

GLOBAL ECONOMIC GOVERNANCE INITIATIVE

CORPORATE GREEN BONDS



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ABSTRACT

This study examines corporate green bonds, a new practice in corporate finance. I document that the issuance of corporate green bonds has become more prevalent over time, particularly in industries where the natural environment is financially material. I further document that green bonds yield i) positive announcement returns, ii) improvements in long-term value and operating performance, iii) improvements in environmental performance, iv) increases in green innovations, and v) an increase in ownership by long-term and green investors. Overall, these results indicate that green bonds are effective—companies invest the proceeds in projects that improve the company's environmental footprint and contribute to long-term value creation—and help attract an investor clientele that is sensitive to the environment.

Keywords: impact investing; sustainable finance; climate change; corporate sustainability; long-term orientation.

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1. Introduction

A recent development in corporate finance is the use of corporate green bonds—that is, bonds whose proceeds are committed to finance environmental and climate-friendly projects, such as renewable energy, green buildings, or resource conservation. For example, in March 2014, Unilever issued a £250M green bond in order to “cut in half the amount of waste, water usage and greenhouse gas emissions of existing factories” (Financial Times, 2014). Similarly, in June 2017, Apple issued a \$1B green bond to finance “renewable energy and energy efficiency at its facilities and in its supply chain” (Forbes, 2017).

Corporate green bonds have become increasingly popular in recent years—Morgan Stanley refers to this evolution as the “green bond boom” (Morgan Stanley, 2017). Corporate green bonds were essentially nonexistent prior to 2013. In that year, the total issuance of corporate green bonds was about \$3B. Since then, the issuance of corporate green bonds has more than doubled every year. In 2017 alone, the corporate sector issued green bonds worth \$49B¹.

While the use of corporate green bonds has become increasingly more prevalent in practice, we know very little about this financial innovation, its effectiveness in terms of financial and environmental performance, and the implications for firm-level outcomes. In particular, do corporate green bonds deliver on their promise and yield improvements in companies’ environmental footprint? Also, do companies benefit from issuing green bonds? And what are the implications for shareholder wealth? Making ground on these questions is important—if corporate green bonds are effective in improving both a firm’s financial and environmental performance, they could serve as a powerful tool against climate change. In this paper, I study this new phenomenon and shed light on these questions. To the best of my knowledge, this paper is the first to study corporate green bonds.

To date, the existing evidence on corporate green bonds is in the form of anecdotal accounts, in which companies often highlight that issuing green bond demonstrates their commitment to the environment, along with the importance of the environment for their business model. For example, referring to Unilever’s £250M green bond issue, Unilever executives stated that “the green bond was another step intended to demonstrate to the financial community the centrality of sustainability to the group’s business model” and that “sustainable consumption makes business sense because it saves us money” (Financial Times, 2014). Similarly, referring to Apple’s \$1B green bond issue, Apple management highlighted their commitment to finance investments in renewable energy, “which we believe is an example of something that’s good for our planet and makes good business sense as well,” further highlighting that “[l]eadership from the business community is essential to address the threat of climate change and protect our shared planet” (Forbes, 2017).

Yet, whether corporate green bonds deliver on their promise is far from obvious. In fact, practitioners have raised major concerns that green bonds may merely be a form of “greenwashing”—i.e., the practice of making unsubstantiated or misleading claims about the company’s environmental commitment. Issuing green bonds would allow firms to portray an environmentally responsible public image without actually delivering. In this vein, commentators highlight that “a few skeptical voices are starting to question the value of this innovation, asking in particular whether green bonds make any real difference or whether they are just another case of greenwashing” (Financial Times, 2015). This greenwashing concern roots in the lack of public governance of corporate green bonds. Indeed, no legal enforcement mechanism exists to ensure compliance with the use of proceeds laid out in the green bond prospectus² Instead, the green bond market relies on private governance regimes such as voluntary certification standards. If the greenwashing motive prevails, corporate green bonds are unlikely to have any real impact. In this paper, I shed light on this question by studying the effectiveness of corporate green bonds, along with the implications for firm outcomes.

¹ This remains a small share of the overall bond market. The size of the worldwide bond market (based on total debt outstanding) is estimated at \$92.18 trillion in 2016 (SIFMA, 2017)

² See Park (2018) for a discussion of the governance challenge that arises in the green bond market due to the absence of public law.

To empirically examine this new phenomenon, I compile the first database of corporate green bonds. This database covers the full universe of corporate green bonds issued by public and private companies across the world since the early days of this market in 2013.

I start the empirical analysis by documenting several stylized facts pertaining to corporate green bonds. First, as mentioned above, corporate green bonds have become increasingly popular over time. Second, green bonds are more prevalent in industries where the natural environment is financially material to the companies' operations (e.g., energy). Third, green bonds are more prevalent in Europe compared to the U.S. and China³.

I then examine how the stock market responds to the issuance of green bonds. Using an event study methodology, I find that the stock market responds positively—in the [-1, 0] window around the announcement of green bond issues, the cumulative abnormal return (CAR) is 0.67%, suggesting that corporate green bonds are value-enhancing.

Next, I examine how corporate green bonds affect long-term value and operating performance. In the years following the issuance of green bonds, I observe an increase in long-term value (measured by Tobin's Q), along with an increase in the return on assets (ROA). These findings, which are consistent with the event study results, indicate that corporate green bonds are beneficial to companies and contribute to long-term value creation.

I then study the implications of corporate green bonds for environmental performance and the pursuit of green innovations. First, I document large improvements in environmental performance. Specifically, I observe i) an increase in the company's environmental score (measured by the environmental rating of Thomson Reuters' ASSET4), and ii) a decrease in CO2 emissions. Second, I observe an increase in the filing of green patents. Overall, these results indicate that green bond issuers do invest the proceeds in green projects that improve their environmental footprint. As such, these results are inconsistent with a greenwashing motive.

Next, I examine how the issuance of corporate green bonds affects a firm's time horizon and investor clientele. Following the issuance of green bonds, I observe an increase in long-term orientation (measured by the LT-index of Flammer and Bansal, 2017) as well as an increase in ownership by i) long-term investors and ii) green investors. These findings suggest that green bonds are conducive to the adoption of a longer time horizon, and help attract an investor base that is mindful of the long term and the environment.

Lastly, I examine cross-sectional characteristics. Specifically, I find that my baseline results are stronger for i) green bonds that are certified by independent third parties—and hence likely represent a stronger commitment towards the environment—as well as ii) issuers operating in industries where the environment is financially material to the firms' operations (based on the materiality scores of the Sustainability Accounting Standards Board (SASB)).

Taken together, the findings of this study show that corporate green bonds are effective—companies invest the proceeds in projects that improve the company's environmental footprint and ultimately contribute to long-term value creation. Moreover, by issuing green bonds, companies are able to attract an investor clientele that values the long term and the natural environment. Importantly, these results indicate that corporate green bonds have real impact, and hence are not merely a tool of greenwashing.

³ Apart from the use of proceeds, green bonds are very similar to regular bonds. In particular, I observe no significant difference in the financial terms of the bond (e.g., coupon and yield-to-maturity). Accordingly, corporate green bonds are unlikely to provide a cheaper source of capital.

One limitation of my analysis is that the issuance of green bonds may correlate with unobservables that also affect the outcomes of interest. Ideally, I would address this endogeneity concern by using an instrument for the issuance of green bonds. Unfortunately, it is difficult to find such an instrument—companies do not randomly issue green bonds, and it is hard to think of an empirical setting in which green bond issuance is (quasi-)random. Instead, to build a plausible counterfactual of how firm-level outcomes would evolve absent the issuance of green bonds, I use a matching. Specifically, I match each green bond issuer to a (non-green) bond issuer in the same country, industry, and year. Within the pool of candidates, I then select the nearest neighbor based on a large set of covariates. This guarantees that counterfactual issuers are as similar as possible to green bond issuers *ex ante*. Nevertheless, I caution that the matching is not a perfect substitute for a (quasi-)experiment.

This study makes several contributions to the literature. First, to the best of my knowledge, this is the first paper that studies corporate green bonds.⁴ As such, I establish a series of empirical facts pertaining to corporate green bonds, and document their increasing prevalence in the corporate landscape. Moreover, I examine how the stock market responds to the issuance of corporate green bonds and study the implications for firm-level outcomes.

Second, this study contributes to the growing literature on impact investing (e.g., Barber, Morse, and Yasuda, 2017; Flammer, 2015a). Impact investing refers to a relatively new set of financial instruments that aim to generate “social and environmental impact alongside financial return” (Global Impact Investing Network, 2018). This paper examines a novel instrument of impact investing—corporate green bonds—and shows that it contributes to both environmental and financial performance.

Third, this paper shows that corporate green bonds help attract an investor clientele that values the long term and the environment. This finding contributes to the literature showing that better environmental, social and governance (ESG) performance improves access to finance (e.g., Cheng, Ioannou, and Serafeim, 2014; El Ghouli, Guedhami, Kwok, and Mishra, 2011), as well as the emerging literature that studies investors’ preferences for ESG (e.g., Barber, 2007; Dimson, Karakas, and Li, 2015; Dyck, Lins, Roth, and Wagner, 2018; Starks, Venkat, and Zhu, 2018).

Finally, my results add to the body of evidence that points at a positive link between companies’ environmental responsibility and stock market performance (e.g., Flammer, 2013; Guenster et al., 2010; Klassen and McLaughlin, 1996), and the nascent literature that studies how climate change affects firm valuation (e.g., Krueger, 2015a)⁵.

The remainder of this paper is organized as follows. Section 2 describes the data on corporate green bonds and presents a series of stylized facts. Section 3 describes the issuer-level data. Section 4 presents the results of the event study. Section 5 describes the analysis of firm outcomes. Section 6 concludes.

4 The existing literature on green bonds has focused on municipal green bonds (and more generally green bonds issued by cities, countries, and supranational organizations), see Karpf and Mandel (2018). Municipal green bonds have a longer tradition, whereas corporate green bonds are a new phenomenon. Importantly, these markets are not comparable given the fundamental differences between corporate and non-corporate entities.

5 See also the literature that documents a positive link between CSR (corporate social responsibility) and stock market performance (e.g., Edmans, 2011, 2012; Edmans, Li, and Zhang, 2017; Flammer, 2015a; Krueger, 2015b).

2. Corporate green bonds

To compile a database of corporate green bonds, I extract all corporate bonds in Bloomberg's fixed income database that are labelled as "green bonds" (more precisely, bonds for which the field "use of proceeds" is "Green Bond/Loan"). I exclude bonds whose issuer's BICS (Bloomberg Industry Classification System) is "Government"⁶. Given the comprehensive coverage of Bloomberg's fixed income database, the resulting dataset is likely to closely map the full universe of corporate green bonds.

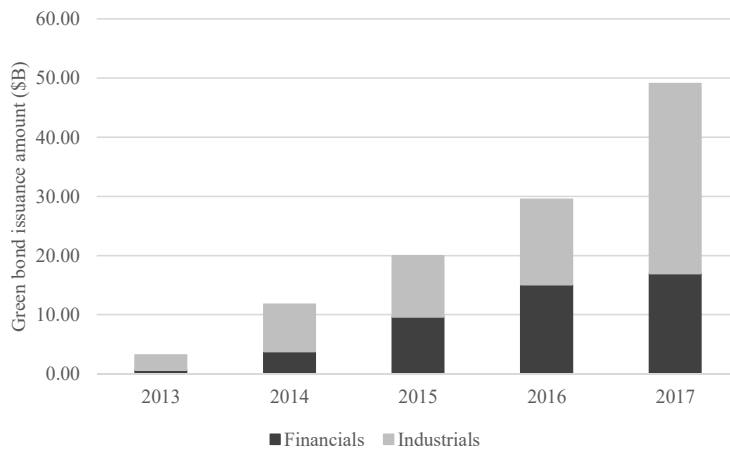
The above criteria yield a total of 368 corporate green bonds from January 1, 2013 until December 31, 2017⁷. For each bond, Bloomberg contains a wealth of information including the amount, currency, maturity, coupon, credit rating, etc. To facilitate comparisons, I convert all amounts in U.S. dollars. In the following, I provide some stylized facts based on these data.

2.1 Corporate green bonds over time

In Figure 1, I plot the evolution of corporate green bonds over the years. This graph shows the rapid growth in corporate green bonds over the past few years. While the total amount issued in 2013 was \$3.2B, it has increased to \$49.1B in 2017. This trend is likely to continue in future years, given the growing popularity of sustainable finance (Morgan Stanley, 2017)⁸.

Figure 1. Corporate green bonds over time

This figure plots the total issuance amount (in \$B) of corporate green bonds on an annual basis, using all corporate green bonds from 2013-2017.



2.2 Corporate green bonds across industries

Panel A of Table 1 provides a breakdown of corporate green bonds by industries. Industries are partitioned according to Bloomberg's BICS codes. As can be seen, corporate green bonds are more common in industries where the environment is likely core to the firms' operations (e.g., utilities, energy, transportation, real estate). In Section 3.2, I provide a more detailed characterization of green bond issuers and confirm that green bonds are significantly more prevalent in industries where the environment is financially material to the firms' operations (based on the materiality scores of the Sustainability Accounting Standards Board (SASB)).

6 Those issuers include development banks and supranational entities (e.g., the European Bank for Reconstruction and Development, the Asian Development Bank, etc.). While these entities qualify as "corporate" due to their private status, they are not "corporations" in a traditional sense.

7 When several tranches are issued by the same company on the same day, I combine them together in one single green bond issue and cumulate the amounts.

8 Most green bond issues are oversubscribed, which is indicative of the high popularity of green bonds among investors (Climate Bonds Initiative, 2017).

Table 1. Corporate green bonds by industry and country

This tables reports the total issuance amount (in \$B) of corporate green bonds by industry (Panel A) and country (Panel B), using all corporate green bonds from 2013-2017. Industries are partitioned according to Bloomberg’s BICS (Bloomberg Industry Classification System) codes.

Panel A. Corporate green bonds by industry		Panel B. Corporate green bonds by country	
Industry	Amount (\$B)	Country	Amount (\$B)
Financials	46.0	France	25.1
Banking	40.2	China	14.7
Real estate	5.9	Netherlands	14.3
		United States	14.1
Industrials	67.3	Mexico	8.0
Utilities	21.8	Germany	6.5
Power generation	18.7	India	4.3
Transportation and logistics	8.0	Spain	3.4
Renewable energy	4.0	Australia	3.3
Forest and paper products manufacturing	3.3	Austria	2.4
Communications equipment	2.5	Brazil	1.9
Waste and environment services and equipment	2.5	Sweden	1.9
Automobiles manufacturing	2.2	Italy	1.8
Food and beverage	1.2	Canada	1.7
Travel and lodging	0.8	Denmark	1.7
Consumer products	0.7	Britain	1.3
Managed care	0.6	Japan	1.2
Electrical equipment manufacturing	0.5	Singapore	1.1
Others	0.5	Chile	1.0
		Costa Rica	1.0
Total	113.4	South Korea	1.0
		Others	1.6
		Total	113.4

2.3 Corporate green bonds across countries

Panel B of Table 1 provides a breakdown by countries. As is shown, green bonds are more prevalent in Europe compared to North America and Asia. This is consistent with the view that Europe tends to be “greener” (e.g., Doh and Guay, 2006; Wall Street Journal, 2017).

2.4 Summary statistics at the bond level

In column (1) of Table 2, I provide summary statistics on the 368 corporate green bonds. As can be seen, green bond issues are fairly large—the average amount is \$308M. About 69% are certified by independent third parties⁹. The average maturity is 7.4 years. 74.7% of the bonds are fixed-rate with an average coupon of 3.4%. Finally, green bonds are relatively safe investments. The median credit rating is A- (based on Standard & Poor’s rating scale) and A3 (based on Moody’s rating scale).

⁹ The certification information is obtained from the Climate Bonds Initiative database. This database compiles information on the certification of each green bond, along with the identity of the third-party certifier. The most common certifiers include Sustainalytics, Vigeo Eiris, Ernst & Young, and CICERO (Center for International Climate Research). Green bonds can be issued under a variety of voluntary standards. Two leading standards that verify the integrity of the “green bond” label are the Green Bond Principles (GBP) and the Climate Bond Standards (CBS). In a nutshell, the certification process is split into two phases. In the pre-issuance phase, the certifier verifies that i) the projects to be financed by the bond proceeds are eligible under the specific certification standards, and ii) the issuer has established internal processes and controls to keep track of how the bond proceeds are used (which includes the submission of annual reports). In the post-issuance phase, the certifier verifies that the proceeds have been allocated to green projects in accordance with the standards.

Table 2. Summary statistics at the green bond level

This table provides summary statistics for all corporate green bonds (column (1)), and separately for corporate green bonds issued by private firms (column (2)) and public firms (column (3)). *Amount* is the issuance amount (in \$M). *Certified* is a dummy variable equal to one if the green bond is certified by an independent third party. *Maturity* is the maturity of the green bond (in years). *Fixed-rate bond* is a dummy variable equal to one if the bond has a fixed coupon payment. *Coupon* is the coupon rate (in %) for fixed-rate bonds. *Credit rating* is the credit rating of the green bond. For each characteristic, the table reports sample means and standard deviations (in parentheses), except for the credit rating, where the median is reported (based on Standard & Poor's and Moody's rating scales, respectively).

	All (1)	Private (2)	Public (3)
# Green bonds	368	151	217
Amount (in \$M)	308.1 (655.6)	294.1 (751.0)	317.8 (581.8)
Certified (1/0)	0.686 (0.464)	0.695 (0.462)	0.680 (0.466)
Maturity (years)	7.4 (26.5)	6.2 (5.0)	8.3 (34.3)
Fixed-rate bond (1/0)	0.747 (0.418)	0.656 (0.452)	0.810 (0.382)
Coupon (for fixed-rate bonds)	3.4 (2.3)	2.9 (2.1)	3.6 (2.3)
Credit rating			
S&P rating (median)	A-	A-	A-
Moody's rating (median)	A3	A3	A3

In columns (2) and (3), I distinguish between green bonds that are issued by private firms (151 bonds) and public firms (217 bonds). Not surprisingly, public firms issue larger bonds. Moreover, these bonds tend to have longer maturities, are more likely to be fixed-rate bonds, and pay a higher coupon. In the remainder of this paper, I restrict the sample to the green bonds of public firms, since detailed firm-level data are available for public firms (e.g., stock market data, accounting data, etc.) that can be used to study how the issuance of green bonds affects firm level outcomes¹⁰.

3. Firm-level data

3.1 Data sources

The firm-level data are obtained from several sources, which are described below.¹¹

Accounting data. The accounting data are obtained from Standard & Poor's Compustat. I use both Compustat North America (that includes data for U.S. and Canadian companies) and Compustat Global (that includes data for all other public companies). Compustat contains detailed accounting information for each firm, along with firm, industry, and location identifiers. The main variables I construct from Compustat are as follows. Size is the natural logarithm of the book value of total assets (in U.S. dollars). Return on assets (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 (obtained as the book value of total assets plus the market value of common stock minus the sum of the book value of common stock and balance sheet deferred taxes) to the book value of total assets. Leverage is the ratio of debt (long-term debt plus debt in current liabilities) to the book value

¹⁰ In Appendix Table 1, I further compare green vs. conventional bonds for the subsample of U.S. public firms issuing green bonds (using the detailed U.S. bond data from Mergent). This comparison shows that green bonds are on average smaller (about half the size of conventional bonds). However, there is no significant difference in the terms of the bonds (maturity, coupon, and yield-to-maturity at issue). This indicates that green bonds are very similar to conventional bonds, and do not represent a cheaper source of capital.

¹¹ In Section 5, I introduce additional data that will be used in the finer-grained analysis.

of total assets. To mitigate the impact of outliers, all ratios are winsorized at the 1st and 99th percentiles of their empirical distribution.

Stock market data. The stock market data are obtained from the daily stock file of the Center for Research in Security Prices (CRSP) and the daily stock file from Compustat Global.

ESG data. The ESG (environmental, social, and governance) data are obtained from Thomson Reuters' ASSET4. ASSET4 specializes in providing objective, relevant, auditable, and systematic ESG information and investment analysis tools to professional investors who build their portfolios by integrating ESG data into their traditional investment analysis. ASSET4 rates companies along three dimensions ("pillars"): environment, social issues, and corporate governance. In the analysis, I use all three ratings (environment rating, social rating, governance rating), along with the ASSET4 composite score that combines all three pillars (composite rating). Note that the ASSET4 universe does not cover all public firms, and hence I do not have ESG data for all bond issuers.

Materiality data. The data on environment materiality (i.e., the extent to which the natural environment is financially material to the company's operations) is obtained from the Sustainability Accounting Standards Board (SASB). SASB is an independent, California-based, standards setting organization dedicated to fostering high-quality disclosure of material sustainability information that meets investor needs. For each industry, SASB assesses the materiality of the environment based on a set of environmental issues ("disclosure topics"). I construct the materiality index as the number of environmental issues that are deemed material for companies in the industry (environment materiality).^{12,13}

3.2 Summary statistics at the issuer level

The 217 green bonds of public firms correspond to 106 unique firm-year observations (since some companies issue multiple bonds in a given year). In column (1) of Table 3, I provide summary statistics for the characteristics described above.¹⁴

Table 3. Summary statistics at the issuer level

Column (1) provides summary statistics for green bond issuers in the year preceding the green bond issue. *Log(assets)* is the natural logarithm of the book value of total assets (in U.S. dollars). *Return on assets* 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. *Leverage* is the ratio of debt to the book value of total assets. All these variables are obtained from Compustat North America and Compustat Global. *Environment rating*, *social rating*, *governance rating*, and *composite rating* are the ESG ratings of Thomson Reuters' ASSET4. *Environment materiality* is the materiality index (i.e., the number of environmental issues that are deemed material for companies in the industry) obtained from SASB data. For each characteristic, the table reports sample means and standard deviations (in parentheses). In column (2), the statistics are based on bond issuers (but not green bond issuers) in the same 2-digit SIC industry, country, and year. In column (3), the statistics are based on bond issuers (but not green bond issuers) in the same country and year, but in a different 2-digit SIC industry. Column (4) reports the *p*-value of the difference-in-means test. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

	<i>N</i>	Green bond issuers	(Non-green) bond issuers in same country and industry	(Non-green) bond issuers in same country but different industry	<i>p</i> -value (dif. in means)
		(1)	(2)	(3)	(4)
Log(assets)	106	11.085 (2.451)	9.377 (1.819)	–	0.000***
Return on assets	106	0.056 (0.048)	0.056 (0.033)	–	0.874
Tobin's Q	106	1.172 (0.393)	1.211 (0.332)	–	0.429
Leverage	106	0.286 (0.161)	0.309 (0.140)	–	0.366
Environment rating (ASSET4)	76	83.374 (16.012)	66.467 (21.108)	–	0.000***
Social rating (ASSET4)	76	79.814 (21.158)	64.324 (21.473)	–	0.000***
Governance rating (ASSET4)	76	66.401 (23.690)	57.906 (18.627)	–	0.008***
Composite rating (ASSET4)	76	80.936 (18.263)	65.661 (20.049)	–	0.001***
Environment materiality (SASB, industry level)	106	2.473 (1.588)	–	1.539 (0.280)	0.000***

12 SASB uses their own industry classification—SICS (Sustainable Industry Classification System)—to partition industries. I obtain the mapping of SICS codes to companies from SASB.

13 For a more detailed description of SASB and the SASB data, see Khan, Serafeim, and Yoon (2016).

14 The statistics are recorded in the fiscal year that ends before the green bond's issue date.

In column (2), I compare green bond issuers with other public firms. To make the comparison informative, the comparison group only consists of public firms that are bond issuers (but not green bond issuers). I identify bond issuers using data from Thomson Reuters' SDC Platinum. For each characteristic, I then compute the average across all firms in the comparison group that are in the same 2-digit SIC industry, country, and year. As can be seen, green bond issuers are on average larger than other bond-issuing public firms, while they are similar based on profitability (ROA), firm value (Tobin's Q), and capital structure (leverage).¹⁵ Moreover, green bond issuers tend to be industry leaders in terms of environmental performance (and ESG performance overall).

Finally, since the last characteristic—environment materiality—is at the industry level, I adjust the comparison group by taking the average across all public firms (that issue bonds but not green bonds) in the same country and year, but in a different 2-digit SIC industry. As can be seen, green bond issuers are significantly more likely to operate in industries where the environment is financially material to the companies' operations. This suggests that green bonds are likely to aim at improving both environmental and financial performance.

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

4.1 Event study methodology

The event study methodology examines the stock price reaction around the announcement of an event. In the following, I use this methodology to assess how the stock market responds to the announcement of the issuance of corporate green bonds. A useful feature of Bloomberg's database is that it contains the announcement date, i.e. the day on which the company announced that it will be issuing the green bond. The announcement date (as opposed to the issuance date) is the relevant date for the event study since it captures the day when the information is provided to the market. In contrast, on the issuance date, no new information is conveyed to the market.

To conduct the event study, I use the announcement date as event date (day 0). Furthermore, following common practice, I account for the possibility that some information may have been known to the public prior to the announcement by including the previous trading day (day -1) in the event window. This two-day event window is denoted by $[-1, 0]$. To see if there is any impact of the event on the stock price before or after the two-day event window, I also consider the time intervals $[-20, -11]$, $[-10, -6]$, $[-5, -2]$ prior to, and the time intervals $[1, 5]$, $[6, 10]$, and $[11, 20]$ after the event window.

For each firm i , I compute the abnormal returns using the market model. The coefficients α_i and β_i of the market model are estimated by Ordinary Least Square (OLS) based on 200 trading days prior to the first event window (i.e., the 200 trading days used in the estimation correspond to the interval $[-220, -21]$) using daily return data from CRSP and the daily stock file of Compustat Global. Formally, I estimate:

$$R_{it} = \alpha_i + \beta_i \times R_{mt} + \varepsilon_{it} ,$$

where R_{it} is the return on the stock of company i on day t , R_{mt} is the daily market return, and ε_{it} is the residual. Market returns are country-specific.¹⁶ The estimated return on the stock of firm i on day t is then given by:

$$\hat{R}_{it} = \hat{\alpha}_i + \hat{\beta}_i \times R_{mt} .$$

I then calculate the abnormal daily return (AR) of firm i on day t as follows:

$$AR_{it} = R_{it} - \hat{R}_{it} .$$

¹⁵ In principle, it could be that companies issue green bonds because of financing constraints—some companies may have a difficult time raising capital, and might only be able to do so by issuing green bonds. This is unlikely, though. First, not all firms have access to the bond market. Those who do tend to be large firms that are unlikely to be financially constrained (e.g., Almeida and Campello, 2010). Second, the summary statistics show that, even within the population of bond issuers, green bond issuers are on average larger compared to other bond issuers, suggesting that green bond issuers are even less likely to be financially constrained.

¹⁶ For the U.S., I use the S&P 500. For all other countries I use the country's leading stock market index (e.g., CAC 40 for France, IBEX 35 for Spain, NIKKEI 225 for Japan, etc.). In robustness checks, I show that the results are similar if instead of using country-specific stock market indices, I use a global stock market index (the MSCI All-Country World Equity Index).

Finally, I compute the cumulative abnormal returns (CAR) for each time interval by summing up the abnormal returns within the specific time window, and report CARs for the timeintervals [-20, -11], [-10, -6], [-5, -2], [1, 5], [6, 10], and [11, 20] in addition to the event window [-1, 0].

4.2 Event study results

The event study results are reported in Table 4. For each event window, I report the average CAR as a percentage (with the corresponding standard error in parentheses). As is shown, the average CAR in the two-day event window [-1, 0] is 0.67% and significant at the 5% level. All other intervals before and after the two-day event window yield CARs that are small and insignificant, which confirms that the results are not driven by unrelated trends around the event dates. The positive stock market reaction indicates that green bonds are value-enhancing—the stock market expects green bonds to contribute to value creation, and responds accordingly.

Table 4. Stock market reaction to the announcement of corporate green bond issuance

This table reports the average cumulative abnormal return (CAR) for different time windows around the announcement of green bond issues. The sample consists of $N = 217$ green bond issues. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

Event time	CAR	Std. Err.
[-20, -11]	0.120	0.975
[-10, -6]	0.257	0.509
[-5, -2]	-0.013	0.487
[-1, 0]	0.673**	0.278
[1, 5]	-0.106	0.625
[6, 10]	0.328	0.659
[11, 20]	-0.281	1.140

4.3 Robustness

In Appendix Table 2, I present a series of robustness checks that address potential concerns. In what follows, I briefly describe each of them.

Global market model based on MSCI world index. In row 1, I re-run the event study, but using a world market index (specifically, the MSCI All-Country World Equity Index) in lieu of country specific market indices. Using this alternative benchmark yields very similar results. Global three-factor model of Fama and French. In the baseline event study, I use the market model to estimate abnormal returns. A concern is that abnormal returns may reflect other factors that are priced during the sample period. To mitigate this concern, I use the global three-factor model of Fama and French (1993) in row 2. As is shown, the results are robust to using this extended set of factors.¹⁷

Industry-adjusted CAR. In row 3, I verify that the results are not driven by industry trends. Specifically, I re-run the event study using industry-adjusted returns at the 2-digit SIC level (industry-adjusted returns are obtained by subtracting the average return across all stocks on a given trading day in the same country and same 2-digit SIC industry). As can be seen, the CARs remain very similar.

Cross-sectional correlation. In row 4, I re-compute standard errors using the “crude dependence adjustment” (CDA) of Brown and Warner (1980, 1985). This correction accounts for cross-sectional correlation in abnormal returns across events. As is shown, my results are robust to this adjustment.

¹⁷ The Fama-French three-factor model includes, in addition to the market factor, the size factor SMB (“small minus big”) and the book-to-market factor HML (“high minus low”). I obtain the global SMB and HML factors from Kenneth French’s website.

Precision-weighted CARs. When computing the average CAR, each stock is given the same weight. An alternative is to compute the precision-weighted average CAR, which gives more weight to less volatile (i.e., more precisely estimated) abnormal returns. As is shown in row 5, the results are robust to using precision-weighted average CARs.

Excluding banking. Green bonds issued by banks are somewhat different. Instead of investing the proceeds in green projects, they invest them in “green loans.” In row 6, I show that the results are robust to excluding the banking sector.

Excluding confounding events. In row 7, I re-estimate CARs, excluding event dates on which companies make other relevant announcements—e.g., the announcement of equity issues, (regular) bond issues, or quarterly earnings. To identify these, I review newspaper articles on each of the 217 event dates considered in the baseline. There are 19 events date with other relevant announcements. As is shown, my results are robust to their exclusion.

Median CAR. Finally, in row 8, I report the median CAR (in lieu of the average CAR) to mitigate the issue that the results might be driven by a small number of stocks with extreme stock price reactions. As can be seen, the median CAR is somewhat lower (0.48 compared to the mean CAR of 0.67). Importantly, it remains significant at the 5% level.

4.4 Cross-sectional heterogeneity

In Table 5, I examine how the announcement returns differ depending on several characteristics. First, the stock market reaction is about twice as large for green bonds that are certified by independent third parties (Panel A). Certification is costly—to qualify as a “certified green bond,” companies have to undergo third-party verification to establish that the proceeds are funding projects that generate environmental benefits, which gives rise to administrative and compliance burdens. Accordingly, certified green bonds likely represent a more credible commitment towards the environment, which could explain the stronger stock market response.

Table 5. Heterogeneity in stock market response

This table reports the average CAR[-1, 0] from Table 4 for different subsamples. Panel A distinguishes between green bonds that are certified by independent third parties and green bonds that are not. Panel B distinguishes between green bond issuers operating in industries with above- and below-median SASB scores of environment materiality. Panel C distinguishes between first-time and seasoned issues of green bonds. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

	CAR[-1, 0]	Std. Err.
<i>Panel A. Certified vs. non-certified</i>		
Certified green bonds ($N = 147$)	0.803**	0.354
Non-certified green bonds ($N = 70$)	0.401	0.427
<i>Panel B. Financial materiality of the environment above vs. below median</i>		
SASB score above median ($N = 109$)	0.908***	0.212
SASB score below median ($N = 108$)	0.437	0.516
<i>Panel C. First-time issue vs. seasoned issue</i>		
First-time green bond issue ($N = 85$)	0.862***	0.252
Seasoned green bond issue ($N = 132$)	0.552	0.427

Second, I find that the stock price increase is larger for companies operating in industries whose environment materiality score is above the median (Panel B). This result is intuitive. In industries where the natural environment is financially material to the firms' operations, the pursuit of green projects contributes more substantially to financial performance. This, in turn, is reflected in a stronger stock market reaction. Finally, I find that the announcement returns are larger for first-time issuers, compared to seasoned issuers (Panel C).^{18,19}

5. Corporate green bonds and firm-level outcomes

In this section, I examine how the issuance of corporate green bonds affects firm-level outcomes—specifically, i) financial performance, ii) environmental performance, iii) green innovation, iv) long-term orientation, and v) the company's ownership structure. In the following, I first describe the outcome variables and the regression framework. I then present the results.

5.1 Data and methodology

FIRM OUTCOMES

Financial performance. To capture financial performance, I use Tobin's Q (as a measure of firm value) and the return on assets (as a measure of profitability). See Section 3.1 for the definition of these variables.

Environmental performance. I use two measures of environmental performance. The first measure is the ASSET4 environmental rating. The second measure captures emissions. It is defined as the ratio of CO2 emissions (in tons) from ASSET4 divided by the book value of assets in U.S. dollars.²⁰ I winsorize this ratio at the 1st and 99th percentiles of its empirical distribution.

Green innovation. Green innovations is defined as the ratio of the number of green patents divided by the total number of patents filed by the company in a given year.²¹

Long-term orientation (U.S. only). To measure long-term orientation, I use the LT-index ("long-term index") of Flammer and Bansal (2017). The LT-index is obtained by conducting a textual analysis of the companies' annual reports. The rationale behind this index is that an organization's time orientation is reflected by its discourse (Slawinski and Bansal, 2012)—companies that use long-term keywords more frequently in their discourse are more likely to have a longer-term orientation. To construct this index, I perform a textual analysis of the firms' 10-K filings, which are obtained from the SEC's EDGAR database, and count the number of keywords referring to the short term ("short run," "short-run," "short term," "short-term") and long term ("long run," "long-run," "long term," "long-term"), respectively. I then compute the LT-index as the ratio of the number of long-term keywords to the sum of long- and short-term keywords.

Ownership structure (U.S. only). I characterize the ownership structure of the firm using holding data from Thomson-Reuters. By tracking changes in ownership, I can examine whether green bonds help attract specific investor clienteles.²² I use three measures of ownership. Institutional ownership is the percentage of shares owned by institutional investors. The other two measures are based on finer categories of institutional owners. Ownership by long-term investors is the percentage of shares owned by long-term institutional investors. To identify

18 A large literature in corporate finance studies how the stock market responds to the issuance of securities. A typical finding in this literature—which is consistent with the pecking order theory of Myers and Majluf (1984)—is that the stock market responds negatively to equity issues, but shows no significant reaction to bond issues (see Eckbo, Masulis, and Norli, 2007, for a survey of the empirical literature). Compared to regular bond announcements, green bond announcements blend two pieces of information: i) a bond issuance, and ii) a commitment to green projects. Since the stock market is typically unresponsive to conventional bond issues, the positive stock market reaction to green bond issues is likely to reflect the latter—consistent with prior studies that document positive CARs in response to the announcement of companies' eco-friendly actions (e.g., Flammer, 2013; Klassen and McLaughlin, 1996; Krueger, 2015b). The fact that CARs are only significant for first-time issuers is consistent with this interpretation. After the first-time issue, the market has learned about the firm's commitment to green projects. The information content of subsequent issues might then be closer to that of conventional bond issues.

19 I caution that the differences across groups in Table 5 are not significant at conventional levels. Given the limited number of events, I may not have sufficient power to identify cross-sectional differences, even if they are present.

20 More precisely, I use item ENERDP023 from ASSET4 (total CO2 and CO2 equivalent emissions in tons).

21 I obtain the patent data from Google Patents. I identify "green patents" as those patents with CPC (Cooperative Patent Classification) codes Y02 (technologies or applications for mitigation or adaptation against climate change), B09 (disposal of solid waste, reclamation of contaminated soil), C02 (treatment of water, waste water, sewage, or sludge), and F03D (wind motors).

22 The existing literature points at the existence of "investor clienteles"—that is, different categories of investors that invest in different companies depending on specific characteristics. In particular, previous work has identified a dividend clientele (Graham and Kumar, 2006) and more broadly the existence of "style" investors who seek specific types of firms (Barberis and Shleifer, 2003).

long-term investors, I use Bushee's (1998, 2001) data that breaks down institutional investors into three groups (transient, quasi-indexers, and dedicated). Long-term investors are those classified as dedicated.²³ Finally, ownership by green investors is the percentage of shares owned by "green" institutional investors. I identify green investors as those who are members of the Ceres Investor Network on Climate Risk and Sustainability. The list of members is obtained from Ceres' website.²⁴

MATCHING

To study how corporate green bonds affect firm-level outcomes, I examine the outcome variables described above in the years following the green bond issuance. One empirical challenge is that the issuance of green bonds is endogenous with respect to firm outcomes—that is, unobservables may drive a spurious relationship between the issuance of green bonds and firm outcomes. For example, suppose we observe a decrease in CO₂ emissions following the issuance of green bonds. Naturally, this would indicate that the proceeds from the green bond are used to finance green projects that reduce the company's emissions. However, it could also be that this relationship is driven by unobservables—e.g., perhaps companies are taking actions to improve their environmental rating, which leads to both a reduction in emissions and the issuance of green bonds. In this scenario, emissions would decrease even absent the green bond issuance.

Ideally, I would address this endogeneity concern by using an instrument for the issuance of green bonds. Unfortunately, it is difficult to find such an instrument—the issuance of corporate green bonds is not random, and it is hard to find an empirical setting in which companies (quasi-) randomly issue green bonds. Instead, to build a plausible counterfactual of how firm-level outcomes would evolve absent the green bond issue, I use a matching. Specifically, for each of the 106 firms that issue green bonds (which, for ease of exposition, I refer to as "treated" firms), I match a "control" firm that is as similar as possible to the treated firm ex ante (i.e., prior to the green bond issuance).

To build the matched control group, I use several matching criteria. First, among the pool of public firms, I only consider those that are bond issuers (but not green bond issuers). Second, I require that the control firm operates in the same country and the same 2-digit SIC industry as the treated firm. Third, out of the remaining candidates, I select the nearest neighbor based on seven firm-level characteristics: size, Tobin's Q, ROA, leverage, and the company's environmental, social, and governance ratings. For each characteristic, I consider the variable in the year preceding the green bond issuance (i.e., at $t - 1$), as well as the "pre-trend" (i.e., the change from $t - 2$ to $t - 1$). Accordingly, 14 matching variables are used. The nearest neighbor is the firm with the lowest Mahalanobis distance to the treated firm across these 14 matching characteristics.²⁵

This matching procedure ensures that control firms are as similar as possible to the treated firms ex ante. In particular, using the environmental rating as a matching characteristic ensures that treated and control firms have similar environmental performance prior to the green bond issuance. The same intuition applies to the other ESG ratings. Using measures of profitability (ROA) and firm value (Tobin's Q) rules out concerns that the treated firms may be more profitable or have better growth opportunities. Using size and debt capacity (leverage) further addresses the possibility that treated firms may have better access to capital markets.²⁶ Moreover, matching firms based on country, industry, and year ensures that treated and matched control firms face the same conditions in their business environment (including economic, regulatory, and other conditions).

23 In Bushee's (1998, 2001) classification, "transient" investors are characterized by a short investment horizon and high turnover to maximize short-term profits. They are mainly speculators seeking near-term appreciation of their stocks. "Quasi-indexers" are characterized by high diversification and low portfolio turnover. They generally follow a passive buy-and-hold strategy that mimics broad stock market indices such as the S&P 500 or the Russell 2000. Finally, "dedicated" investors are characterized by large investments in specific companies and low turnover. They commit themselves to providing long-term capital and support for their investees. Essentially, they are akin to permanent shareholders who seek long-term shareholder value, and their objectives are more relationship- than transaction-driven. Dedicated investors are often considered long-term investors (e.g., Brochet, Loumioti, and Serafeim, 2015).

24 Ceres is a sustainability nonprofit organization working with investors and companies to build leadership and drive solutions to sustainability challenges, including climate change, water scarcity, and pollution.

25 Formally, the Mahalanobis distance δ between treated firm i and candidate firm j is given by $\delta = [(X_i - X_j)' \Sigma^{-1} (X_i - X_j)]^{1/2}$, where X is a (14×1) vector containing the 14 matching variables and Σ is the (14×14) covariance matrix of these 14 matching variables. See, e.g., Fresard and Valta (2016) and Flammer (2015b) for a similar methodology.

26 The four Compustat characteristics (i.e., size, ROA, Tobin's Q, and leverage) are commonly used in the economics and finance literature to construct a set of comparable firms (e.g., Almeida, Campello, Laranjeira, and Weisbenner, 2012; Fresard and Valta, 2016).

To illustrate the similarity between treated and control firms, Table 6 reports descriptive statistics for the 14 matching characteristics (Panel A) and several non-matching characteristics (Panel B). Levels (e.g., $\log(\text{assets})$) are measured in the year preceding the green bond issuance, while pre trends (e.g., $\Delta \log(\text{assets})$) are measured in the two-year window preceding the green bond issuance. For each characteristic, the table reports means, medians, and standard deviations for the 106 treated firms and the 106 matched control firms.^{27,28} In the last two columns, the table further reports the p-value of the difference-in-means test and the difference-in-medians test, respectively. As is shown, treated and control firms are very similar along all these characteristics. In particular, the null of equal means cannot be rejected (with p-values ranging from 0.11 to 0.92). Neither can the null of equal medians (p-values from 0.13 to 0.98). Overall, these statistics confirm that control firms are very similar to treated firms, and hence likely provide a reliable counterfactual of how treated firms would behave absent the green bond issuance.

Table 6. Matching

This table presents descriptive statistics comparing treated and matched control firms. Levels (e.g., $\log(\text{assets})$) are measured in the year preceding the green bond issue ($t - 1$), while pre-trends (e.g., $\Delta \log(\text{assets})$) are measured in the two-year window preceding the green bond issue (changes from $t - 2$ to $t - 1$). The variables in Panel A are described in Table 3; those in Panel B are described in Tables 7 and 8. The last two columns report the p-value of the difference-in-means and difference-in-medians test, respectively. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

		Obs.	Mean	Median	Std. Dev.	p-value (diff. in means)	p-value (diff. in medians)
<i>Panel A. Matching characteristics</i>							
Log(assets)	Green bond	106	11.085	10.813	2.451	0.280	0.461
	Matched control	106	10.993	10.773	2.276		
Return on assets	Green bond	106	0.056	0.053	0.048	0.243	0.680
	Matched control	106	0.058	0.051	0.047		
Tobin's Q	Green bond	106	1.172	1.023	0.393	0.202	0.527
	Matched control	106	1.140	1.012	0.286		
Leverage	Green bond	106	0.286	0.242	0.161	0.189	0.131
	Matched control	106	0.309	0.286	0.162		
Environment rating (ASSET4)	Green bond	76	83.37	91.36	16.01	0.311	0.783
	Matched control	76	82.39	91.18	16.29		
Social rating (ASSET4)	Green bond	76	79.81	90.36	21.16	0.364	0.921
	Matched control	76	79.05	90.41	22.09		
Governance rating (ASSET4)	Green bond	76	66.40	73.73	23.69	0.705	0.424
	Matched control	76	66.15	70.93	22.64		
$\Delta \text{Log}(\text{assets})$	Green bond	106	0.022	0.030	0.158	0.632	0.668
	Matched control	106	0.020	0.027	0.116		
$\Delta \text{Return on assets}$	Green bond	106	0.001	-0.001	0.019	0.296	0.810
	Matched control	106	0.000	-0.001	0.016		
$\Delta \text{Tobin's Q}$	Green bond	106	-0.002	-0.002	0.159	0.316	0.753
	Matched control	106	0.001	-0.003	0.121		
$\Delta \text{Leverage}$	Green bond	106	0.003	0.000	0.033	0.596	0.811
	Matched control	106	0.002	0.001	0.046		
$\Delta \text{Environment rating (ASSET4)}$	Green bond	76	3.897	0.955	9.958	0.916	0.870
	Matched control	76	3.899	0.960	9.972		
$\Delta \text{Social rating (ASSET4)}$	Green bond	76	4.051	1.415	9.675	0.302	0.338
	Matched control	76	3.775	1.460	9.283		
$\Delta \text{Governance rating (ASSET4)}$	Green bond	76	3.901	3.065	10.719	0.772	0.474
	Matched control	76	3.773	3.100	10.499		

27 The ESG ratings from ASSET4 are available for 76 out of the 106 firms. For companies without ASSET4 coverage, the matching is done based on the other four characteristics (i.e., eight matching variables).

28 The number of observations varies depending on data availability.

**Table 6. Matching
(continued)**

		Obs.	Mean	Median	Std. Dev.	<i>p</i> -value (diff. in means)	<i>p</i> -value (diff. in medians)
<i>Panel B. Other characteristics</i>							
CO ₂ emissions / assets	Green bond	69	77.87	17.91	168.12	0.245	0.503
	Matched control	69	75.10	17.26	181.06		
Green patents / total patents	Green bond	43	0.140	0.000	0.254	0.776	0.982
	Matched control	43	0.128	0.000	0.152		
LT-index (U.S. only)	Green bond	32	0.793	0.747	0.148	0.481	0.510
	Matched control	32	0.755	0.745	0.156		
Institutional ownership (U.S. only)	Green bond	32	0.416	0.402	0.372	0.409	0.717
	Matched control	32	0.428	0.411	0.348		
Ownership by long-term investors (U.S. only)	Green bond	32	0.071	0.049	0.089	0.106	0.220
	Matched control	32	0.057	0.035	0.084		
Ownership by green investors (U.S. only)	Green bond	32	0.040	0.016	0.037	0.632	0.554
	Matched control	32	0.038	0.014	0.052		
Δ CO ₂ emissions / assets	Green bond	69	-0.773	-0.024	19.947	0.757	0.971
	Matched control	69	-0.708	-0.019	20.703		
Δ Green patents / total patents	Green bond	43	0.004	0.000	0.162	0.878	0.980
	Matched control	43	0.001	0.000	0.193		
Δ LT-index (U.S. only)	Green bond	32	0.009	0.005	0.118	0.749	0.597
	Matched control	32	0.004	0.005	0.106		
Δ Institutional ownership (U.S. only)	Green bond	32	0.009	0.003	0.101	0.812	0.569
	Matched control	32	0.006	0.003	0.122		
Δ Ownership by long-term investors (U.S. only)	Green bond	32	0.003	0.002	0.021	0.591	0.823
	Matched control	32	0.001	0.001	0.025		
Δ Ownership by green investors (U.S. only)	Green bond	32	0.008	0.005	0.044	0.337	0.691
	Matched control	32	0.005	0.004	0.038		

DIFFERENCE-IN-DIFFERENCES SPECIFICATION

To examine how corporate green bonds affect firm-level outcomes, I estimate a difference-in-differences specification using all firm-year observations of the treated and matched control firms from 2010-2017.²⁹ Specifically, I estimate the following regression:

$$y_{it} = \alpha_i + \alpha_c \times a_t + \alpha_s \times a_t + \beta \times \text{Green bond}_{it} + \varepsilon_{it}, \quad (1)$$

where *i* indexes firms, *t* indexes years, *c* indexes countries, and *s* indexes 2-digit SIC industries; *y* is the outcome variable of interest (e.g., Tobin's Q, CO₂ emissions, etc.); α are firm fixed effects; $\alpha_c \times a_t$ are country by year fixed effects; $\alpha_s \times a_t$ are industry by year fixed effects; Green bond is a dummy variable ("treatment dummy") that equals one if firm *i* has issued a green bond by year *t* and zero otherwise; ε is the error term.³⁰ I cluster standard errors at the 2-digit SIC industry level. The coefficient of interest is β which measures the difference-in-differences in outcome variable *y* between treated and matched control firms. In other words, β measures the effect of the green bond issue on *y* accounting for contemporaneous changes in *y* at otherwise comparable firms that do not issue green bonds.

²⁹ To allow for a sufficient treatment window, I start the sample three years before the first green bond issuance in 2013. The results are similar if I use a longer treatment window.

³⁰ I do not include controls in the regression. By construction, the matching ensures that the two groups of firms are similar based on relevant covariates. Nevertheless, I have verified that my results are unchanged if the matching characteristics are included as controls.

The difference-in-differences specification in equation (1) can be extended to characterize the dynamics of the treatment. To do so, I estimate a variant of (1) in which I replace the treatment dummy Green bond with a set of three dummies: i) Green bond (pre-issue year), which is equal to one in the year preceding the green bond issuance, ii) Green bond (short-term, 1 year), which is equal to one in the year following the green bond issuance, and iii) Green bond (long-term, 2+ year), which is equal to one in the subsequent years. This specification allows me to distinguish between the short- and long-term impact of corporate green bonds, and formally test for pre trends in the data. In the following, I estimate both specifications for each outcome variable.

5.2 Results

Financial performance. The analysis of firm value (Tobin's Q) is presented in columns (1) and (2) of Table 7. As is shown—and consistent with the event study results—firm value increases significantly following the issuance of corporate green bonds.³¹ Moreover, the results in columns (3) and (4) show that profitability (ROA) increases in the long run. This suggests that the projects funded by green bonds improve companies' operating performance and contribute to value creation. This echoes the previous finding that green bonds are more prevalent in industries where the environment is financially material to the firms' operations (Section 3.2).

Table 7. Implications of green bond issuance for firm outcomes—financial performance, environmental performance and green innovation

This table reports estimates of the difference-in-differences specification in equation (1). *Green bond* is a dummy variable equal to one if the firm has issued a green bond. *Green bond (pre-issue year)* is a dummy variable equal to one in the year preceding the green bond issue. *Green bond (short-term, 1 year)* and *Green bond (long-term, 2+ year)* are defined analogously with respect to the year following the green bond issue and the subsequent years, respectively. *Tobin's Q*, *ROA*, and *environment rating* are described in Table 3. *CO₂ emissions / assets* is the ratio of CO₂ emissions (in tons) from ASSET4 divided by the book value of assets in U.S. dollars. *Green patents / total patents* is the ratio of the number of green patents divided by the total number of patents filed by the company in a given year. The patent data are obtained from Google Patents. The sample includes all firm-year observations of the treated and matched control firms from 2010-2017. Standard errors (reported in parentheses) are clustered at the 2-digit SIC industry level. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

	Financial performance				Environmental performance				Green innovation	
	Tobin's Q		ROA		Environment rating		CO ₂ emissions / assets		Green patents / total patents	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Green bond	0.028**		0.005**		6.132**		-16.977**		0.021	
	(0.012)		(0.002)		(2.619)		(7.130)		(0.016)	
Green bond (pre-issue year)		0.003		0.001		0.448		1.228		0.002
		(0.013)		(0.003)		(2.722)		(7.986)		(0.016)
Green bond (short-term, 1 year)		0.026**		0.002		4.407		-9.168		0.012
		(0.013)		(0.003)		(2.885)		(7.411)		(0.016)
Green bond (long-term, 2+ years)		0.029**		0.006**		7.283**		-21.585***		0.034*
		(0.014)		(0.003)		(2.988)		(8.071)		(0.019)
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	971	971	1,005	1,005	795	795	600	600	416	416
R-squared	0.89	0.89	0.86	0.86	0.88	0.88	0.92	0.92	0.66	0.66

Environmental performance. In columns (5)-(8), I find that environmental performance goes up substantially in the long run. The ASSET4 environment rating goes up by 7.3 percentage points, which corresponds to an increase by 8.8% (given the mean of 83.4 from Table 6). Similarly, emissions are reduced by 21.6 tons of CO₂ per \$1M of assets, a reduction by 27.7% (given the mean of 77.9 from Table 6). These results indicate that green bonds (or more precisely, the green projects financed by the green bond proceeds) yield substantial improvements in the company's environmental footprint. As such, green bonds have real effects, which is inconsistent with a greenwashing motive.

³¹ Tobin's Q increases by 0.026 after one year, and 0.029 in the long run. Given a mean of 1.17 (Table 6), this corresponds to an increase in firm value by 2.2% and 2.5%, respectively. This suggests that the 0.7% increase in shareholder value over the 2-day event window (Table 4) does not revert in the long run. On the contrary, it increases further, confirming that corporate green bonds contribute to long-term value creation.

Green innovations. In columns (9) and (10), I observe an increase in green patenting (the number of green patents as a ratio of total patents) in the long run. This increase is large in economic terms—the ratio increases by 3.4%. Yet, I caveat that this increase is only marginally significant in statistical terms (t-statistic = 1.79).

Long-term orientation. In columns (1) and (2) of Table 8, I examine whether the issuance of corporate green bonds contributes to a longer-term orientation. As can be seen, it does. In the years following the green bond issue, the LT-index significantly increases by 3.9 percentage points, which corresponds to an increase by 4.9% (given the mean of 79.3 from Table 6).

Table 8. Implications of green bond issuance for firm outcomes—long-term orientation and ownership structure

This table reports estimates of the difference-in-differences specification in equation (1). *Green bond* is a dummy variable equal to one if the firm has issued a green bond. *Green bond (pre-issue year)* is a dummy variable equal to one in the year preceding the green bond issue. *Green bond (short-term, 1 year)* and *Green bond (long-term, 2+ year)* are defined analogously with respect to the year following the green bond issue and the subsequent years, respectively. The dependent variables used in this table are only available for U.S. companies. *LT-index* is the long-term index of Flammer and Bansal (2017). *Institutional ownership* is the percentage of shares owned by institutional investors. *Ownership by LT investors* is the percentage of shares owned by long-term institutional investors, that is, investors coded as “dedicated” in Bushee’s (1998, 2001) dataset. *Ownership by green investors* is the percentage of shares owned by “green” institutional investors, that is, investors who are members of the Ceres Investor Network on Climate Risk and Sustainability. The sample includes all firm-year observations of the treated and matched control firms from 2010-2017. Standard errors (reported in parentheses) are clustered at the 2-digit SIC industry level. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

	Long-term orientation		Ownership					
	LT-index		Institutional ownership		Ownership by LT investors		Ownership by green investors	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Green bond	0.039** (0.016)		0.010 (0.010)		0.015* (0.008)		0.030** (0.012)	
Green bond (pre-issue year)		0.014 (0.017)		0.003 (0.009)		0.001 (0.007)		0.005 (0.013)
Green bond (short-term, 1 year)		0.032* (0.017)		0.010 (0.009)		0.007 (0.008)		0.017 (0.013)
Green bond (long-term, 2+ years)		0.044** (0.019)		0.012 (0.010)		0.023** (0.011)		0.041** (0.015)
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	382	382	316	316	316	316	316	316
R-squared	0.84	0.84	0.90	0.90	0.57	0.57	0.72	0.72

Ownership structure. Finally, in columns (3)-(8) of Table 8, I examine the implications for ownership structure. In columns (3)-(4), I find that institutional ownership increases slightly, but not significantly. Importantly, in columns (5)-(8), I find that the share of i) long-term investors and ii) green investors increases significantly (by 1.5% and 3.0%, respectively). This indicates that the issuance of green bonds helps attract an investor clientele that values the long-term and the environment.

5.3 Cross-sectional heterogeneity

In Table 9, I examine how the results of Tables 7 and 8 vary depending on cross-sectional characteristics. In Panel A, I interact Green bond with two dummy variables that indicate whether or not the green bond is certified by independent third parties. As can be seen, the impact is large and significant for certified green bonds, while it is small and insignificant for non-certified green bonds. These findings are consistent with the view that certification reflects a stronger commitment towards green projects.³²

³² I caution that the differences are not significant at conventional levels, except in columns (8) and (9), where the p-values are 0.076 and 0.098, respectively. This suggests that long-term and green investors are especially sensitive to certification.

Table 9. Implications of green bond issuance for firm outcomes—cross-sectional heterogeneity

This table presents variants of the regressions in Tables 7 and 8, but interacting *Green bond* with dummy variables that indicate different subsamples. Panel A distinguishes between green bonds that are certified by independent third parties and green bonds that are not. Panel B distinguishes between green bond issuers operating in industries with above- and below-median SASB scores of environment materiality. The sample includes all firm-year observations of the treated and matched control firms from 2010-2017. Standard errors (reported in parentheses) are clustered at the 2-digit SIC industry level. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

	Tobin's Q	ROA	Environment rating	CO ₂ emissions / assets	Green patents / total patents	LT-index	Institutional ownership	Ownership by LT investors	Ownership by green investors
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
<i>Panel A. Certified vs. non-certified green bonds</i>									
Green bond × certified	0.032** (0.014)	0.006** (0.003)	7.165** (2.893)	-19.354** (7.714)	0.025 (0.018)	0.043** (0.020)	0.011 (0.015)	0.022** (0.010)	0.040** (0.018)
Green bond × non-certified	0.021 (0.013)	0.004 (0.003)	4.201 (2.701)	-11.849 (7.330)	0.016 (0.017)	0.029 (0.019)	0.008 (0.014)	0.006 (0.009)	0.014 (0.017)
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-year fixed effects	Yes	Yes	Yes	Yes	Yes	-	-	-	-
Industry-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	971	1,005	795	600	416	382	316	316	316
R-squared	0.89	0.86	0.88	0.92	0.66	0.84	0.90	0.57	0.72
<i>Panel B. Financial materiality of the environment above vs. below median</i>									
Green bond × high SASB score	0.041*** (0.013)	0.008*** (0.003)	7.210** (2.931)	-19.197** (7.510)	0.023 (0.018)	0.041** (0.019)	0.011 (0.013)	0.018** (0.009)	0.032** (0.015)
Green bond × low SASB score	0.017 (0.013)	0.003 (0.002)	5.414** (2.698)	-14.883** (7.429)	0.020 (0.018)	0.036** (0.018)	0.010 (0.014)	0.014* (0.009)	0.027* (0.015)
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-year fixed effects	Yes	Yes	Yes	Yes	Yes	-	-	-	-
Industry-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	971	1,005	795	600	416	382	316	316	316
R-squared	0.89	0.86	0.88	0.92	0.66	0.84	0.90	0.57	0.72

Finally, in Panel B, I interact Green bond with two dummies that indicate whether the SASB materiality score is above or below the median across all industries. While the impact of corporate green bonds is somewhat larger in industries with a higher SASB score, the difference is only large and significant for the measures of financial performance in columns (1) and (2).³³ This is intuitive given that the SASB materiality score is meant to capture industries in which green initiatives are more likely to contribute to financial performance.

³³ The p-values are 0.057 in column (1) and 0.023 in column (2), respectively. ³⁴ In this spirit, Apple's \$1B green bond was issued following President Trump's withdrawal of the U.S. from the Paris climate agreement. Commenting on the green bond issue, Apple stated that "this green bond is meant to show that businesses are still committed to the goals of the 194-nation accord" (Reuters, 2017).

6. Conclusion

Do corporate green bonds deliver on their promise? Or are they merely a form of greenwashing? The results of this study are consistent with the former. Corporate green bonds are effective they not only yield improvements in companies' environmental footprint, but also contribute to financial performance. Moreover, they help attract an investor base that values the long run and the natural environment. Overall, my results indicate that corporate green bonds bring several benefits to both companies and the natural environment. Accordingly, the findings of this study suggest that corporate green bonds represent a powerful tool in climate finance to fight climate change—a tool that can be used by the private sector regardless of (the lack of) government actions.³⁴

This study—which is the first attempt at understanding corporate green bonds—calls for future research. First, since corporate green bonds are a new phenomenon, the results are based on a relatively small number of observations. As more data become available, future research could provide larger-scale evidence and a more refined characterization of the long-term impact of corporate green bonds. Second, while the matching used in this study helps mitigate the endogeneity of corporate green bonds, it does not substitute for a (quasi-)experiment. In this vein, future developments in the green bond market (e.g., regulations) may provide alternative empirical settings that could help deepen our understanding of green bonds. Third, future work could explore how the issuance of green bonds affects other debt instruments of the company—e.g., does it reduce or enhance the company's ability to issue other (conventional) bonds? Does it increase or decrease the overall cost of financing? Making ground on these questions is an exciting avenue for future research.

³⁴ I caution that the differences are not significant at conventional levels, except in columns (8) and (9), where the p- values are 0.076 and 0.098, respectively. This suggests that long-term and green investors are especially sensitive to certification.

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