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Corporate green bonds: a credible commitment toward the environment?

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Abstract

This paper examines the corporate green bonds market between 2013 and 2021. The total annual issuance of this market has increased by 99% from 2020 to 2021, mainly in industries related to manufacturing and raw materials. Further, the funds of these corporate bonds should be exclusively used for green projects. This paper, therefore, examines whether corporate green bonds are a credible commitment toward the environment. My findings suggest that the stock market reacts positively to the issuance of corporate green bonds. In addition, I find significant evidence that the environmental performance is affected by the issuance of corporate green bonds. Finally, my findings show that corporate green bonds do not provide a cheaper source of financing relative to non-green bonds of the same issuer. Overall, my results provide some evidence that the issuance of corporate green bonds currently functions as a credible commitment toward the environment.

Keywords: Green bonds; Corporate sustainability; Corporate responsibility; Environmental social and governance (ESG); Climate change; Impact investing; Sustainable finance

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1. Introduction

In 2007, the European Investment Bank (EIB) issued the world's first labelled green bond; the Climate Awareness Bond (EIB, 2022). The green bond market later developed strongly as the International Capital Market Association (ICMA) developed the Green Bond Principles (GBP) in 2014 (ICMA, 2022). These voluntary principles provided companies with an incentive and framework to report on their environmental performance. In 2015, all United Nations member states agreed on the 17 Sustainable Development Goals (SDGs) when they adopted the "2030 Agenda for Sustainable Development". Since then, Environmental, Social, and Governance (ESG) measurements have become important research topics in both professional and academic areas. Recently, the European Commission (2021) adopted the Green Deal, which legally bound the member states of the European Union to become climate neutral by 2050. In addition, their greenhouse gas emissions must be reduced by 55% by 2030 relative to the 1990 levels. Similarly, China has set itself the goal of achieving carbon neutrality by 2060, whilst having its greenhouse gas emissions peak before 2030 (IEC, 2021). During these developments,

the market of green bonds has grown exponentially as the total annual green bond issuance has increased by 75% between 2020 and 2021 (CBI, 2021). In the same period, the market of corporate green bonds has increased by 99% (section 4.1).

The attractive characteristic of green bonds is that it offers the possibility to finance environmental and climate-friendly projects. Further, the issuance of green bonds mandates companies to use the acquired funds exclusively for green projects, which in turn limits the available investment opportunities for these companies. This may make it more attractive to issue conventional bonds and invest these proceeds into green projects if these are deemed more financially viable than other non-green projects. Even so, this constraining nature could signal a credible commitment toward the environment. For instance, it is difficult for investors to quantify a company's influence on the environment since they are mostly dependent on voluntary disclosures by issuers (Tang & Zhang, 2020). Global environmental standards and certificates might, therefore, potentially lead to more credibility and transparency on the green bond market. This raises the question whether corporate green bonds are currently a credible commitment towards the environment. This paper closely examines the market of corporate green bonds. To compile a database of corporate green bonds, I extract both private and public corporate green bonds that were issued between 2013 and 2021 from Eikon and Bloomberg. Then, I empirically examine the corporate green bond market over time, by industry, and by country (section 4.). This analysis shows that the number of corporate green bonds and the total annual issuance of this market has increased continually since 2013, and that these bonds are most prevalent in industries that heavily affect the environment (e.g., "Materials" and "Utilities"). In addition, these bonds are mostly issued in China, the United States, and Europe (especially in the Netherlands, France, and Germany). Finally, corporate green bonds tend to have a high bond rating, as barely any bond has a rating below investment grade.

Green bonds can be used to signal a company's commitment toward the environment. In addition, these bonds could be used to improve economic performance by managing the environmental risks (e.g., Sharfman & Fernando, 2008; Bachelet, Becchetti & Manfredonia,

2019; Amiraslani, Lins & Servaes, 2022). In other words, green bonds could be used to signal value beyond the expected risk and return characteristics of a security (section 2.1). However, investors often lack sufficient information to evaluate a company's commitment toward the environment (Lyon & Montgomery, 2015). This could in turn affect the credibility of the corporate green bond market. Thus, I have examined the stock market's reaction to the announcement of corporate to observe whether investors see corporate green bonds as a credible commitment toward the environment (section 5.). Using an event study with 103 event dates, I find no evidence that the stock market reacts to the issuance of corporate green bonds. However, I find significant positive results when using a nonparametric test. This provides some evidence that the abnormal returns are systematically higher surrounding the issuance, which could suggest that investors see the issuance of corporate green bonds as a credible signal.

In several countries, it is not mandatory to use an external reviewer to issue a green bond. In addition, the taxonomy of green bonds and the definition of green activities differ globally (Ehlers & Packer, 2017). This could subsequently lower the credibility of the green bond market and form an opportunity for certain companies to make unsubstantiated claims about their environmental performance (section 2.2). To account for this possibility, I have examined whether the environmental performance of companies improves after the issuance of corporate green bonds (section 6.). This paper matches firms as there are no strict counterfactuals of how firm-level outcomes would evolve in absence of the corporate green bond issuance. My control group consists of bond issuers that operate in the same industry, country, and year. Next, the nearest neighbor is selected based on multiple firm-level characteristics in the previous year. These groups are then compared using a difference-in-differences methodology. The results show that the environmental rating and the CO_2 emissions (weighted) have significant negative values. This enforces the notion that the issuance of corporate green bonds is a credible signal of a firm's commitment towards the environment. Subsequently, this contradicts the suspicions that greenwashing is a motive behind the issuance of corporate green bonds.

Another rationalization to issue green bonds might be that investors may be willing to sacrifice financial returns to make a social impact (section 2.3). This could lower the cost of debt, which is mainly based on a company's default risk due to uncertainty its future activities. In addition, some view environmental risk as an inherent part of this risk-return tradeoff since it could prevent environmental events, and possible litigation and compliance costs, for example (Sharfman & Fernando, 2008). Consequently, I have examined whether corporate green bonds might improve company's access to cheaper financing (section 7.). This method uses a within issuer matching approach, which avoids the challenge of finding similar securities that differ due to structural differences. Next, the sample is restricted to bonds that have non-missing information on the yield at issue, and the control group consists of bonds that have the same coupon type and credit rating as the corresponding corporate green bonds. Next, the nearest neighbor is selected based on multiple bond-level characteristics. The results show that there is a significant difference between the yield at issue of green corporate green bonds and non-green bonds. However, this result becomes insignificant when including firm fixed effects. Whilst there is no green premium, corporate green bonds do seem to be a credible commitment toward the environment.

This paper contributes to the current literature on multiple on multiple levels. First, it adds to the growing literature about the green bond market (e.g., Zerbib, 2019; Bachelet et al., 2019; Tang & Zhang, 2020; Flammer, 2021). In addition, this paper looks at more recent data. This is interesting as the corporate green bond market has grown significantly over recent years. In line with earlier papers (e.g, Tang & Zhang, 2020; Flammer, 2021), my finding show that the stock market reacts to the issuance of corporate green bonds. Second, I found significant environmental improvements following the issuance of corporate green bonds. This is in line with the findings of Flammer (2021), who found that issuers improve their environmental performance after issuing corporate green bonds. Also, this enforces the notion that the issuance of corporate green bonds is a credible signal of a firm's commitment towards the environment. Next, this paper does not produce significant evidence that corporate green

bonds grant access to a cheaper source of financing. This contributes to the literature that did not find a significant difference in the yields between green corporate bonds and non-green bonds (e.g. Tang & Zhang, 2020; Flammer, 2021).

The remainder of this paper is organized as follows: Section 2. forms a theoretical background around the market of corporate green bonds. Section 3. discusses the required data sources and how to obtain this data. Section 4. shows the development of corporate green bonds over time and across industries and countries. Section 5. examines the stock market reaction to the issuance of corporate green bonds by using an event study. Section 6. examines whether the issuance of green corporate bonds affects firm-level outcomes by using a difference-in-differences methodology. Section 7. identifies whether there is a green bond premium. Finally, Section 8. concludes this paper and provides recommendations for further research.

2. Theoretical background

In this section, I will discuss the most common rationales for issuing green bonds. The first rationale is that companies can use corporate green bonds to signal their commitment toward the environment. The second rationale is that companies use corporate green bonds as a tool of greenwashing. In addition, I will describe several standards that can be used to limit greenwashing. The final rationale is that companies can issue corporate green bonds to acquire a cheaper source of financing.

2.1 Signaling

According to Lyon & Montgomery (2015), investors often lack sufficient information to evaluate a company's commitment toward the environment. From the investors' perspective, this information asymmetry adds a transaction cost to the purchase of a corporate green bond. Thus, it may be in the best interest of a firm to decrease this information asymmetry by taking actions that credibly supports their commitment and aspirations. The literature has shown that

CSR and ESG measures have led to a significant positive effect on financial performance and firm value, in both the short and long term (Tang & Zhang, 2020). Also, Amiraslani et al. (2022) found that high-CSR firms were better able to sustain themselves during the previous economic crisis, as they were able to borrow relatively more money and on better terms than conventional bond issuers. Their paper also stated that this was because investors believed that high-CSR firms were less likely to engage in asset substitution and diversion. However, these findings might also be explained from the perspective that high-CSR firms internalize environmental externalities. In line with this, Bachelet et al. (2019) found that companies are increasingly starting to realize that managing their environmental exposure might simultaneously improve their economic performance whilst managing their environmental risks. This is especially attractive to risk averse investors and those that consider environmentally friendly projects when investing. In congruence with this, Reichelt (2010) found that green products broaden the investor base of companies as investors seem to increasingly incorporate ESG criteria into their analysis. Further, Klassen & McLaughlin (1996) and Flammer (2013) found that environmentally responsible behavior leads to a significant stock price increase, whilst irresponsible behavior leads to a decrease in the stock price. More recently, Tang & Zhang (2020) and Flammer (2021) found a significant increase in stock prices following the announcement of a corporate green bond issuance. Nonetheless, signals about company's environmental commitment are only credible if the issuance of corporate green bonds demands sufficiently less effort for the high-quality senders than for low-quality senders. Otherwise, investors can't distinguish between the two. According to Flammer (2021), green bonds likely meet this required differentiation and credibility, since green bonds are often certified by independent third parties to ensure that the proceeds are used for green projects. This process requires substantial managerial effort and resources, and non-compliance with this certification is costly (section 2.2). Finally, it should be noted that green bonds limit the investment opportunities. This constraining nature could be another reason why issuing corporate green bonds is a credible signal of a company's commitment toward the environment.

2.2 Greenwashing & certification

Theoretically speaking, companies can issue green bonds as long as they can substantiate that they will use the funds to invest in green projects. However, it is difficult for investors to quantify a company's influence on the environment since they are mostly dependent on voluntary disclosures (Tang & Zhang, 2020). As a result, companies could potentially use green corporate bonds as a tool of greenwashing. This is the practice of misleading people into adopting overly positive beliefs about an organization's environmental performance. Practitioners have raised concerns since the green bond market relies on private governance, which lacks the enforcement mechanisms that public regulation provides (Flammer, 2021). Also, it differs globally what the taxonomy of a green bond is, and what activities are recognized as an activity that benefits the environment (Ehlers & Packer, 2017). To avoid such ambiguities, the European Commission commissioned the High-Level Expert Group (HLEG) on Sustainable Finance to give advice on how to achieve the climate targets of 2030 and beyond. According to them, it is important to create a technically robust classification system for activities, with the aim of making it easy to mobilize capital for sustainable purposes (EU HLEG, 2018). The HLEG expects that a shared taxonomy and sustainability labels will make it easier to identify which investments and assets contribute to the EU's goals. Currently, the GBP and the Climate Bond Initiative (CBI) are the largest initiatives for the certification of green bonds. The GBP requires that an issuer meets the following criteria: (1) the use of proceeds should explain how the issuer's green project can provide clear environmental benefits, and how these factors can be quantified, (2) the process for project evaluation and selection should be explained in a transparent manner, (3) the management of proceeds should be tracked periodically to track the balance of the projects, and (4) the issuer should provide annual information on the use of proceeds (ICMA, 2021). The CBI has a similar approach but distinguishes itself by using sector-specific eligibility criteria to determine the carbon value and suitability for a green bond. In addition, the certificate from CBI requires that an issuer has used external verification to check their environmental standards (Ehlers & Packer, 2017). If a company meets the conditions for a CBI certificate, green bonds do not present a logical greenwashing mechanism due to the costly

and time intensive nature of meeting the conditions for this certification.

2.3 Cost of Capital

The costs for realizing projects come from both equity and debt. The cost of equity theoretically depends on a tradeoff between risk and return. Some view environmental risk as an inherent part of this risk-return tradeoff since it could prevent possible litigation and compliance costs (Sharfman & Fernando, 2008). This is especially attractive to risk averse investors and those that consider sustainable and environmentally friendly projects when investing. In addition, environmental risk management can be used to reduce the likelihood of extreme environmental events, and the consequences of environmental regulation. Also, early movers might experience more favorable circumstances since they have room to invest more evenly in sustainability. If environmental risk management leads to a decrease in systematic risk, investors should reward this with a lower cost of equity, all else equal. Furthermore, Heinkel, Kraus & Zechner (2001) found that green investors only invest in companies that incorporate environmental risk management, whilst non-green investors do not show this preference. This could mean that the absence of environmental risk management potentially leads to a smaller investor base. Subsequently, if there is less demand for non-green securities the cost of equity would likely increase. Further, the cost of debt is the applicable interest rate on a company's debt instruments and is mainly based on a company's default risk due to uncertainty its future activities. If investors view environmental risk management activities as a valid contribution to the company's overall risk management, these efforts will be rewarded with lower required interest rates. Despite that, Sharfman & Fernando (2008) found a significant positive relation between environmental risk management and the cost of debt. These results do not change after controlling for leverage, size, and industry effects. Furthermore, their results show that better environmental risk management allows firms to increase their leverage, and that these companies also achieve higher tax benefits. When controlling for these phenomena, the cost of debt remains positively and significantly related to environmental risk management. Similarly, Magnanelli & Izzo (2017) found that corporate social performance (CSP) has a significant

positive relationship with the cost of debt. These results seem to suggest that pro-environmental bonds are not interpreted as a risk reduction factor. In contrast, Kaenzig et al. (2013) found that investors are willing to accept a 16% lower yield to change to a more environmentally friendly default electricity mix. Further, Zerbib (2019) found a small significant premium in the green bond market that was related to the pro-environmental preferences of investors. Whilst Bachelet et al. (2019) found a positive premium for private green bonds, they found a negative green premium for institutional green bonds. When the former is divided into certified and non-certified, it appears that this positive premium is mainly caused by non-certified green bonds. Flammer (2021) and Tang & Zhang (2020) have specifically examined the corporate green bond market. Tang & Zhang (2020) found that corporate green bonds have a yield spread that is 0.69% lower than that of non-green corporate bonds. These results become insignificant after comparing these yields within the same issuing firm and in the same year. This seems to be in line with Flammer (2021), who found no differing yield at issue after matching green and non-green corporate bonds of the same issuer using multiple characteristics.

3. Data

To compile a database of corporate green bonds, I extract bonds from the Eikon database that are labeled as “corporate” and as “green bonds”. Eikon uses green bonds that have been certified by CBI (Refinitiv, 2021). I exclude Sukuks as these are fundamentally different than regular bonds. For example, bond are debt obligations whilst a sukuk indicates the ownership of a specific asset that are compliant with Shariah (SEC Nigeria, n.d.). Besides, bond prices are mainly based on credit rating whilst the price of sukuk are based on the underlying value of the aforementioned assets. Next, I extract corporate green bond from Bloomberg’s fixed income database for which the “Green bond indicator” is “Yes”. Bonds marked as “Government” in the Level 1 BICS (Bloomberg Industry Classification System) will be removed since they are fundamentally different in nature from other bonds. Bloomberg tags a bond as “green” when the concerning company has additional statements that the green bonds are in line with the

GBP, and (1) labels their bond as a green bond, or (2) identifies the bond as an "environmental sustainability-oriented bond" (ICMA, 2017). Besides, the use of the proceeds must be fully dedicated to green activities, and the issuer must provide a mandatory term sheet, and optionally a side letter, a syndicate email, an official statement from the issuer, or publish a review by an external party. Next, the certified corporate green bonds from Eikon are combined with the "self-labelled" corporate green bonds from Bloomberg in order to create a sizeable sample. This paper only uses bonds that have a unique observation after merging these datasets on the bond ISIN. Finally, all currencies are converted to US dollars ($) to simplify the mutual comparison of the bonds.

This paper collects its accounting and stock market data from Compustat North America and Compustat Global. Compustat contains accounting information for each firm and the identifiers for their firm, industry, and location. This data is used to construct the following variables: "Size" is the natural logarithm of the book value of total assets (in $); the "Return on Assets" or ROA is the ratio of operating income before depreciation to the book value of total assets; "Tobin's Q" is the ratio of the market value of total assets to the book value of total assets, and "Leverage" is the ratio of debt to the book value of total assets. Since it is practically impossible to verify the reliability of all values, the ratios are winsorized at the 1^{st} and 99^{th} percentiles. This operation replaces values smaller than the 1^{st} percentile by the mean of the 1^{st} percentile, for example.

Further, the ESG data is obtained from Eikon's ASSET4. This database specializes in providing auditable and systematic ESG information. In this process, companies are judged along three pillars: environment, social issues, and corporate governance. The downside of these specific ratings is the lack of agreement across different raters which subsequently decreases the mutual comparability (Chatterji et al., 2016). According to Berg, Koelbel & Rigobon (2020), these ratings tend to diverge due to differing measurements of the same firm (weight divergence) and differing rating categories (scope divergence). A global shared taxonomy for ESG ratings is, therefore, invaluable for the development of the green bond market. Due to the

subjective nature of ESG ratings, I use carbon dioxide (CO_2) emissions as a measure of transparency and verifiability. Two variables CO_2 emissions are extracted from Eikon; (1) ENRO26V: the percentage change of total CO2 equivalent emissions (year-over-year), and (2) ENRDP023: the total CO_2 and CO_2 equivalents emission in tons (including scope 1 and scope 2). The latter is used the create the following two variables: (1) "log(CO_2 emissions)" which is the natural logarithm of the CO_2 emissions, and (2) "CO_2 emissions (weighted)" which weights the CO_2 emissions by the book value of assets. The CO_2 variables are all winsorized at the 1st and 99th percentiles of its distribution.

4. Corporate green bonds

The selection of section 3. has yielded a sample of 3772 corporate green bonds that were issued between 2013 and 2021. Subsequently, this section examines the developments of the corporate green bond market over time, by country and by industry. Then, it will be examined how the characteristics of corporate green bonds differ on the bond- and firm-level.

4.1 Corporate green bonds over time

Figure 1 and Figure 2 show the development of the corporate green bond market over time. From this figure, it is evident that the number of corporate green bonds has increased significantly since 2013. Table A.1 shows that the amount of these bonds increased by 68% between 2020 and 2021, whilst the annual issuance has increased by 99% in the same period. This trend is likely to be reinforced by the increasing interest of investors in green projects (section 2.1). In addition, mainly due to sustainability risks related to regulation, I expect that companies will more often choose to issue green instruments (section 2.3). Finally, the average issuance amount fluctuates each year, which could have been caused by a variation in size of the issuers.

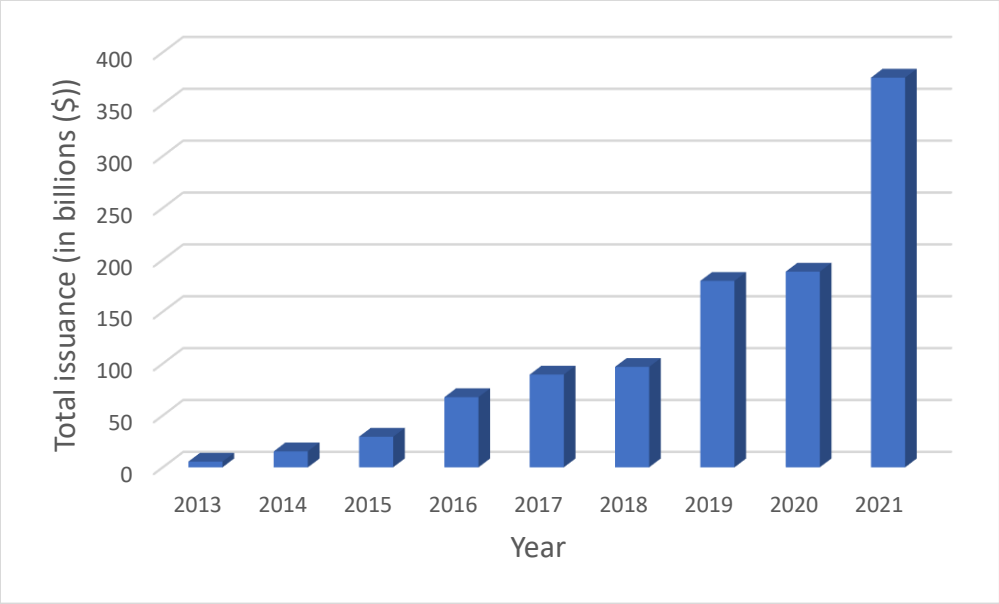

Figure 1: The annual issuance amount of the issued corporate green bonds

This figure shows the developments of corporate green bonds over time. Also, this figure contains information about the amount of bonds and the amount issued (in $B) between 2013 and 2021 based on the available information on Eikon and Bloomberg.

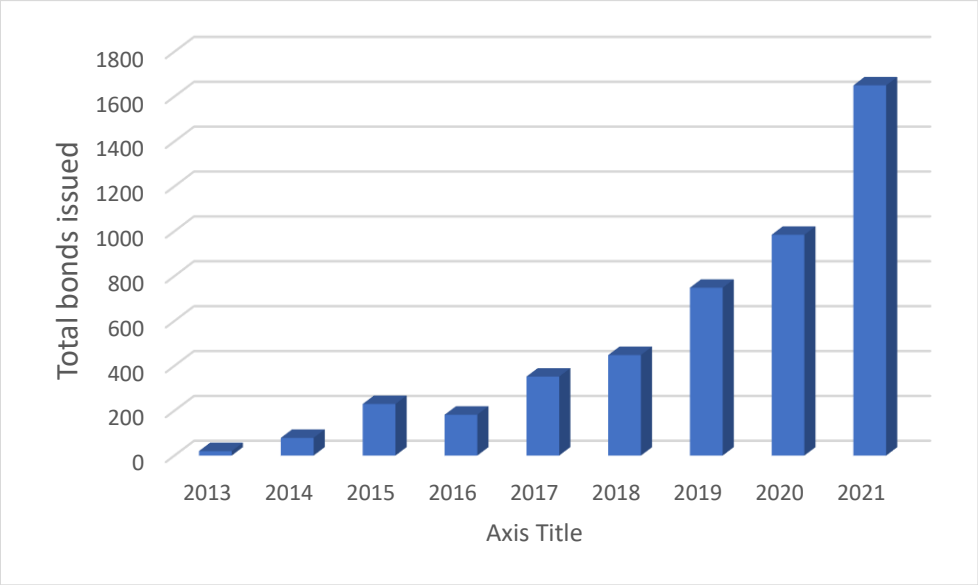

Figure 2: The annual number of issued corporate green bonds

This figure shows the developments of corporate green bonds over time and contains information about the amount of bonds and the amount issued (in $B) between 2013 and 2021 based on the available

information on Eikon and Bloomberg.

4.2 Corporate green bonds across industries

Figure 2 and Table A.2 show the distribution of corporate green bonds across industries. These industries are based on the level 1 BICS from Bloomberg. Beside the financial sector, corporate green bonds are more prevalent in industries that heavily affect the environment, such as "Materials" and "Utilities". Table A.3 provides a more subdivided picture of the distribution of corporate green bonds across specific industries. These industries are based on the level 2 BICS from Bloomberg. It should be noted that these instruments are mainly issued in industries related to manufacturing and raw materials, such as "Automobiles Manufacturing", "Metals & Mining", and "Pipeline".

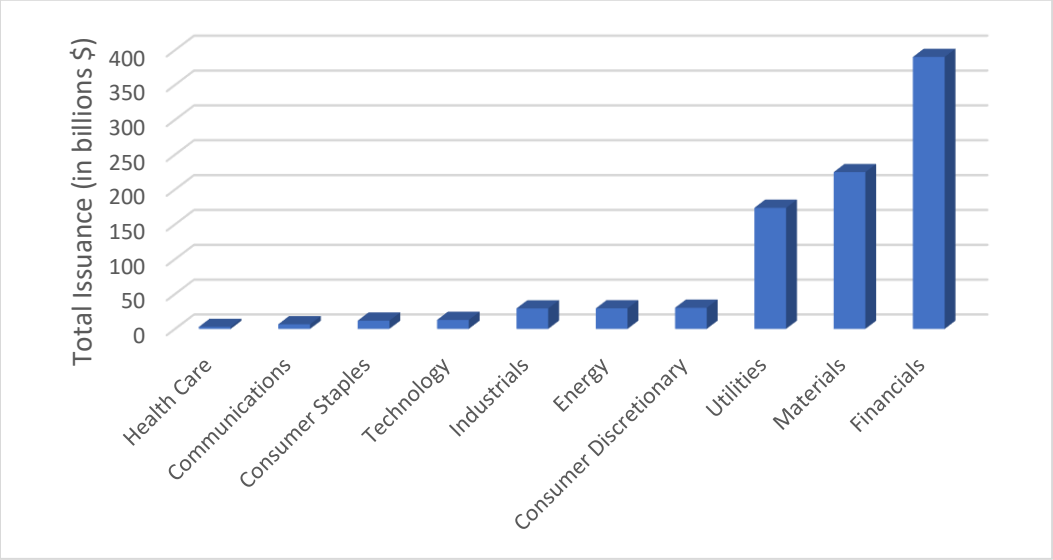

Figure 3: Corporate green bonds by industry

This figure shows the developments of corporate green bonds across industries. The industries are based on the level 1 BICS (Bloomberg Industry Classification System) from Bloomberg. Also, this figure contains information about the amount of bonds and the amount issued (in $B) between 2013 and 2021

based on the available information on Eikon and Bloomberg.

4.3 Corporate green bonds across countries

Next, Figure 3 and Table A.4 show the distribution of corporate green bonds across countries. These bonds are mostly present in China, the United States, and Europe (especially in the Netherlands, France, and Germany). Note that these results may have been affected by countries that grant subsidies to companies to issue green bonds (e.g., China, Hong Kong, Japan, and Singapore).

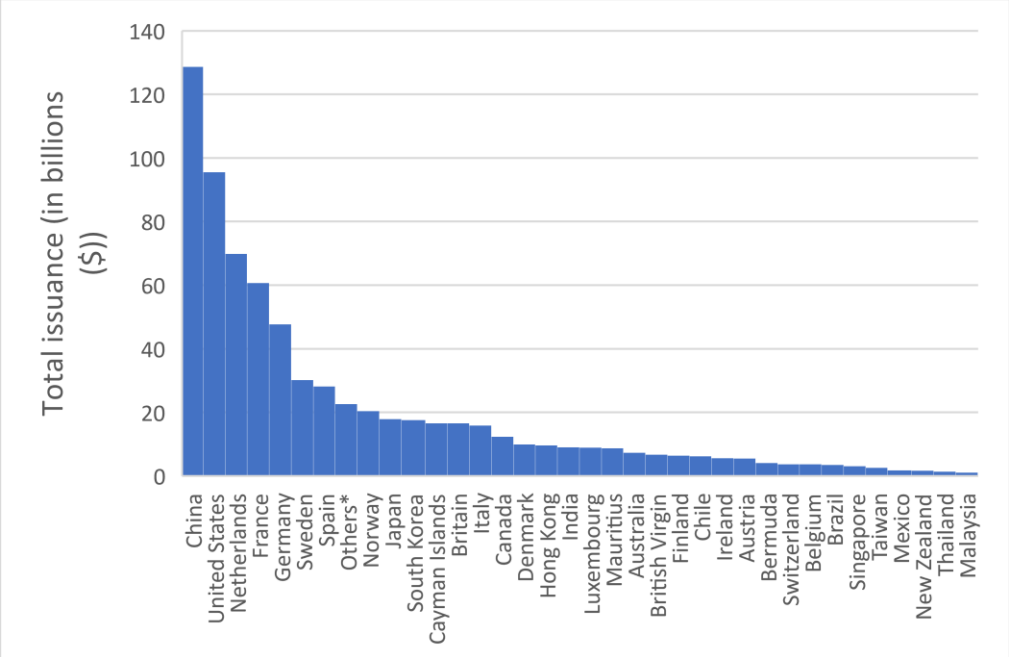

Figure 4: Corporate green bonds across countries

This figure shows the developments of corporate green bonds across countries. Also, this figure contains information about the amount of bonds and the amount issued (in $B) between 2013 and 2021 based on the available information on Eikon and Bloomberg.

(*) "Others" refers to countries that have issued less than 10 corporate green bonds.

4.4 Summary statistics at the bond-level

Table 1 shows the summary statistics at the green bond-level, and it differentiates between private and public companies. Column (1) provides the summary statistics for all 3772 corporate green bonds which were issued by 1300 companies. Since several companies have issued multiple bonds on the same day and in the same year, there are 2860 green bond issuer-days and 1939 green bond issuer-years. A majority of 67.1% are fixed-rate bonds and the average coupon is 2.5% with a maturity of 7.3 years. The median S&P credit rating is BB+, Baa1 for Moody and BBB+ for the Bloomberg's composite rating. Column (2) and column (3) provide specific information about private and public firms. Private firms have issued 2562 bonds divided over 764 unique firms, whilst 1210 bonds were issued by 531 public firms. Note that there are relatively more private corporate green bonds. Further, a relatively larger share of public companies is certified, and public companies tend to issue relatively larger bonds that have slightly lower ratings, on average. In its entirety, corporate green bond issuers have a high rating, as barely any bond has a rating below investment grade (lower than Baa3 for Moody's, lower than BBB- for S&P, and lower than BBB- for Bloomberg's composite rating).

Table 1: Summary statistics at the green bond-level

	All (1)	**Private (2)**	**Public (3)**
# Green bonds	3772	2562	1210
# Green bonds issuer-days	2860	1825	1035
# Green bonds issuer-years	1939	1152	787
# Green bonds issuers	1300	772	528
Issuance amount (in billions $)	0.243 (0.325)	0.194 (0.250)	0.320 (0.428)
Certified (1/0)	0.869 (0.338)	0.844 (0.363)	0.920 (0.272)
Maturity	7.26 (6.26)	7.38 (5.96)	7.00 (6.84)
Fixed-rate bond (1/0)	0.671 (0.470)	0.665 (0.472)	0.685 (0.472)
Coupon (for fixed-rate bonds)	0.024 (0.021)	0.025 (0.021)	0.022 (0.021)

Credit rating			
S&P rating (median)	BBB+	BBB	BBB
Moody's rating (median)	Baa1	A3	Baa2
Bloomberg's composite rating (median)	BBB+	BBB	BBB

This table shows the summary statistics of corporate green bonds, and it differentiates between all corporate green bonds (column 1), private (column 2), and public companies (column 3). This table contains information about corporate green bonds between 2013 and 2021 based on the available information on Eikon and Bloomberg. Also, this table contains the number of observations (obs), and the standard deviations are given between brackets. #Green bond issuer-days are unique days on which corporate green bonds are issued by a company; #Green bond issuer-years are unique years in which corporate green bonds are issued by a company; #Green bond issuers are the number of unique firms; Certified is a dummy variable which is equal to one if a firm is certified by the Climate Bonds Initiative database; Maturity is the amount of years until the maturity of a corporate green bond; Fixed-rate bond is a dummy that is equal to one if the coupons are fixed; Coupon is the coupon rate for the corporate green bonds that have a fixed-rate; S&P rating is the median rating of Standard & Poor's; Moody's rating is the median rating of Moody, and Bloomberg's composite rating is the median rating formed by Bloomberg.

4.5 Summary statistics at the firm-level

Table 2 shows the summary statistics at the firm-level, and it differentiates between corporate bond issuers and non-green bond issuers. This data is based on the fiscal year before the issue date. Column (1) provides the summary statistics for 1194 corporate green bond issuers and 33861 non-green bond issuers. The non-green bond issuer consists of companies that are identified as bond issuers by Eikon. Their characteristics are shown as the average of firms that are in the same country, year and two-digit SIC industry. As this table shows, corporate green bond issuers are different with regard to all the characteristics. Table 3 compares green bonds in the year before the issue with the full sample of these green bonds. These groups differ on the CO_2 emissions (percentage) and the social rating. This might suggest that the corporate

green bond issuer tend to differ near the issuance of these bonds. Finally, section 6. provides a more detailed comparison of corporate green bond issuers and non-green bond issuers at the firm-level

Table 2: Summary statistics of corporate bond issuers

	Obs.	**Green bond issuers**	**Obs.**	**(Non-green) bond issuers**	**p-value (diff. in means)**
Size	12798	9.265 (2.966)	78955	9.468 (0.755)	0.000
ROA	10363	-0.006 (0.730)	78955	0.007 (0.025)	0.000
Tobin's Q	8592	1.372 (9.704)	69210	1.003 (0.473)	0.000
Leverage	12749	0.254 (0.290)	78955	0.258 (0.051)	0.001
CO_2 emissions (percentage)	714	0.925 (27.255)	44551	3.255 (10.113)	0.000
Log(CO_2 emissions)	1110	13.758 (2.170)	67851	12.518 (1.439)	0.000
CO_2 emissions (weighted)	1110	66.238 (159.250)	67851	95.396 (145.137)	0.000
Environment rating	1282	61.545 (24.636)	68778	47.699 (10.609)	0.000
Social rating	1282	58.530 (21.857)	68778	51.770 (7.065)	0.000
Governance rating	1282	59.693 (25.188)	68778	50.680 (8.802)	0.000

This table shows the summary statistics of corporate bond issuers, and it differentiates between all corporate green bonds (column 1), and non-green bonds in same country, (SIC) industry and year (column 2). This table contains information about corporate green bonds issuers between 2013 and 2021 based on the available information on Eikon and Bloomberg. Also, this table contains the number of observations (obs), and the standard deviations are given between brackets. $*$, $**$, and $***$ denotes significance at the 10%, 5%, and 1% level, respectively.

Table 3: Summary statistics of corporate green bond issuers

	Obs.	Green bond issuers (full sample)	Obs.	Green bond issuers (pre-issue year)	p-value (diff. in means)
Size	12798	9.265 (2.966)	1296	9.345 (2.854)	0.396
ROA	10363	-0.006 (0.730)	1034	-0.005 (0.727)	0.944
Tobin's Q	8592	1.372 (9.704)	946	1.126 (4.196)	0.408
Leverage	12749	0.254 (0.290)	1266	0.252 (0.206)	0.742
CO_2 emissions (percentage)	129	-3.358 (17.079)	586	1.869 (28.949)	0.049***
Log(CO_2 emissions)	144	13.557 (2.193)	966	13.788 (2.166)	0.233
CO_2 emissions (weighted)	144	47.935 (146.080)	966	68.967 (161.014)	0.139
Environment rating	1282	61.545 (24.636)	165	61.582 (23.850)	0.984
Social rating	1282	58.530 (21.857)	165	61.931 (20.910)	0.032**
Governance rating	1282	59.693 (25.188)	165	62.081 (23.789)	0.192

This table shows the summary statistics of corporate green bond issuers in the year before the issuance. This table contains information about corporate green bonds issuers between 2013 and 2021 based on the available information on Eikon and Bloomberg. Also, this table contains the number of observations (obs), and the standard errors are given between brackets. $*$, $**$, and $***$ denotes significance at the 10%, 5%, and 1% level, respectively.

5. Stock market reaction to the issuance of corporate green bonds

In this section, I will use an event study methodology to observe the market's reaction to a company's announcement that they will issue corporate green bonds. These announcements provide information about the bond issuance and a company's commitment towards the environment. The announcement date is obtained from Bloomberg's fixed income database

which yields a sample of 103 event dates between 2013 and 2021.

5.1 Event study methodology

An event study methodology is applied to examine the stock market reaction to the issuance of corporate green bonds. The announcement dates will serve as an event date since this is the first time that the stock market receives information about the issuance of the corporate green bonds. Next, I use the following baseline windows surrounding the event date: [-5, 10], [-3, 3], and [-1, 1]. In keeping with Flammer (2021), I will consider the windows [-20, -11] and [-10, -6] since it is possible that information about this issue has come out at an earlier time. Also, I will consider the event window [11, 20] to account for a possible delay in the market's reaction.

This paper uses the daily abnormal returns (Equation (2)) to capture the stock market's reaction to the issuance of corporate green bonds. The abnormal return captures the situation when the stock market performance diverges from a company's expected return. This paper uses the Capital Asset Pricing Model (CAPM) in Equation (1) to approach the expected return with an Ordinary Least Squares (OLS) regression. The MSCI All Country World Equity Index is used to represent the market return since Flammer (2021) found that this index yields similar results as country-specific market indices. Next, the cumulative abnormal return (CAR) is computed for each firm using Equation (3). Since it is practically impossible to verify the integrity of every return, the returns are winsorized at the 1st and 99th percentiles of its distribution.

$$R_{i,t} = \alpha_i + \beta_i * R_{m,t} + \varepsilon_{i,t} \quad (1)$$

where $R_{i,t}$ is the expected return for company i at time t, $R_{m,t}$ is the expected market return at time i, β_i represents the systematic risk, and ε_i represents the residual

$$Abnormal\ return_{i,t} = R_{i,t} - \hat{R}_{i,t} \quad (2)$$

where $R_{i,t}$ is the actual return for company i at time t and $\hat{R}_{i,t}$ is the expected return for company i at time t

$$CAR = \Sigma AR_{i,t} \quad (3)$$

where $AR_{i,t}$ is the abnormal return for company i at time t

5.2 Results

Table 4 shows the CARS for the selected intervals using 103 event dates. The results of the t-test show that the abnormal returns are insignificant in all the event windows. These results would suggest that the stock market does not react to the issuance of corporate green bonds. However, this parametric test relies on the assumption that the test statistic has a normal distribution. According to Serra (2002), the distribution of abnormal returns tends to have fat tails and are right skewed. Our returns seem to show the same characteristics. To account for possible asymmetry, I used the nonparametric Wilcoxon Signed Rank Test since this test assumes no fixed probability distribution, and it considers both the magnitude and the sign of the test statistic. This test returns a significant positive market reaction in the [-1, 1] event interval. The CAR is, therefore, only systematically higher during this specific event period. Thus, this paper finds some evidence of a small positive market reaction to the issuance of corporate green bonds. This is in line with the findings of Tang & Zhang (2020) and Flammer (2021) who find a significant increase in stock prices following the announcement of a corporate green bond issuance.

Table 4: Event study; stock market reaction following the announcement of a green bond issue

Event interval	Obs.	CAR	sd	P-value (t-test)	P-value (Wilcoxon signed-rank test)
[-20, -11]	102	0.097	1.196	0.314	0.122
[-10, -6]	98	-0.028	0.730	0.669	0.909
[-5, 10]	103	0.066	1.406	0.571	0.941
[-3, 3]	99	0.012	0.845	0.874	0.195
[-1, 1]	103	0.001	0.696	0.992	0.069*
[11, 20]	100	-0.095	1.205	0.310	0.637

This table shows the average cumulative abnormal return (CAR, Equation (3)) for each firm using the Capital Asset Pricing Model (CAPM) model (Equation (1)). Also, this table contains the number of observations (obs) and the standard deviations (sd). ∗, ∗∗, and ∗∗∗ denotes significance at the 10%, 5%, and 1% level, respectively.

6. Corporate green bonds and firm-level outcomes

In this section, I will test whether the issuance of corporate green bonds lead to an improvement in firm-level outcomes. This could suggest whether corporate green bonds function as a credible commitment toward the environment. If greenwashing were to be present, there should be no tangible improvements in environmental performance following the issuance.

6.1 Matching methodology

This paper matches firms with each other as there is no strict counterfactual of how firm-level outcomes would evolve in absence of the green bond issuance. This matching method allows for the relevant outcome variables to be compared with each other in the years following the green bond issuance. It should be noted that the selection of the matching criteria is relatively subjective, which might make it difficult to compare studies. In line with Flammer (2021), the control group consists of bond issuers that operate in the same two-digit SIC industry, country,

and year. These measures are taken to ensure a similar business environment among the matched firms. In addition, information from the Eikon database is used to confirm which companies are bond issuers. Next, the green bond issuers are matched with the nearest non-green bond issuer using the Mahalanobis distance across the following firm-level characteristics in the previous year (t-1): (1) Tobin's Q, (2) ROA, (3) leverage, and (4) size. Tobin's Q and ROA are used to differentiate whether firms are more profitable or have better growth perspectives. Further, leverage and size are selected to determine the extent to which a company has access to the financial markets.

Table 5 shows the summary statistics of the green and the matched firms in the year before the issuance. This table sheds light on the similarities between the green and non-green firms in the year before the issuance of the green bond. For the difference-in means, the following matching criteria are similar: size, leverage, and CO_2 emissions (p-values between 0.114 and 0.589). For the difference-in-medians, the following matching criteria are similar: size, ROA, leverage, log(CO_2 emissions) and CO_2 emissions (weighted) (p-values between 0.211 and 0.965). Table 6 shows the summary statistics of the pre-trend of the green and the matched firms. This descriptive data focusses on possible similar pre-trends, which is measured as the difference between t-1 and t-2. The tests of equal means cannot be rejected (with p-values from 0.351 to 0.886). Surprisingly, the same does not hold true for the tests of equal medians (with p-values equal to 0.000).

For robustness, I created a sample that included the ESG ratings to the firm-level matching criteria (see Appendix A). This was done to observe whether the addition of the variables increases the similarity between the matched groups. Unsurprisingly, Table A.5 shows that the samples become more similar with respect to the ESG ratings, but these groups tend to diverge on the other factors. Further, there are significantly less control firms as the matching criteria become stricter. Whilst this remains true for Table A.6, the results are similar to those of Table 6. Ultimately, I chose to use the matching process without the ESG matching criteria. This larger sample will likely provide a better picture of the corporate green bond market.

Table 5: Summary statistics for treated and control firms (pre-issue year).

		Obs.	Mean	Median	sd	P-value (diff. in means)	P-value (diff. in medians)
Matching variables							
Size	Green issuer	14417	9.407	9.093	2.831	0.114	0.965
	Matched	8992	9.466	9.093	2.646		
ROA	Green issuer	12405	-0.003	0.030	0.577	0.002***	0.559
	Matched	8556	0.017	0.030	0.125		
Tobin's Q	Green issuer	11632	1.063	0.724	6.202	0.010***	0.000***
	Matched	8375	0.882	0.686	1.991		
Leverage	Green issuer	14375	0.267	0.229	1.774	0.133	0.011**
	Matched	8988	0.239	0.220	0.224		
Environment rating	Green issuer	1651	59.066	64.250	25.654	0.000***	0.000***
	Matched	1645	51.315	56.280	27.961		
Social rating	Green issuer	1651	57.288	60.550	24.386	0.000***	0.000***
	Matched	1645	49.736	53.280	26.011		
Governance rating	Green issuer	1651	58.788	60.970	21.472	0.000***	0.000***
	Matched	1645	52.065	53.740	22.519		
Other variables							
CO_2 emissions	Green issuer	901	-0.258	-3.150	25.074	0.568	0.021**
(percentage)	Matched	775	0.491	-2.080	28.630		
Log(CO_2 emissions)	Green issuer	1422	13.515	13.346	2.135	0.005***	0.876
	Matched	1214	13.281	13.339	2.138		
CO_2 emissions	Green issuer	1422	53.069	2.444	140.380	0.034**	0.211
(weighted)	Matched	1214	67.547	3.109	207.754		

This table shows the summary statistics of corporate green bond issuers in the year preceding the bond issue, and it differentiates between green and matched firms. This table contains information about

corporate green bonds issuers between 2013 and 2021 based on the available information on Eikon and Bloomberg. Also, this table contains the number of observations (obs) and the standard deviations (sd). $*$, $**$, and $***$ denotes significance at the 10%, 5%, and 1% level, respectively.

Table 6: Summary statistics for treated and control firms (pre-trend).

		Obs.	Mean	Median	sd	P-value (diff-in means)	P-value (diff-in medians)
Matching variables							
Δ Size	Green issuer	13125	0.003	0.000	0.622	0.841	0.000***
	Matched	7694	0.001	0.000	0.724		
Δ ROA	Green issuer	10547	-0.003	0.000	0.423	0.523	0.000***
	Matched	7113	0.000	0.000	0.128		
Δ Tobin's Q	Green issuer	9780	0.012	0.000	3.668	0.767	0.000***
	Matched	6854	-0.002	0.000	1.787		
Δ Leverage	Green issuer	13061	-0.002	0.000	2.606	0.922	0.000***
	Matched	7688	0.000	0.000	0.243		
Δ Environment rating	Green issuer	1363	-0.012	0.000	10.642	0.709	0.000***
	Matched	1226	-0.202	0.000	15.095		
Δ Social rating	Green issuer	1363	-0.061	0.000	12.519	0.582	0.000***
	Matched	1226	-0.367	0.000	15.715		
Δ Governance rating	Green issuer	1363	-0.176	0.000	13.595	0.582	0.000***
	Matched	1226	-0.507	-0.105	16.896		
Other variables							
Δ CO_2 emissions	Green issuer	498	0.839	0.000	29.549	0.881	0.000***
(percentage)	Matched	354	0.489	0.000	38.366		
Δ log(CO_2 emissions)	Green issuer	1148	-0.003	0.000	0.552	0.893	0.000***

	Matched	885	0.000	0.000	0.601		
Δ CO_2 emissions	Green issuer	1148	0.293	0.000	51.601	0.795	0.000***
(weighted)	Matched	885	1.016	0.000	73.897		

This table shows the summary statistics of corporate green bond of the possible pre-trend, and it differentiates between green and matched firms. The delta (Δ) represents the pre-trend and is measured as the difference between t-1 and t-2. This table contains information about corporate green bonds issuers between 2013 and 2021 based on the available information on Eikon and Bloomberg. Also, this table contains the number of observations (obs) and the standard deviations (sd). ∗, ∗∗, and ∗∗∗ denotes significance at the 10%, 5%, and 1% level, respectively.

6.2 Difference-in-differences methodology

In this subsection, I will examine how firm-level outcomes evolve following the issuance of corporate green bonds using a difference-in-differences methodology. The variables of interest are the environment rating and the CO_2 emission variables. Next, I address the parallel trend assumption of the difference-in-differences method to ensure the internal validity. This assumption requires that the treatment and control group have almost parallel trends prior to the treatment. Failure to meet this condition will lead to biased results. A visual inspection is used as there is no statistical test to test this assumption (see Appendix B). The environmental score in Figure B.1 and the CO_2 emissions (percentage) in Figure B.2 have a similar trend among the treatment and control groups. In other words, the distance between the average observations remains relatively constant over time. In contrast, the log(CO_2 emissions) in Figure B.3 and the CO2 emissions (weighted) total in Figure B.4 seem to deviate from this parallel trend. Next, the difference-in-differences formula of Equation (4) will be used to describe the characteristics of the treatment. In line with Flammer (2021), this paper uses multiple green bond variables to distinguish between short- and long-term influences. This has been done to characterize the dynamics of the treatment variable. Robust standard errors have been used to account for possible heteroscedasticity.

$$y_{i,t} = \alpha_i + \alpha_c * \alpha_t + \alpha_s * \alpha_t + \beta * Green\ bond_{i,t} + \varepsilon_{i,t} \quad (4)$$

where $y_{i,t}$ is the outcome variable of interest; α_i represents the firm fixed effects; $\alpha_c * \alpha_t$ represents the country by year fixed effects; $\alpha_s * \alpha_t$ represents the industry by year fixed effects; $Green\ bond_{i,t}$ is a dummy variable that is equal to 1 if a firm issues green bonds, and zero otherwise, ε_i represents the residual.

6.3 Results

Table 7 shows the results of the difference-in-differences method that was applied to multiple environmental performance measures. The results show that green bond issuers have lower environment ratings in the year prior to the issuance of the corporate green bond. This trend seems to hold true in the year following the issuance as well. In addition, the CO_2 emissions (weighted) are significantly lower in the year following the corporate green bond issuance. These results seem to indicate that the issuance of corporate green bonds is a credible commitment towards improving the environment. This is in line with the findings of Flammer (2021), who found that greenwashing does not seem to be the motive behind the issuance of corporate green bonds. It should be noted that the results of the difference-in-differences test consist of a limited number of observations in the years beyond the issue date since most of my sample was issued in 2021. As more projects are initiated and developed, this could lead to different results for the years following the issuance.

Table 7: Difference-in-differences results (environmental performance)

	Environment rating	**CO_2 emissions (percentage)**	**Log(CO_2 emissions)**	**CO_2 emissions (weighted)**
Green bond (pre-issue year, t-1)	-2.610 (1.337)**	3.655 (4.072)	0.019 (0.711)	3.922 (4.812)
Green bond (issue year)	-1.520 (1.569)	-3.278 (4.144)	-0.015 (0.069)	4.004 (5.833)

Green bond (post-issue year, t+1)	-3.250 (1.863)**	4.894 (5.006)	0.026 (0.106)	-9.936 (6.868)*
Green bond (t+2+)	-1.954 (2.312)	-6.923 (6.063)	0.118 (0.106)	4.445 (13.401)
Firm fixed effects	Yes	Yes	Yes	Yes
Country-year fixed effects	Yes	Yes	Yes	Yes
Industry-year fixed effects	Yes	Yes	Yes	Yes
Observations	2768	1501	2358	2207
R-squared	0.007	0.053	0.066	0.218

This table shows the difference-in-differences regression as specified in Equation (4). This table contains information about the matched corporate green bond issuers and non-green bonds issuers between 2013 and 2021. The green bond dummy is constructed in four ways; (1) using the pre-issue year, (2) using the issue year, (3) using the year following the issue (short-term), and (4) using the observation from two years following the issuance (long-term). *, **, and *** denotes significance at the 15%, 10%, and 5% level, respectively.

7. Greenium

Environmental risk management can be used to reduce the likelihood of extreme environmental events and the consequences of environmental regulation. In section 2.3, I discussed that efforts regarding environmental risk management could result in lower required interest rates if it was perceived as a valid contribution to a company's overall risk management. In this section, I will identify the effect of pro-environmental preferences in the form of a green bond premium (or "greenium"). This premium is defined as the difference between the yield at issue of corporate green bonds and non-green bonds of the same issuer.

7.1 Matching methodology

This section uses a within issuer matching approach which avoids the challenge of finding similar securities that differ due to structural differences (e.g., credit quality and tax treatment). The sample is restricted to the bonds that have non-missing information on the yield at issue.

Subsequently, the non-green bonds will be collected from these issuers, and those bonds will be linked to the most comparable green bonds of the same issuer with the same coupon type and bond rating. Next, the corporate green bonds are matched with the nearest non-green bond neighbor using the Mahalanobis distance and the following characteristics: (1) log(issuance), (2) maturity, and (3) the amount of time between the issuance between the corporate green bond and non-green bond. These characteristics ensure that the corporate green bonds differ only because of the green projects. The differences in yield between the corporate green bonds and the matched non-green bond are observed using an OLS regression (Equation (5)). The control variables in this formula consist of the variables that have not been matched exactly. Thus, these variables control for factors that are not completely covered by our matching method.

$$\Delta y_{i,t} = \alpha_o + \beta_1 * \Delta\, Issued + \beta_2 * \Delta\, Maturity_{i,t} + \beta_3 * \Delta\, Issuedate_{i,t} + \varepsilon_{i,t} \qquad (5)$$

where $\Delta y_{i,t}$ is the yield spread between green bonds and the matched non-green bond of the same issuer; α_o captures the time invariant effect of the greenness; Δ Issued is the natural logarithm of the total issuance amount; Δ M*aturity* is the time to maturity; Δ Issuedate is the difference in the issuance date, and ε_i represents the residual.

7.2 Results

Table 8 shows the results of the comparison of the yield at issue between 97 couples of corporate green bonds and non-green bonds. My results reveal that there is a significant difference of 37.2 basis points between the yields of the matching and the control group. This difference seems to be caused by the pro-environmental preference of investors as these bonds should ideally differ only on the greenness of the bond. This is in line with the findings of Zerbib (2019) and Kaenzig et al. (2013). Also, these results are consistent with the cost of capital argument that suggests that companies issue corporate green bonds to acquire a cheaper source of financing. This should intuitively lead to a positive stock return since investors might

benefit from this cheaper source of debt financing, and this allows a company to invest in more strategic activities. However, similar to Tang & Zhang (2020), these significant results become insignificant when adding firm fixed effects. This also adds to the findings of Flammer (2021) and , who found no differing yield at issue after matching green and non-green corporate bonds. Altogether, these results do not point to a conclusive confirmation these green instruments are rewarded with a lower cost of debt.

Table 8: Comparison of yield at issue between corporate green bonds and non-green bonds.

	Yield spread	
	(1)	**(2)**
Green	-0.372 (0.118)***	-0.196 (1.128)
Δ Log(issuance)	0.112 (0.031)	-0.067 (0.046)
Δ Maturity	0.000 (0.000)***	0.000 (0.000)***
Δ Bond Rating	-0.000 (0.000)***	-0.001 (0.000)***
Issuer FE	No	Yes
R-squared	0.555	0.779
Observations	97	97

This table shows the differences of the yield at issue (in percentages) using an OLS regression (Equation (5)). *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

8. Conclusion

This paper examines the continually growing corporate green bond market between 2013 and 2021. With that, this paper examines more recent data than most other papers about the green bond market (e.g., Zerbib, 2019; Bachelet et al., 2019; Tang & Zhang, 2020; Flammer, 2021). The attractive characteristic of these bonds is that they offer the possibility to finance environmental and climate-friendly projects, which in turn could also affect the ESG profiles of companies. Further, corporate green bonds are more prevalent in industries that heavily affect

the environment (e.g., “Materials” and “Utilities”). In addition, these bonds are mostly present in China, the United States, and Europe (especially in the Netherlands, France, and Germany). Some countries (e.g., China, Hong Kong, and Singapore) grant subsidies for issuing corporate bonds which may decrease comparability. Thus, further research could examine whether these subsidies affect the credibility of corporate green bonds. Next, I find that the announcement of a corporate green bond issuance has a significant effect on a company’s stock prices. The results of the event study might suggest that investors see the issuance of corporate green bonds as a credible signal towards the environment. This is in line with the findings of Flammer (2021), who found that issuers improve their environmental performance after issuing corporate green bonds. Since I solely use the MSCI All Country World Equity Index as the market proxy, further research could differentiate between market indices to increase robustness. Further, I find that the environment rating and the CO_2 emissions (weighted) are significantly influenced by the issuance of corporate green bonds. Again, this enforces the notion that the issuance of corporate green bonds is a credible signal of a firm’s commitment towards the environment. Subsequently, this contradicts the suspicions that greenwashing is a motive behind the issuance of corporate green bonds. Note that my sample consist of a limited number of observations in the years following the issuance date as most bonds were issued in 2020 and 2021. Thus, future research should observe the corporate green bond market over the next few years to see if my results are still representative of the corporate green bond market. Finally, I find that the yield at issue is lower for green corporate bonds than for non-green bonds of the same issuer. However, these significant results become insignificant when adding firm fixed effects. Thus, this paper does not produce significant evidence that corporate green bonds grant access to a cheaper source of financing. This contributes to the literature that did not find a significant difference in the yields between green corporate bonds and non-green bonds (e.g. Tang & Zhang, 2020; Flammer, 2021). This insignificant green premium is interesting as I find significant differences between the environmental and stock market performance of green and non-green bonds. Thus, whilst there is no green premium, corporate green bonds do seem to be a credible commitment toward the environment.

Appendix A: Tables

Table A.1: Corporate green bonds over time

Year	# Bonds	Mean	sd	Total Issuance (year)
2013	20	0.274	0.454	5.5
2014	79	0.195	0.306	15.4
2015	230	0.128	0.228	29.5
2016	182	0.371	0.551	67.6
2017	352	0.254	0.388	89.4
2018	448	0.216	0.389	96.8
2019	748	0.240	0.381	179.7
2020	984	0.192	0.269	188.6
2021	1650	0.228	0.279	375.6
Total	4693	0.223	0.331	1048.1

This table shows the developments of corporate green bonds over time. Also, this table contains information about the amount of bonds and the amount issued (in $B) between 2013 and 2021 based on the available information on Eikon and Bloomberg. The last column shows the total issuance by year. Also, this table contains the standard deviations (sd).

Table A.2: Corporate green bonds by industry

Industry	# Bonds	Mean	sd	Total Issuance (industry)
Communications	10	0.657	0.221	6.6
Consumer Discretionary	128	0.237	0.304	30.3
Consumer Staples	37	0.318	0.354	11.8
Energy	315	0.094	0.152	29.5
Financials	1763	0.221	0.350	390.2

Health Care	9	0.312	0.370	2.8
Industrials	190	0.154	0.159	29.3
Materials	79	0.315	0.249	24.9
Technology	30	0.430	0.396	12.9
Utilities	585	0.297	0.302	173.7
Total	3146	0.226	0.320	711.9

This table shows the developments of corporate green bonds across industries. The industries are based on the level 1 BICS (Bloomberg Industry Classification System) from Bloomberg. Also, this table contains information about the amount of bonds and the amount issued (in $B) between 2013 and 2021 based on the available information on Eikon and Bloomberg. The last column shows the total issuance by industry. Finally, this table contains the standard deviations (sd).

Table A.3: Corporate green bonds by industry (detailed)

Industry	**# Bonds**	**Mean**	**sd**	**Total**
Airlines	3	0.087	0.030	0.3
Apparel & Textile	2	0.292	0.294	0.6
Auto Parts Manufacturing	6	0.309	0.203	1.9
Automobiles Manu	37	0.378	0.458	14.0
Banks	812	0.247	0.434	200.8
Cable & Satellites	1	0.700	-	0.7
Chemicals	21	0.332	0.203	7.0
Coal Operations	1	0.065	-	0.1
Commercial Finance	49	0.187	0.198	9.1
Communications	4	0.734	0.495	2.9
Construction Materials	2	0.028	0.020	0.1
Consumer Finance	90	0.265	0.341	23.9
Consumer Product	6	0.126	0.149	0.8
Consumer Services	1	0.086	-	0.1

Containers & Packaging	15	0.438	0.216	6.6
Department Store	2	0.061	0.024	0.1
Diversified Bank	75	0.484	0.423	36.3
Educational Services	2	0.180	0.158	0.4
Electrical Equipment	7	0.173	0.189	1.2
Entertainment	1	0.060	-	0.1
Exploration	1	0.075	-	0.1
Financial Services	81	0.093	0.151	7.5
Food & Beverage	24	0.338	0.286	8.1
Forest & Paper P	21	0.310	0.234	6.5
Funds & Trusts	1	0.500	-	1.0
Hardware	9	0.200	0.178	1.8
Health Care Faci	7	0.289	0.371	2.0
Home Improvement	5	0.162	0.106	0.8
Homebuilders	2	0.294	0.253	0.6
Industrial Other	93	0.110	0.125	10.3
Integrated Oils	2	0.066	0.016	0.1
Internet Media	1	0.300	-	0.3
Life Insurance	13	0.415	0.216	5.4
Machinery Manufacturing	6	0.220	0.179	1.3
Manufactured Goo	2	0.119	0.029	0.2
Mass Merchants	1	1.704	-	1.7
Medical Equipment	1	0.750	-	0.8
Metals & Mining	20	0.237	0.304	4.7
Pharmaceuticals	1	0.039	-	0.0
Power Generation	327	0.228	0.286	74.6
Property	6	0.441	0.321	2.6
Railroad	11	0.301	0.169	3.3
Real Estate	635	0.163	0.194	103.5

Refining & Markets	10	0.162	0.180	1.6
Renewable Energy	301	0.092	0.152	27.6
Retail - Consume	8	0.188	0.193	1.5
Retail - Consume	1	0.500	-	0.5
Semiconductors	15	0.540	0.398	8.1
Software & Services	2	0.029	0.012	0.1
Supermarkets & P	5	0.140	0.202	0.7
Transportation &	35	0.134	0.159	4.7
Travel & Lodging	59	0.172	0.198	10.1
Utilities	258	0.384	0.299	99.1
Waste & Environment	36	0.228	0.181	8.2
Wireless Telecom	2	0.816	0.038	1.6
Wireline Telecom	6	0.656	0.228	3.9
Total	3146	0.226	0.320	711.9

This table shows the developments of corporate green bonds across industries. The industries are based on the level 2 BICS (Bloomberg Industry Classification System) from Bloomberg. Also, this table contains information about the amount of bonds and the amount issued (in $B) between 2013 and 2021 based on the available information on Eikon and Bloomberg. The last column shows the total issuance by industry. Finally, this table contains the standard deviations (sd).

Table A.4: Corporate green bonds across countries

Country	**# Bonds**	**Mean**	**sd**	**Total Issuance (country)**
Australia	22	0.332	0.238	7.3
Austria	26	0.211	0.232	5.5
Belgium	12	0.305	0.290	3.7
Bermuda	13	0.314	0.203	4.1
Brazil	50	0.070	0.120	3.5
Britain	66	0.252	0.245	16.6

British Virgin	29	0.231	0.176	6.7
Canada	43	0.289	0.176	12.4
Cayman Islands	56	0.297	0.176	16.6
Chile	12	0.518	0.274	6.2
China	399	0.323	0.517	128.7
Denmark	23	0.435	0.287	10.0
Finland	22	0.289	0.231	6.4
France	287	0.211	0.349	60.7
Germany	316	0.151	0.222	47.7
Hong Kong	47	0.206	0.237	9.7
India	32	0.284	0.200	9.1
Ireland	13	0.432	0.195	5.6
Italy	35	0.453	0.272	15.9
Japan	149	0.120	0.157	17.9
Luxembourg	30	0.301	0.232	9.0
Malaysia	123	0.009	0.025	1.1
Mauritius	22	0.402	0.148	8.8
Mexico	10	0.176	0.163	1.8
Netherlands	115	0.608	0.265	69.9
New Zealand	14	0.120	0.117	1.7
Norway	117	0.174	0.256	20.4
Singapore	16	0.191	0.184	3.1
South Korea	105	0.167	0.193	17.6
Spain	84	0.335	0.330	28.2
Sweden	381	0.079	0.115	30.2
Switzerland	25	0.148	0.095	3.7
Taiwan	35	0.073	0.056	2.6
Thailand	26	0.056	0.033	1.4
United States	292	0.327	0.376	95.5

Others*	99	0.229	0.227	22.7
Total	3146	0.226	0.320	711.9

This table shows the developments of corporate green bonds across countries. Also, this table contains information about the amount of bonds and the amount issued (in $B) between 2013 and 2021 based on the available information on Eikon and Bloomberg. The last column shows the total issuance by country. Also, this table contains the standard deviations (sd). (*) "Others" refers to countries that have issued less than 10 corporate green bonds.

Table A.5: Summary statistics for treated and control firms (pre-issue year) – alternative method.

		Obs.	Mean	Median	sd	P-value (diff. in means)	P-value (diff. in medians)
Matching variables							
Size	Green issuer	10889	9.593	9.133	3.082	0.000***	0.000***
	Matched	1838	12.073	12.478	2.838		
ROA	Green issuer	8995	0.005	0.031	0.623	0.025**	0.000***
	Matched	1798	0.038	0.038	0.057		
Tobin's Q	Green issuer	8238	1.148	0.743	7.110	0.039**	0.000***
	Matched	1779	0.800	0.655	0.538		
Leverage	Green issuer	10847	0.281	0.221	2.153	0.825	0.000***
	Matched	1838	0.270	0.251	0.161		
Environment rating	Green issuer	1947	57.747	60.920	26.043	0.008***	0.204
	Matched	1507	55.368	59.870	26.142		
Social rating	Green issuer	1947	56.024	58.100	25.380	0.004***	0.272
	Matched	1507	53.523	57.200	25.272		
Governance rating	Green issuer	1947	58.087	63.380	22.042	0.000***	0.000***
	Matched	1507	53.959	56.460	20.757		

Other variables							
CO_2 emissions	Green issuer	891	3.216	-1.360	30.950	0.109	0.939
(percentage)	Matched	754	0.941	-1.630	25.660		
Log(CO_2 emissions)	Green issuer	1617	13.681	13.639	2.089	0.000***	0.030**
	Matched	1203	13.392	13.401	1.985		
CO_2 emissions	Green issuer	1617	52.814	3.026	134.465	0.164	0.011**
(weighted)	Matched	1203	61.469	1.846	195.734		

This table shows the summary statistics of corporate green bond issuers in the year preceding the bond issue, and it differentiates between green and matched firms. This table contains information about corporate green bonds issuers between 2013 and 2021 based on the available information on Eikon and Bloomberg. Also, this table contains the number of observations (obs) and the standard deviations (sd). ∗, ∗∗, and ∗∗∗ denotes significance at the 10%, 5%, and 1% level, respectively.

Table A.6: Summary statistics for treated and control firms (pre-trend) – alternative method.

		Obs.	**Mean**	**Median**	**sd**	**P-value (diff-in means)**	**P-value (diff-in medians)**
Matching variables							
Δ Size	Green issuer	9605	0.000	0.000	0.670	0.707	0.002
	Matched	1588	0.007	0.000	0.591		
Δ ROA	Green issuer	7195	-0.001	0.000	0.594	0.954	0.014
	Matched	1528	-0.001	0.000	0.062		
Δ Tobin's Q	Green issuer	6472	0.048	0.000	5.196	0.709	0.006
	Matched	1500	0.298	0.000	0.298		
Δ Leverage	Green issuer	9544	0.020	0.000	2.120	0.723	0.000
	Matched	1588	0.001	0.000	0.099		
Δ Environment rating	Green issuer	1659	0.103	0.000	10.430	0.734	0.000

	Matched	1157	-0.060	0.000	14.960		
Δ Social rating	Green issuer	1659	0.066	0.000	12.826	0.879	0.000
	Matched	1157	0.147	0.000	15.040		
Δ Governance rating	Green issuer	1659	-0.027	0.000	12.701	0.462	0.000
	Matched	1157	-0.433	0.000	16.545		
Other variables							
Δ CO_2 emissions	Green issuer	481	0.039	0.000	26.925	0.841	0.000
(percentage)	Matched	343	-0.411	-0.390	37.443		
Δ log(CO_2 emissions)	Green issuer	1335	0.010	0.000	0.513	0.916	0.000
	Matched	897	0.007	0.000	0.450		
Δ CO_2 emissions	Green issuer	1355	0.879	0.000	49.229	0.873	0.000
(weighted)	Matched	897	1.265	0.000	64.552		

This table shows the summary statistics of corporate green bond of the possible pre-trend, and it differentiates between green and matched firms. The delta (Δ) represents the pre-trend and is measured as the difference between t-1 and t-2. This table contains information about corporate green bonds issuers between 2013 and 2021 based on the available information on Eikon and Bloomberg. Also, this table contains the number of observations (obs) and the standard deviations (sd). $*$, $**$, and $***$ denotes significance at the 10%, 5%, and 1% level, respectively.

Appendix B: Figures

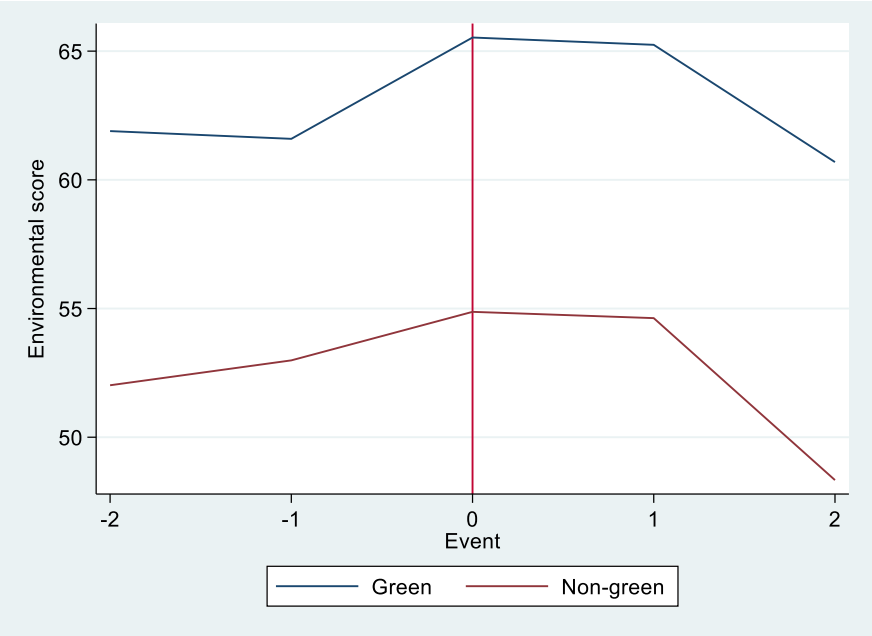

Figure B.1: Environmental score trend among the treatment and control groups

The horizontal axis shows the days until the event (t=0). In addition, the vertical axis shows the average over these time periods. The blue line represents the treatment group consisting of the corporate green bonds. The red line represents the control group consisting of the non-green bonds.

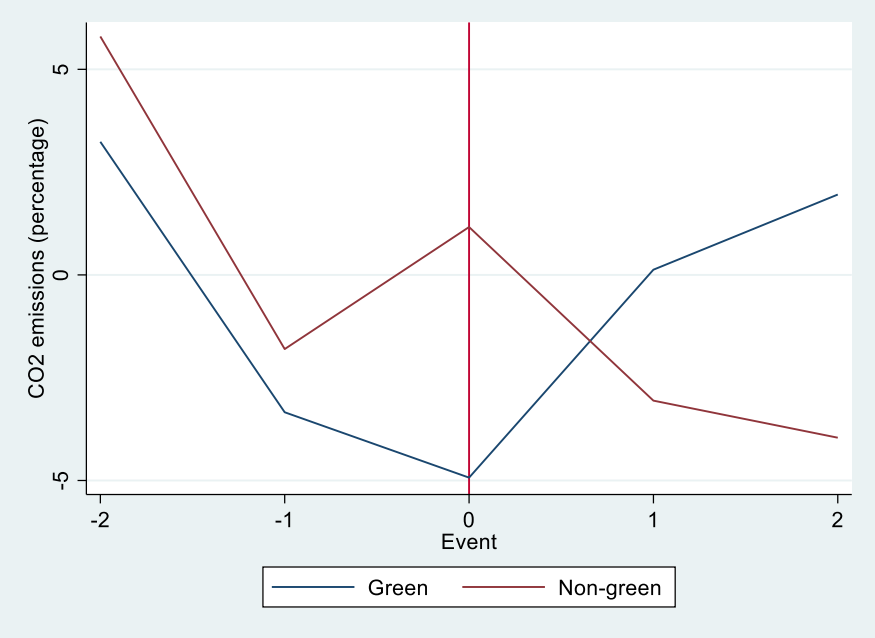

Figure B.2: CO_2 *emission (percentage) among the treatment and control groups*

The horizontal axis shows the days until the event (t=0). In addition, the vertical axis shows the average over these time periods. The blue line represents the treatment group consisting of the corporate green bonds. The red line represents the control group consisting of the non-green bonds.

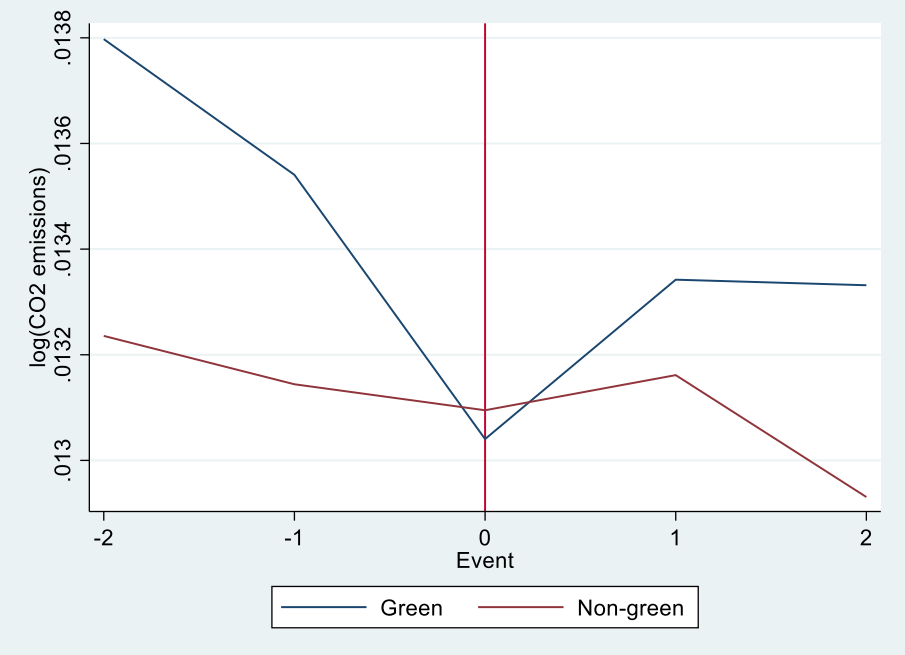

Figure B.3: log(CO_2 emissions) among the treatment and control groups

The horizontal axis shows the days until the event (t=0). In addition, the vertical axis shows the average over these time periods. The blue line represents the treatment group consisting of the corporate green bonds. The red line represents the control group consisting of the non-green bonds

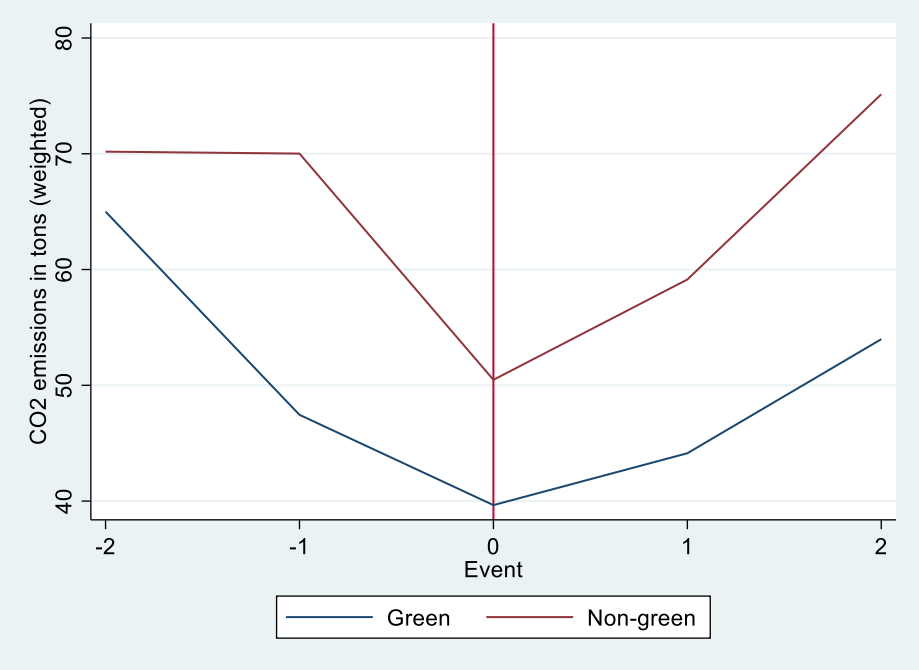

Figure B.4: CO_2 emissions (weighted) among the treatment and control groups

The horizontal axis shows the days until the event (t=0). In addition, the vertical axis shows the average over these time periods. The blue line represents the treatment group consisting of the corporate green bonds. The red line represents the control group consisting of the non-green bonds.

References

Amiraslani, H., Lins, K. V., Servaes, H., & Tamayo, A. (2022). Trust, social capital, and the bond market benefits of ESG performance. *Review of Accounting Studies*. https://doi.org/10.1007/s11142-021-09646-0

Bachelet, M. J., Becchetti, L., & Manfredonia, S. (2019). The Green Bonds Premium Puzzle: The Role of Issuer Characteristics and Third-Party Verification. *Sustainability, 11*(4), 1098. https://doi.org/10.3390/su11041098

Berg, F., Koelbel, J., Rigobon, R., 2020. *Aggregate confusion: the divergence of ESG ratings.* Unpublished working paper. Massachusetts Institute of Technology.

Chatterji, A.K., Durand, R., Levine, D.I., Touboul, S. (2016). Do ratings of firms converge? Implications for managers, investors and strategy researchers. *Strategic Management Journal 37*, 1597–1614.

CBI. (2021). *Interactive Data Platform*. Consulted via https://www.climatebonds.net/market/ data/

Ehlers, T. & Packer, F. (2017). Green Bond Finance and Certification. *BIS Quarterly Review*.

European Commission. (2021). *European Climate Law*. Consulted via https://ec.europa.eu/clima/eu-action/european-green-deal/european-climate-law_en

European Investment Bank (EIB). (2022). *15 years of EIB green bonds: leading sustainable investment from niche to mainstream*. Consulted via https://www.eib.org/en/ press/ all/2022 -308-15 -years-of-eib-green-bonds-leading-sustainable-investment-from-niche-to-mainstream

Flammer, C. (2013). Corporate social responsibility and shareholder reaction: the environmental awareness of investors*. Academy of Management Journal, 56*, 758–781.

Flammer, C. (2021). Corporate green bonds. *Journal of Financial Economics, 142, 499-516.* doi: /10.1016/j.jfineco.2021.01.010

Heinkel, H., Kraus, A. & Zechner, J. (2001). The Effect of Green Investment on Corporate Behavior. *Journal of Financial and Quantitative Analysis, 36*(4), 431-449. https://doi-org.eur.idm.oclc.org/10.2307/2676219

ICMA. (2017). *The GBP Databases and Indices Working Group - Summary of Green Bond*

Database Providers. Consulted via https://www.icmagroup.org/assets/documents/Regulatory/Green-Bonds/Green-Bond-Databases-Summary-Document-190617.pdf

ICMA. (2021). *Green Bond Principles Voluntary Process Guidelines for Issuing Green Bonds.* Consulted via https://www.icmagroup.org/sustainable-finance/the-principles-guidelines-and-handbooks/green-bond-principles-gbp/

ICMA. (2022). *Green Bond Principles (GBP)*. Consulted via https://www.icmagroup.org/sustainable-finance/ the-principles-guidelines-and-handbooks /green-bond-principles-gbp/

IEC. (2021). *An energy sector Roadmap to carbon neutrality in China*. Consulted via https://www.iea.org/reports/an-energy-sector-Roadmap-to-carbon-neutrality-in-china

Kaenzig, J., Heinzle, S. L., & Wüstenhagen, R. (2013). Whatever the customer wants, the customer gets? Exploring the gap between consumer preferences and default electricity products in Germany. *Energy Policy, 53*, 311–322. https://doi.org/10.1016/j.enpol.2012.10.061

Klassen, R.D., McLaughlin, C.P. (1996). The impact of environmental management on firm performance. *Management Sciences, 42*, 1199–1214.

Lyon, T.P. & Montgomery, A.W. (2015). The Means and End of Greenwash. *Organization & Environment, 28*(2), 223-249. doi: /10.1177/1086026615575332

Magnanelli, B.S. & Izzo, M.F. (2017). Corporate social performance and cost of debt: The relationship. *Social Responsibility Journal, 13*(2), 250-265. doi:10.1108/SRJ-06-2016-0103

Refinitiv. (2021). *ESG data and solutions from Refinitiv*.

Reichelt, H. (2010). Green bonds: a model to mobilise private capital to fund climate change mitigation and adaptation projects. *The Euromoney Environmental Finance Handbook, 1*.

SEC Nigeria. (n.d.). Sukuk (Islamic bond) at a glance. Consulted via https://sec.gov.ng/investor-education/sukuk-islamic-bond-at-a-glance/

Sharfman, M.P. & Fernando, C.S. (2008). Environmental risk management and the cost of capital. *Strategic Management Journal, 29*, 569–592.

Tang, D.Y. & Zhang, Y. (2020). Do shareholders benefit from green bonds? *Journal of Corporate Finance, 61*. doi: /10.1016/j.jcorpfin.2018.12.001

Zerbib, O. D. (2019). The effect of pro-environmental preferences on bond prices: Evidence from green bonds. *Journal of Banking & Finance, 98*, 39–60. https://doi.org/10.1016/j.jbankfin. 2018.10.012