Role of underwriters in the green bond market*

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Abstract

This paper explores the role of underwriters in the green bond market and studies how past relationships with underwriters can impact the environmental performance of companies. I find that companies that partnered with major green bond underwriters tend to increase emissions after green bond issuance. In contrast, companies that issued green bonds without having a prior green bond underwriter relationship demonstrate a significant reduction in carbon emissions in the long term. I further investigate the casual effect of green bond issuance on carbon emissions utilizing firms' prior relationships with major green bond underwriters as an instrument for green bond issuance. I find that companies maintain the same level of emissions for two and more years following green bond issuance. Taken together, my results suggest that green bonds serve primarily as a commitment device for companies that genuinely seek the opportunity to issue a green instrument, whereas for companies with established green underwriter partnerships, it can be a greenwashing opportunity.

Keywords: Sustainable finance, Impact investing, Green bonds, Underwriters

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1 Introduction

Corporate green bonds have emerged as a recent prominent instrument that companies use to finance environmentally friendly projects. Green bonds are distinguished from conventional bonds by a green label that enables companies to signal their commitment to the environment. The green bond market is growing very fast, allowing supporting more sustainable initiatives. In 2021, the global green bond market exceeded \$560 billion, more than doubling the market value of \$263 billion recorded in 2019[1]. Despite their popularity, green bonds are often criticized for lack of transparency, the absence of universal standardization, and the potential risk of greenwashing[2]. While previous literature provides mixed evidence on the effectiveness of green bonds (Daubanes et al., 2021; Flammer, 2021; Aswani & Rajgopal, 2022), it remains unclear whether and, more importantly, how the market can distinguish company's genuine intention to improve its ESG perfromance from the greenwashing.

In this paper, I investigate whether past relationships with underwriters can help identify genuine intentions of companies to reduce carbon emissions with green bond financing. In fact, entering green bond market can be costly due to a different pool of socially responsible investors and rigorous standards and requirements necessary to validate ex-ante use of proceeds (Su et al., 2023). Established relationships with green bond underwriters can help alleviate these costs as underwriters provide insurance for unsold bonds and assistance in documenting and marketing (Yasuda, 2005). Nevertheless, some companies issue green bonds without having past relationships with green bond underwriters. Such actions can be a signal of a higher quality of the firm: it genuinly seeks the opportunity to issue a green instrument and is confident in the strong investor demand for their securities.

The empirical analysis in the paper studies how prior relationships with major green bond underwriters affect emission intensity after green bond issuance. I present empirical evidence based on data provided by the SDC Platinum and Refinitiv Thompson Reuters.

I identify past relationships with major green bond underwriters based on lead underwriters for conventional bonds issued before 2014. I show that companies without established prior relationships with major green bond underwriters significantly improve their emission intensity two and more years following green bond issuance. By

[1]S&P Global. Global sustainable bonds 2023 issuance to exceed \$900 billion. S&P Global. Retrieved 12/14/2023, from source.

[2]Baker McKenzie. (2019). Green Bonds.

contrast, companies that have past relationships with major green bond underwriters slightly increase emissions post-issuance. These findings are consistent with the idea that green bonds may serve as a commitment device for companies that intentionally seek opportunities to issue green debt securities, that is, companies without established relationships with green bond underwriters. Conversely, companies with existing relationships may not be genuinely committed to reducing emissions and may instead issue green bonds to emulate the practices of environmentally conscious companies.

I proceed the analysis with studying the general effectiveness of green bonds. The empirical challenge in approaching this question is that the decision to issue a green bond is not random and can be driven by unobservable factors that could impact both green bond issuance and the company's emissions (e.g., an environmentally friendly CEO, climate risk awareness). To address the endogeneity problem, I introduce a novel instrumental variable and use prior relationships between firms and major green bond underwriters as an instrument for green bond issuance. Prior relationships are expected to positively affect the likelihood of issuing green bonds while having no direct effect on the firm's decision to change its carbon emissions. I show that in an OLS regression, green bond issuance is associated with a subsequent reduction in carbon emissions, consistent with prior papers (Daubanes et al., 2021; Flammer, 2021). However, when I instrument green bond issuance using prior relationships with green bond underwriters, I no longer find this effect: green bond issuance per se does not significantly change the firm's level of emissions, either in the short or the long term. This result is consistent with recent findings of Aswani & Rajgopal (2022) and Mao (2023) indicating that effectiveness of green bond financing can be overestimated.

In addition, I analyze the green bond premium and study whether investors value a firm's green commitment. Following the methodology of Larcker and Watts (2020) and Flammer (2021), I examine the yield difference between a green and a conventional bond of the same issuer. Consistent with previous studies, I find no significant difference in yields between green and conventional bonds. This result persists for both companies with prior underwriter relationships and without them. Next, I examine whether green bond issuers can benefit from a lower cost of debt compared to non-issuers. Exploiting the same methodology, I find a small premium for green bond issuers, which can be interpreted as investors' recognition of green initiatives.

My study contributes to the growing literature on green bonds (Baulkaran, V., 2019; Zerbib, 2019; Larcker & Watts, 2020; Daubanes et al., 2021; Flammer, 2021; Baker et al., 2022; Barbalau & Zeni, 2023). This literature primarily focuses on the effect of green bonds on firm-level outcomes (e.g., institutional ownership, carbon emissions, stock price reaction, green premium). My study contributes to this literature by introducing a novel instrument that allows disentangling the causal effect of green bond issuance on environmental performance.

Additionally, my findings contribute to the literature on impact investing. Investors with non-pecuniary motivations can generate social and environmental impact by financing companies that promote social benefit (Barber et al., 2021; Berk & Van Binsbergen, 2021; Geczy et al., 2021). While green bonds are believed to improve firms' environmental performance (Daubanes et al., 2021; Flammer, 2021), the present study complements this body of research by revealing the presence of greenwashing opportunities under green bond financing.

Finally, this research adds to the nascent literature on the role of underwriters in promoting ESG policies (Houston & Shan, 2022; Kim et al., 2022; Wang & Wu, 2022; Su et al., 2023). In particular, my findings can indicate that in the presence of underwriters as intermediaries, heterogeneous types of agents can enter the green bond market.

The remainder of the paper is organized as follows. Section 2 provides the literature review and discusses the specifics of the green bond market. Section 3 describes the data. In Section 4, I explain the methodology. Section 5 presents and discusses the estimation results. Section 6 concludes.

2 Background

Green bonds are the most predominant type of green debt security available on the financial market. A specific feature of green bonds is the limited use of proceeds, which are earmarked for environmentally-friendly projects. Examples of such projects implemented by large corporations include the energy conservation project by Intel Corp.[3] and the carbon mitigation project implemented by Apple[4], 2021 projects. In contrast to other green debt securities (e.g., sustainability-linked bonds), green bonds

[3]Intel Corp. invested $300 mln of green bond funds in efficient lighting, chilled water cooling, compressed air and heat recovery and electrification projects: Intel Corporation, Annual Green Bond Report, 2023

[4]Apple Inc. invested $10 mln of green bond proceeds in the development of the low-carbon aluminum for iPhone SE and MacBook Pro in partnership with Elysis: Apple Inc., Annual Green Bond Impact Report

assume an ex-ante commitment to finance green projects while not requiring ex-post reporting. Moreover, payment on green bonds is independent from any ESG outcome, which makes it difficult to verify the direct impact of investments. This characteristic has led to discussions about 'greenwashing', a term referring to bonds that are marketed as 'green' but fail to make a significant environmental impact. To illustrate the specifics of green bond contracts, we can look at the example of Intel Corp. In August 2022, the company issued a green bond, stating on its website that "Intel announced the pricing of its inaugural green bond issuance, totaling $1.25 billion. The net proceeds of the green bond offering will be used to fund eligible projects in six key areas that support Intel's sustainability goals...". Along with making the statement, the company issued a legal bond prospectus describing the contract's conditions in detail. In particular, they state that "There can be no assurance that use of proceeds from the sale of the green bonds to finance Eligible Projects will be suitable for the investor criteria of an investor... no assurance can be given that we will be able to implement or implement substantially any such Eligible Projects...". While the company publicly announced a green bond issuance to fund sustainability projects, its official bond prospectus casts doubt on the implementation and suitability of the projects it aims to fund.

The lack of ex-post commitment under green bond financing can create potential incentives for greenwashing. This inspired the scholars to study the ESG outcomes of green bond financing. Daubanes et al. (2021), Fatica & Panzica (2021), and Flammer (2021) analyze the carbon emissions post-issuance and conclude that green bonds contribute to reducing pollution. These papers, however, mention the endogeneity problem that might lead to biased estimates of the impact of green bonds on carbon emissions. Indeed, there could be unobserved factors that influence both the decision to issue green bonds and a firm's carbon emissions. For example, increased climate risks could lead to both the decision of a company to issue green bonds and to lower carbon emissions. These concerns do not allow for bringing about a valid conclusion. I address the endogeneity concerns by introducing a novel instrument for green bond issuance. By leveraging firms' established relationships with major green bond underwriters, I strive to provide evidence on causal impact of green bond financing. I describe the IV approach in more detail in section 3.2.2.

The major motivation for green bond issuance that is discussed in the literature is a lower cost of capital provided under green bond financing. Another considerable part of the green bond literature discusses green bond pricing. Some prior work provided evidence on a green premium suggesting that socially responsible investors can forgo pecuniary profit to generate positive environmental value (Baker et al., 2018; Zerbib, 2019). The most recent work (Larcker & Watts, 2020; Flammer, 2021) employs matching techniques and finds no significant differences in yields between green and conventional bonds.

The final part of the green bond literature explores the effect of green bond issuance on shareholders. Tang and Zhang (2020) and Flammer (2021) investigate the post-issuance reaction of the stock price and infer that green bonds credibly signal a commitment to the environment. They further analyze changes in ownership structure after green bond issuance and denote that the share of long-term investors increases significantly.

3 Data

To examine the effect of green bond issuance on carbon emissions, I construct a data set comprising several parts. The major component of my analysis involves collecting data on all corporate bonds along with information about bond underwriters and green bond identifiers. The second component consists of information on company-level carbon emissions. The final data component involves financial characteristics such as total debt and enterprise value to market value.

3.1 Bond data

I collect data on all corporate bonds from the SDC Platinum database issued from 2008 to 2021. I start the analysis in 2008 to ensure enough observations before the appearance of the green bond market in 2014. For each corporate bond deal, I collect information on bond issuance date, maturity date, industry, nation, bond rating, use of proceeds, yield to maturity at issuance, coupon payment, and lead underwriters. Using information on the use of proceeds, I identify green bonds. For this period, I derive 6,118 green bonds, close to the number of green bonds in other databases (Bloomberg: 6,027; Refinitiv Eikon: 5,874).

The major component of my study involves analyzing firms' relationships with bank underwriters. To identify the firm's previous relationships with the major green bond underwriters, I focus on the variable of 'lead underwriters' (Yasuda, 2005). The summary statistics is presented in Table 1. An average firm in the data set issues four bonds partnering with three different underwriters in a year. For each deal, most companies have one or two lead underwriters.

3.2 Carbon emissions data

The major part of the empirical analysis utilizes data on firm's environmental performance which can be captured by emission intensity (Hartzmark and Shue, 2022). Following Flammer (2021), I measure emission intensity as carbon emissions scaled by assets. I collect data on carbon emissions from Refinitiv Eikon[5], which allows me to investigate the effect of green bond issuance on carbon emissions. Using the company name and ticker, I merge carbon emissions data with corporate bonds information. I manually check the results to ensure that the information is properly merged. For the analysis of the effect of green bonds on carbon emissions, the unit of observation in the data is a company that issues a conventional bond in a period from 2008 to 2021 and provides information about its carbon emissions. The final data set consists of 20,924 company-year observations for 1,896 unique companies.

3.3 Financial characteristics

The final component of collected data involves firms' financial characteristics, such as total debt and enterprise value to market value which is available through Refinitiv Eikon. I use these characteristics for company matching to investigate the yield difference between green and conventional borrowers in Section 5. For this part of the analysis, the unit of observation is a corporate bond issued from 2008 to 2021 and its issuer provides information on financial characteristics.

4 Methodology

In the empirical analysis, I investigate the association between green bond issuance and corporate environmental performance and study how past relationships with underwriters can influence this performance. As a measure of environmental performance, I use the intensity of the emissions following the methodology proposed by Flammer (2021). Specifically, I use total carbon equivalent emissions in tons relative to assets in dollars. Total carbon emissions are objectively measured and include both direct (scope 1) and indirect (scope 2) emissions.

[5]From Refinitiv Eikon, I use item CO2EmissionTotal, which includes direct (scope1) and indirect (scope 2) emissions.

4.1 Simple OLS

The work of Ferrel, Liang, Renneboog (2016), El Ghoul et al. (2016), and Cronqvist and Yu (2017) demonstrate that corporate practices can improve environmental indicators. The empirical approach I utilize is to examine whether green bond issuance can improve carbon emissions. A straightforward OLS model, similar to the one proposed by Flammer (2021), allows me to see the effect of green bond issuance on pollution.

$$CO_2 \ emissions = \beta_0 + \beta_1 * GB \ issuance + \beta_2 * Post \ GB \ + \gamma_i + \delta_t + u \quad (1)$$

Here, the Y variable represents the pollution caused by a company, defined as carbon emissions in tons divided by the book value of assets. On the right hand side, I have a green bond issuance binary variable, which is equal to 1 if a company issued a green bond in a given year, along with a post-issuance binary variable for indicating the long term effect of the green instrument. The coefficient of interest β_1 shows how the issuance of green bonds changes carbon emissions.

Examining the effect of green bond issuance on a firm's environmental behavior under this simple specification can cause endogenous concerns. The reason for this is that the issuance of green bonds is not random and can depend on many firm related factors such as environmentally-friendly CEO or board members. To mitigate this endogenous problem, I introduce a novel instrument that I describe below.

4.2 Instrumental variable approach

The association between green bond issuance and the firm's environmental behavior may not show a causal effect of green bonds, since the issuance of this financial instrument is not random and can depend on many unobserved factors, such as the environmental friendly nature of its CEO or board members, which may also be correlated with the firm's environmental performance. To mitigate this endogeneity problem, I introduce a novel instrument to disentangle the causal effect of green bond issuance on carbon emissions. Specifically, I use prior relationships with major green bond underwriters established before the increased popularity of green bonds in 2014 (Flammer, 2021; Barbalau & Zeni, 2023).

To show the relevance of the instrument, I study how the probability of green bond issuance is affected by prior relationships with major green bond underwriters (Table 2). To construct the prior relationship variable, I introduce two definitions for a major green bond underwriter. According to the first definition, a major green bond underwriter is one of the top five most frequent green bond underwriters across all years. This definition may exclude from the analysis early green bond underwriters that started the market in 2014 by issuing first few green bonds. For this reason, in the main of the analysis I utilize another definition for a major green bond underwriter that takes top 5 most frequent underwriters in each year and combine the results for all years. In doing so, I might face a potential selection problem caused by the characteristics of underwriters: better quality firms, which to issue green bonds more frequently prefer to work with large underwriters. Moreover, a company's choice to work with a small green bond underwriter can be endogenous, i.e., a company may choose to partner with a small green bond underwriter with intentions to issue green bonds in the future. To address this concern, I exclude small banks from the list of major green bond underwriters and keep only large banks that can be either green bond issuers or non-green bond issuers.

Some scholars argue that the selection of underwriters by companies might be a deliberate decision wherein firms establish strategic relationships with banks to enhance their access to the debt market (Yasuda, 2005). To address this potential concern, I analyze firms' relationships with banks before a threshold year, specifically 2014, during a nascent stage of development in the green bond market. By doing so, I aim to establish a condition where the choice of underwriters by firms remains independent of their intentions to issue green bonds. This approach ensures a more robust examination of the underwriter selection process and its association with green bond issuance. Thus, the prior relationship variable shows whether a company started working with major green bond underwriters before green bonds became widespread.

I present the results of the first stage in Table 2. It demonstrates that companies with prior relationships with major green bond underwriters are significantly more likely to issue green bonds: given the 1.4% of green bonds in the data, companies that partnered with major green bond underwriters are 1.1 times more likely to issue a green bond, which is an economically significant effect.

$$CO_2\ emissions = \beta_0 + \beta_1 * \widehat{GB\ issuance} + \gamma_i + \delta_t + u \tag{2}$$

$$\widehat{GB\ issuance} = \alpha_0 + \beta_2 * Prior\ relationships + \gamma_i + \delta_t + u \tag{3}$$

4.3 Green premium analysis

A prevailing perspective in academic discourse suggests that green bonds provide a lower cost of capital, thereby enabling firms to undertake environmentally beneficial projects that might not be funded otherwise (Baker et al., 2018; Flammer, 2021; Ameli et al., 2022). I study whether green bond issuers benefit from a lower cost of capital.

I explore the pricing of green bonds and study whether green bond issuers have a lower cost of debt. Some prior work (Karpf & Mandel, 2017; Baker et al., 2018; Zerbib, 2019; Larcker & Watts, 2020; Flammer, 2021) provide mixed evidence on the presence of green bond premium with either small or insignificant premium. I revisit these studies and apply the methodology from the most recent papers of Larcker and Watts (2020) and Flammer (2021).

I examine the presence of green bond premium in two ways. First, I look at the difference in yields at issuance within firms. Specifically, I follow the methodology of Larcker and Watts (2020) and match each green bond to a quasi-identical conventional bond of the same issuer. I restrict the search to the same issuers of green and conventional bonds with the same credit rating and a maximum of one day difference in the date of issuance. The following matching restriction limits the difference in maturity to be within one year. Finally, I pick the nearest neighbor using the Euclidean distance based on the coupon. The final sample consists of 119 pairs of bonds of the same issuers.

For the second approach, I extend the sample and include non-green bond issuers in the analysis. In particular, for each green bond issuer, I find a non-green bond company that issued a conventional bond in the same year with the same credit rating. I require companies to operate in the same industry and issue bonds in the same country. To find the most similar non-green bond issuer, I minimize Mahalanobis distance of the following parameters: (i) total debt [6]; (ii) enterprise value to market capitalization [7]. The final sample under this approach consists of 316 pairs.

[6] Represents total debt outstanding, which includes: Notes Payable/Short-Term Debt, Current Portion of Long-Term Debt/Capital Leases and Total Long-Term Debt

[7] This is the Historic Enterprise Value divided by the Market Capitalization for the fiscal period

5 Results

5.1 Effect on carbon emissions under IV approach

I employ a linear IV regression framework to estimate the effect of green bonds on carbon emissions. In Table 3, I present the results for the IV regression together with an OLS regression. As discussed earlier, the dependent variable is carbon emissions in tonnes relative to the book value of assets in thousand dollars. I use prior relationships with major green bond underwriters to instrument for green bond issuance. I find that green bond issuers do not exhibit significant changes in carbon emissions post-issuance in the short or long run of two or more years after the green bond issuance. This finding drastically differs from the OLS regression result, suggesting that IV addresses potential endogeneity issues and gives a more precise estimate of the effect of green bond issuance.

5.2 Role of prior relationships with major green bond underwriters

The results from the previous section demonstrate that green bonds endogenously lead to a reduction in carbon emissions. However, this reduction is mostly driven by projects that would be financed regardless. I advance the analysis by exploring the factors that can affect reduction of carbon emissions.

I proceed with analyzing the role of firms' prior relationships with major green bond underwriters in improving environmental behavior. A potential channel is that entering the green debt securities market can be costly, and having prior relationships with green bond underwriters can facilitate this process. Therefore, I study whether firms that partnered with green underwriters behave differently from firms without prior relationships.

I find that companies with prior relationships with major green bond underwriters do not significantly decrease their carbon emissions in the short term and can insignificantly increase carbon emissions two or more years post-issuance. By contrast, companies without prior relationships with underwriters significantly decrease carbon emissions in the short and long term. Specifically, the results show that given a mean carbon emission ratio of 1.34, green bond issuers without prior relationships reduce carbon emissions by almost 5%.

The effect of prior relationships with major green bond underwriters can be illustrated by Figure 3.

These findings suggest that green bonds could act as a commitment mechanism for companies actively seeking opportunities to issue green bonds. I observe that companies without established relationships with green bond underwriters may use green bonds to demonstrate their commitment to reducing emissions. On the other hand, companies with existing relationships may have a different level of genuine commitment to emission reduction and might use green bonds to mimic the practices of environmentally-conscious companies.

5.3 Effect of green bonds on the cost of debt

I present the results of the green bond premium analysis in Table 5 and Table 6. Table 5 shows the result for the within-firm yield comparison. As discussed above, in this table, I compare bond yields at the issuance of the same issuer. I reveal that similar to previous findings of Larcker and Watts (2020) and Flammer (2021), the difference in yields is not statistically significant. Moreover, when I look at the difference in means, I do not observe any difference in yields.

I proceed with the analysis by looking at the yield difference between firms with prior relationships with major green bond underwriters and without them. The results in Table 5 reveal a small green premium in medians, while the difference in means is not statistically significant. This finding can suggest that green bond issuers can benefit from a slightly lower cost of debt relative to non-green bond issuers.

In addition, I present evidence on green bond yields between firms. For each green bond issuer, I find the most similar firm following the methodology described in Section 4.3. Table 6 does not show any significant difference in yields.

Similarly to the case of within-firm comparison, I find no significant difference in yields between the group of firms partnered with major green bond underwriters and those without such relationships.

My findings indicate that green bond issuers can have a slight premium by issuing green bonds. Nevertheless, the market of green bonds is at its early stage; therefore, these findings may not necessarily apply to future years.

6 Conclusion

Although green bonds have been an important instrument in the promotion of ESG policies, few studies have investigated the environmental consequences of green bond issuance. In this paper, I study how green bond issuance affects changes in carbon emissions. Using firms' prior relationships with major green bond underwriters, I address potential endogeneity concerns and disentangle the causal effect of green bond issuance on carbon emissions. My findings under the IV approach show that the overall effect of green bonds indicates that companies maintain similar emission levels for two or more years following green bond issuance. Moreover, I reveal that having prior relationships with major green bond underwriters can affect firms' environmental behavior: companies that partnered with underwriters do not experience significant changes in emissions, while companies that did not partner with them reduce carbon emissions by almost 5% in the year of issuance and by 6.5% two and more years after green bond issuance. I further investigate the presence of green premium and infer that there can be a small premium for green bond issuers compared to non-green bond issuers. To conclude, green bonds can serve as an efficient commitment device for companies that genuinely seek the opportunity to issue a green instrument. In contrast, for companies with established underwriter relationships, it can create greenwashing incentives.

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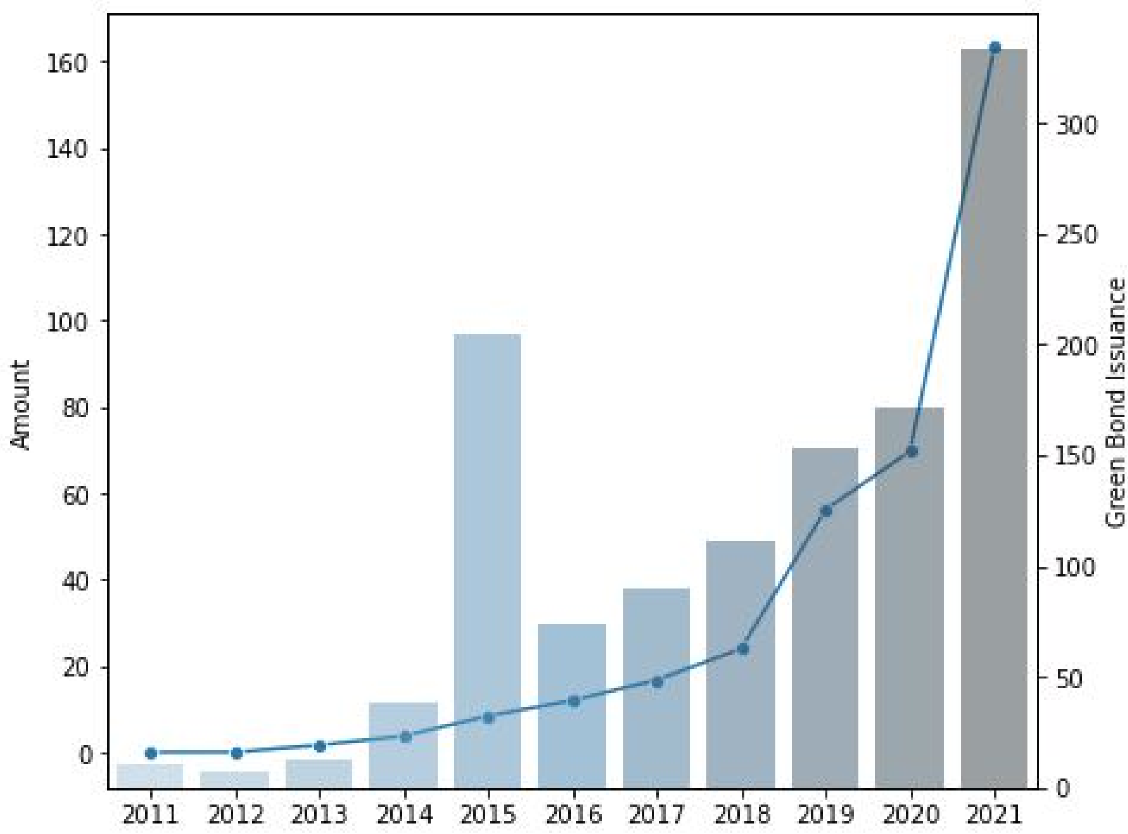
A Tables and Figures

Table 1. Summary Statistics

	Mean	Standard deviation	Min	Max
Bond deals per year	2.74	2.41	1	177
Bank partners per deal	3.28	2.90	1	32
Bank partners in a year	4.32	0.68	1	50
Emissions in tonnes	5.172	27.77	0.0	289.42
Emission intensity	0.00932	0.00362	-1.88	3.05

This table presents summary statistics. Emission intensity is measured by carbon emissions in tonnes scaled by assets in dollars.

Figure 1. Growth of US green bond market.



This graph shows the growth of US green bond market. The blue line shows the dollar amount of green bond issuance per year. The bar plot shows the number of green bonds issued per year.

Table 2. Effect of prior relationships with banks on GB issuance

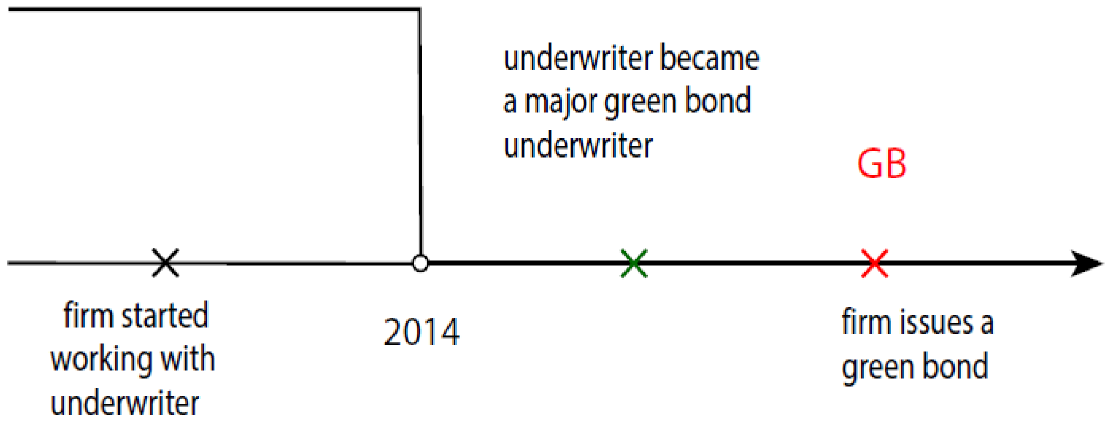
	Probability of GB issuance		
	(1)	(2)	(3)
A. major GB underwriters (by year)			
Prior relationships	0.0088***	0.0065***	0.096***
	(0.0015)	(0.0015)	(0.0018)
R^2	0.002	0.002	0.002
N	20,924	20,924	20,603
Year FE	YES	YES	YES
Industry FE		YES	YES
Country FE			YES
B. major GB underwriters (general case)			
Prior relationships	0.0092***	0.0066***	0.0091***
	(0.0015)	(0.0015)	(0.0018)
R^2	0.002	0.002	0.002
N	20,924	20,924	20,603
Year FE	YES	YES	YES
Industry FE		YES	YES
Country FE			YES

Robust standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

This table presents the effect of prior relationships with major green bond underwriters on the probability of green bond issuance. This table reports the first stage of the 2SLS model in Eq. (3). *Prior relationships* is a binary variable equal to one if the firm has established relationships with the major green bond underwriters before 2014. *GB issuance* is a binary variable that indicates a green bond in the data. The sample includes all firm-year observations. Standard errors are clustered at the two-digit SIC industry and firm level. In panel A, major GB underwriters are determined for each year. In panel B, major GB underwriters are defined for a general case.

Figure 2. Instrumental variable.



This figure shows the instrumental variable. I use relationships with major green bond underwriters established before 2014 as an instrument for green bond issuance.

Table 3. Effect of prior relationships with banks on GB issuance

OLS Regression		IV Regression		
	(1)		(2)	(3)
	CO_2 emissions		CO_2 emissions	CO_2 emissions
GB issuance	−0.054	GB issuance	0.24	
(short term)	(0.17)	(short term)	(5.92)	
Post GB	−0.17 **	Post GB		0.23
(long term)	(0.087)	(long term)		(5.69)
Year FE	YES	Year FE	YES	YES
Country FE	YES	Country FE	YES	YES
Observations	20,603	Observations	20,603	20,603
R-squared	0.04	F-stats	66.82	86.19

Robust standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Effect of green bond issuance on CO2 emissions. This table reports estimates of the OLS regression and IV regression. The outcome variable is *CO2 emissions* divided by book value of assets in thousand dollars. *GB issuance* is a binary variable equal to one if a company issued a green bond in a given year. *Post GB* is a binary variable equal to one to represent subsequent years after green bond issuance (two and more years post-issuance). All standard errors are clustered at the two-digit SIC industry level.

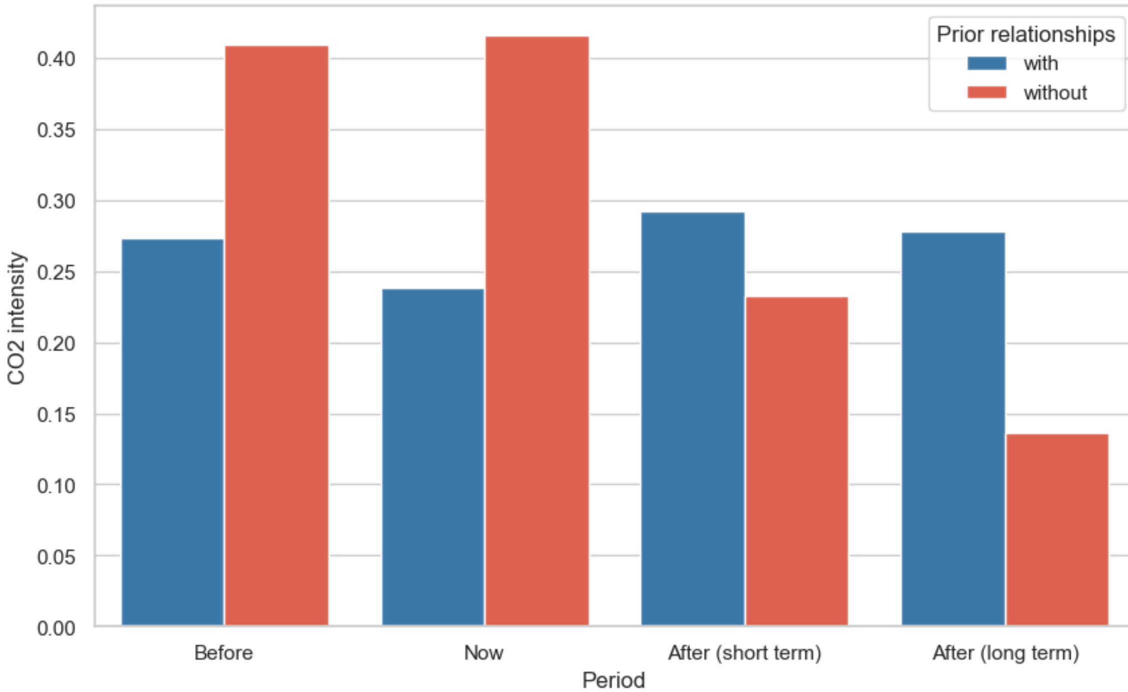
Table 4. Interaction regression model

	(1) CO_2 emissions	(2) CO_2 emissions	(3) CO_2 emissions	(4) CO_2 emissions
GB w/o relationships	-0.097	-0.08		
(short term)	(0.098)	(0.102)		
GB w/ relationships	0.144	0.23**		
(short term)	(0.129)	(0.012)		
GB w/o relationships			-0.26**	-0.27**
(long term)			(0.112)	(0.107)
GB w/ relationships			0.24	0.35**
(long term)			(0.17)	(0.156)
R^2	0.22	0.25	0.3	0.25
N	20,924	20,603	20,924	20,603
Industry FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Country FE		YES		YES

Robust standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

This table presents the effect of prior relationships with major green bond underwriters on CO2 emissions. This table reports estimates of the OLS regression with *Prior relationships* as a term. The outcome variable is *CO2 emissions* scaled by the book value of the assets in thousand dollars. *GB* is a binary variable equal to one if a company issued a green bond in a given year. *Post GB* is a binary variable equal to one for representing subsequent years after green bond issuance (two and more years post-issuance). *No relationships* and *With Relationships* are dummy variables indicating the relationships between a firm and an underwriter. All standard errors are clustered at the two-digit SIC industry level and year.

Figure 3. The effect of prior relationships with major green bond underwriters on emission intensity.



This graph shows the effect of prior relationships with major green bond underwriters on emission intensity. The red bars represent companies with no prior relationships, while the blue bars denote companies with a history of prior relationships.

Table 5. Yield comparison (within firm univariate analysis)

	(1) Green	(2) Conventional	(3) Difference	(4) t-stat
Full sample				
Yield	2.17	2.55	-0.36	0.8
Firms with prior relationships				
Yield	2.08	2.72	-0.64	0.9
Firms without prior relationships				
Yield	2.29	2.34	-0.05	0.8

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

This table reports the mean difference in yields at issuance between green and conventional bonds issued by the same company. Panel A shows the difference in yields for the full sample. Panel B presents the difference for a subsample of firms that had prior relationships with major green bond underwriters. Panel C report the greenium for a subsample of firms that did not have prior relationships with major green bond underwriters.

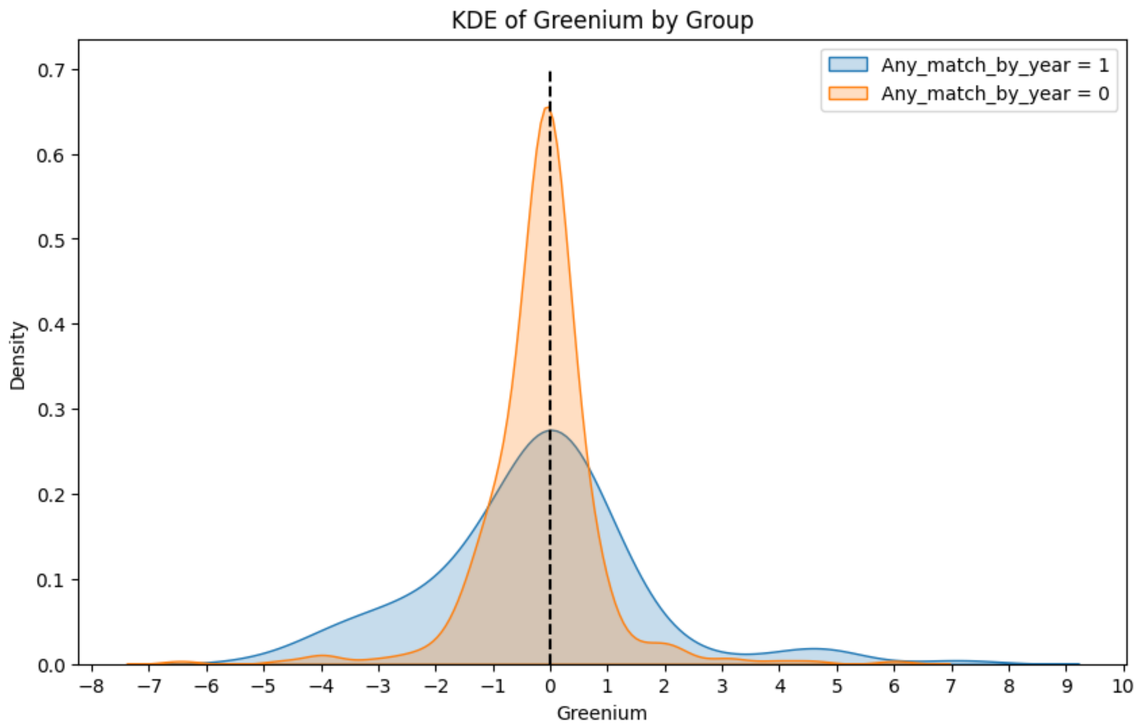
Table 6. Yield comparison (between firm univariate analysis)

	(1) Green	(2) Conventional	(3) Difference	(4) t-stat
Full sample				
Yield	2.95	3.15	-0.19***	-3.23
Firms with prior relationships				
Yield	4.85	5.13	-0.28	1.67
Firms without prior relationships				
Yield	2.26	2.42	-0.16***	2.91

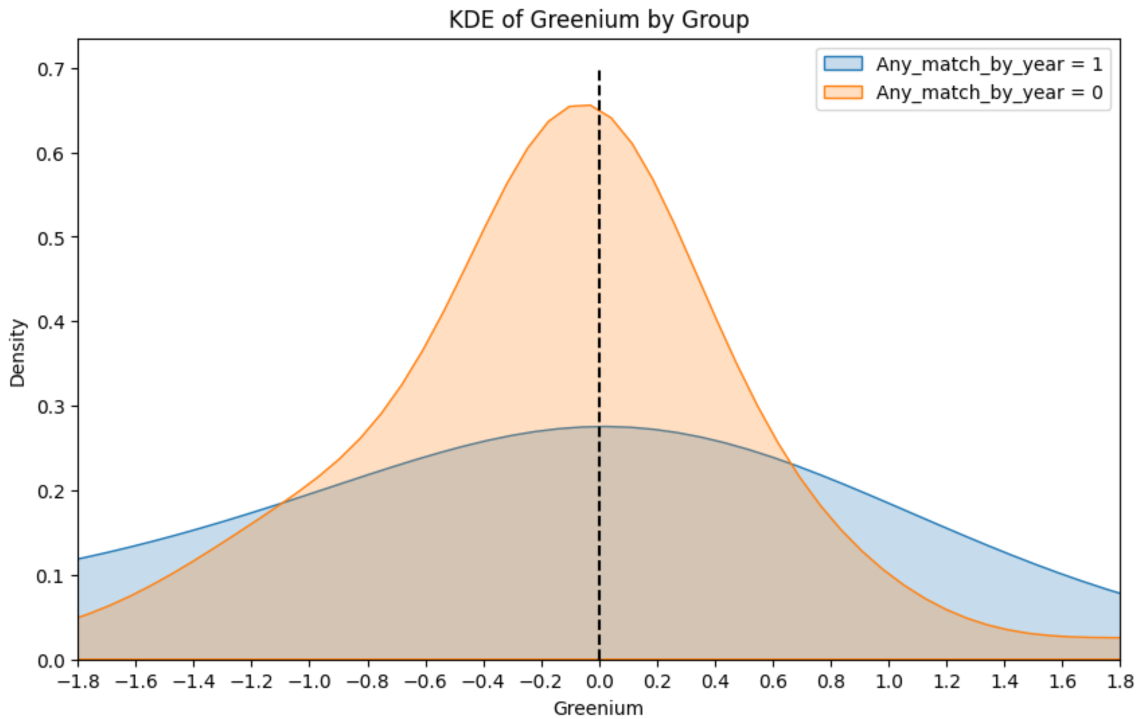
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

This table reports the mean difference in yields at issuance between green and conventional bonds of the matched sample. Panel A shows the difference in yields for the full sample. Panel B presents the difference for a subsample of firms that had prior relationships with major green bond underwriters. Panel C report the greenium for a subsample of firms that did not have prior relationships with major green bond underwriters.

B Appendix One



This figure plots the density distribution of greenium for two groups.



This figure plots the density distribution of greenium for two groups.