capita, a 2-tailed Pearson correlation was performed, as shown in Table 3.

**Table 3** Linear correlation between issues of green Eurobonds and CO2 emissions per capita for the EU-27

		Green Eurobonds	CO2 per capita
Green Eurobonds (EU-27)	Pearson Correlation	1	.122
	Sig. (2-tailed)		.410
	N	48	48
CO2 per capita (EU-27)	Pearson Correlation	.122	1
	Sig. (2-tailed)	.410	
	N	48	80

Source: Authors' work

The results show that the correlation coefficient between green Eurobonds and CO2 per capita is .122 and the p-value is .410. This correlation coefficient indicates a weak correlation between these two variables. The p-value is greater than .05, which means that the correlation coefficient is not statistically significant and there is no indication that there is a true relationship between two variables.

## 5. Discussion and conclusion

The results of the analysis of data on issued green Eurobonds and CO2 emissions per capita of the EU-27 for the period from 2013 to 2017 indicate that while there was a significant increase in green bond emissions, there was only a modest decrease in CO2 emissions per capita. Additionally, the analysis found that there was no significant correlation between these two variables. These findings are aligned with previous research, such as the studies of Ehlers et al. (2020), Kant (2021), and Benlemlih et al. (2022), which also found no significant reduction in carbon emissions among green bond issuers. Furthermore, these results confirm the concerns about the potential for greenwashing with green financial instruments, as reported in previous literature (Schneeweiß, 2019; Tuhkanen & Vulturius, 2020; Sartzetakis, 2021). The risk of greenwashing seems to be greater the more the EU tries to accelerate the growth of the green bond market instead of focusing on its organic growth (Demary & Neli-gan, 2018).

Concerns about a possible link between green financial instruments and greenwashing are the very issues that the European Commission's Action Plan on Financing Sustainable Growth (European Commission, 2021) is attempting to address through improvements to the regulatory framework for

green bonds. The plan includes the development of the EU Green Bond Standard (European Union, 2021) and guidance to improve the disclosure of climate-related information by companies and financial market participants. The foundation for these actions is the establishment of a clear and detailed EU taxonomy. This taxonomy allows for improved monitoring, reporting and assurance of green bond proceeds, making it easier for investors to invest in green bonds with confidence. These actions not only promote sustainable growth but also create business opportunities for entities, investors and financial intermediaries to participate in the transition to a more environmentally sustainable economy.

In summary, the analysis highlights the need for more research to fully understand the relationship between green bond issuance and carbon emissions. While an increase in green bond issuances may indicate a shift towards more sustainable investments, it may not necessarily result in a decrease in CO2 emissions. It is also important to note that further research is needed to understand the underlying factors that may contribute to strengthening the relationship between green bond issuances and carbon emissions reduction. Future studies may benefit from a more extensive and long-term examination of green bond projects and their impact on carbon emissions. Additionally, it would be valuable to explore the specific characteristics of green bond projects and issuers that may be associated with reduced carbon emissions.

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