CORPORATE GREEN BONDS

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Abstract

I examine corporate green bonds, whose proceeds finance climate-friendly projects. These bonds have become more prevalent over time, especially in industries where the environment is financially material to firm operations. I document that investors respond positively to the issuance announcement, a response that is stronger for first-time issuers and bonds certified by third parties. The issuers improve their environmental performance post issuance (i.e., higher environmental ratings and lower CO_2 emissions), and experience an increase in ownership by long-term and green investors. Overall, the findings are consistent with a signaling argument—by issuing green bonds, companies credibly signal their commitment towards the environment.

Keywords: sustainable finance; climate change; green bonds; impact investing; corporate sustainability; environment.

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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 inexistent prior to 2013. In that year, the total issuance of corporate green bonds was about $5B. Since then, the issuance of corporate green bonds has skyrocketed. In 2018 alone, the corporate sector issued green bonds worth $95.7B.[1]

While the use of corporate green bonds has become increasingly more prevalent in practice, we know very little about this new financial instrument. Intuitively, it might seem puzzling that companies choose to issue green bonds in lieu of conventional bonds as the proceeds from green bonds are committed to green projects, which restricts companies' investment policies. Moreover, 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 costs. Given the constraining nature of green bonds, a seemingly superior strategy would be to issue conventional bonds, and then invest the proceeds in

[1] This represents only a small share of the overall bond market. The size of the worldwide bond market (based on total debt outstanding) is estimated at $102.8 trillion in 2018 (SIFMA, 2019).

green projects if they are deemed to be financially more viable than other projects.[2]

So, what are the rationales for issuing corporate green bonds, and what are their implications? There are three potential rationales. First, green bonds may serve as a credible signal of the company's commitment towards the environment (*signaling argument*). Such a signal can be valuable, as investors often lack sufficient information about the company's environmental commitment (e.g., Lyon and Maxwell, 2011; Lyon and Montgomery, 2015). Due to their constraining nature, green bonds may allow companies to credibly signal that they are indeed committed to undertaking investments in green projects and improving their environmental footprint. Second, issuing green bonds could be a form of "greenwashing"—that is, the practice of making unsubstantiated or misleading claims about the company's environmental commitment. In this vein, companies would issue green bonds to portray themselves as environmentally responsible, but without taking tangible actions (*greenwashing argument*).[3] Third, if green bond investors are willing to trade off financial returns for societal benefits, companies may issue green bonds to obtain cheaper financing (*cost of capital argument*). This paper examines these three rationales, and provides evidence suggesting that corporate green bonds serve as a credible signal of companies' commitment towards the environment.

To empirically examine corporate green bonds, I compile a dataset of corporate green bonds from Bloomberg's fixed income database. The dataset covers the full universe of corporate green bonds followed by Bloomberg issued by public and private companies across the world since the early days of this market in 2013 until 2018.

[2] This is analogous to mathematical optimization. The feasible set is largest when optimizing an objective function without constraints. It follows that any unconstrained optimum is (weakly) superior to a constrained optimum. In this vein, companies issuing conventional bonds are able to choose from a wider set of investment strategies to maximize firm value compared to companies that issue green bonds.

[3] This greenwashing concern originates in the lack of public governance of the green bonds market (see Section 2.2).

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, corporate green bonds are more prevalent in industries where the natural environment is financially material to the companies' operations (e.g., energy). Third, corporate green bonds are especially prevalent in China, the U.S., and Europe.

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 a short time window around the announcement of green bond issues, the cumulative abnormal return (CAR) is 0.49%, which is significantly different from zero at the 5% level. Moreover, CARs are larger for i) green bonds that are certified by independent third parties, and ii) first-time issuers of green bonds.

Previous work has shown that the stock market responds positively to companies' eco-friendly behavior (e.g., Flammer, 2013; Klassen and McLaughlin, 1996; Krueger, 2015).[4] Accordingly, if corporate green bonds do provide a (credible) signal of companies' commitment to the environment, one would indeed expect i) a positive stock market reaction to the announcement of green bond issuance, ii) a stronger response for certified green bonds (i.e., green bonds for which the signal is more costly), and iii) a stronger response for first-time issuers (i.e., when the green bond signal is provided to the market for the first time). All of which I find. These results are most consistent with the signaling argument.

Next, I examine the evolution of various firm-level outcomes following the issuance of green bonds. To obtain a plausible counterfactual of how green bond issuers would have fared had

[4] The rationale is that eco-friendly behavior is beneficial to firms, at least in the long run. This rationale is consistent with the large (and growing) literature that documents a positive relationship between ESG and performance (e.g., Eccles, Ioannou, and Serafeim, 2014; Edmans, 2011, 2012; Flammer, 2015; Flammer, Hong, and Minor, 2019; Guenster, Bauer, Derwall, and Koedijk, 2011) and a negative relationship between ESG and risk (e.g., Godfrey, Merrill, and Hansen, 2009; Hoepner, Oikonomou, Sautner, Starks, and Zhou, 2019).

they issued a regular bond (in lieu of a green bond), I use a matching methodology. Specifically, in the year preceding the bond issuance, 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 ensures that the comparison group—that is, (non-green) bond issuers—are as similar as possible to green bond issuers ex ante.

Using this matching approach, I find that green bond issuers improve their environmental performance post issuance—specifically, I observe i) an increase in the company's environmental rating (measured by the environmental score of Thomson Reuters' ASSET4), and ii) a decrease in CO_2 emissions. These findings are again consistent with the signaling argument. To the extent that green bonds provide a credible signal of the firm's commitment towards the environment, one would expect significant improvements in environmental performance going forward. Importantly, these findings are inconsistent with the greenwashing argument. If companies were to issue green bonds to portray themselves as environmentally conscious, but without any intent to deliver, one would not observe tangible improvements in environmental performance post issuance.

Note that the above results need not imply a causal effect of green bonds on environmental performance. In fact, the green bonds themselves are likely too small to bring about significant improvements at the firm level (among public firms, the average green bond issue is \$0.26B compared to the average issuer's asset size of \$33.5B). Instead, and consistent with the signaling argument, a natural interpretation is that green bonds signal a credible commitment towards the environment. As this commitment materializes in eco-friendly behavior, companies improve their environmental performance. Some of these improvements—but not necessarily all of them—may be due to the projects that are financed by the green bond proceeds.

I also examine how equity ownership evolves following the green bond issuance. Using the matching methodology described above, I find that green bond issuers (compared to otherwise similar bond issuers) experience an increase in ownership by i) long-term investors, and ii) green investors post issuance. These findings are again consistent with the signaling argument—as green bonds provide a credible signal of the commitment towards the environment, companies are better able to attract an investor base that is mindful of the long term and the natural environment.

Finally, I explicitly examine the cost of capital argument. To study the pricing of corporate green bonds, I follow the methodology used by Larcker and Watts (2019) in the context of municipal green bonds. Specifically, for each green bond, I match an otherwise similar "brown" (i.e., non-green) bond by the *same issuer*. This ensures that the two bonds are as similar as possible, expect for the "greenness." When comparing the yields of both, I find that the median difference is exactly zero, and the average difference is small and statistically insignificant. This is consistent with Larcker and Watts' (2019) finding of no pricing difference between green and brown bonds in the market for municipal bonds.[5] This is also consistent with industry practice—qualitative evidence from surveys and interviews reveals that investors would not invest in green bonds if the returns were not competitive (e.g., Chiang, 2017). As such, my finding of no pricing differential for corporate green bonds is inconsistent with the cost of capital argument, according to which companies would issue green bonds to benefit from a cheaper source of financing.

Taken together, the findings of this study suggest that corporate green bonds serve as a credible signal of companies' commitment towards the environment. As this commitment materializes, companies reduce their CO_2 emissions, achieve higher environmental ratings, and

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[5] Prior work on the green bond premium (Baker et al., 2018; Karpf and Mandel, 2017; Zerbib, 2019) found mixed results. Larcker and Watts (2019, p. 8) revisit this literature and argue that "the mixed evidence from prior studies is the result of methodological design misspecifications that produce biased estimates" (p. 8). I review and discuss this literature in Section 7.

become attractive for an investor clientele—such as long-term and green investors—that values the environment.

This study makes several contributions to the literature. First, it contributes to the growing literature that studies the green bond market (e.g., Baker et al., 2018; Karpf and Mandel, 2017; Zerbib, 2019). This literature—which is reviewed in Section 7—focuses primarily on the pricing of green bonds in the market for municipal (and sovereign) green bonds. An exception is the contemporaneous article by Tang and Zhang (2019) who also study corporate green bonds. Consistent with my results, they find that the stock market responds positively to the issuance of corporate green bonds. My study complements this body of research by examining how firm-level outcomes evolve following the issuance of green bonds.

Second, this study contributes to the growing literature on impact investing (e.g., Barber, Morse, and Yasuda, 2019; Geczy, Jeffers, Musto, and Tucker, 2019). 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 relatively novel instrument of impact investing—corporate green bonds.

Third, this paper indicates 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 Ghoul, 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, 2019; Ilhan, Krueger, Sautner, and Starks, 2020; Krueger, Sautner, and Starks, 2019; 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; Hamilton, 1995; Klassen and McLaughlin, 1996), as well as the broader literature that documents a positive relationship between corporate social responsibility (CSR) and stock market performance (e.g., Edmans, 2011, 2012; Edmans, Li, and Zhang, 2017; Flammer, 2015; Krueger, 2015).

The remainder of this paper is organized as follows. Section 2 presents the conceptual framework. Section 3 describes the data on corporate green bonds and presents a series of stylized facts. Section 4 describes the issuer-level data. Section 5 presents the results of the event study. Section 6 describes the analysis of firm outcomes. Section 7 discusses the pricing of corporate green bonds. Finally, Section 8 concludes.

2. Conceptual framework

What are the rationales for issuing green bonds and their implications? In the following, I discuss three potential rationales: 1) signaling (i.e., corporate green bonds provide a credible signal of the company's commitment towards the environment); 2) greenwashing (i.e., companies issue green bonds to portray themselves as environmentally responsible, yet do not take tangible actions); and 3) the cost of capital (i.e., green bonds provide a cheaper source of financing).

2.1. Signaling

Companies know more about their capabilities than their investors. This information asymmetry induces a transaction cost of identifying companies with desirable characteristics (e.g., Akerlof, 1970; Williamson, 1985). Accordingly, it is in the companies' best interest to reduce this information asymmetry by sending a "signal"—i.e., take actions that credibly convey this information. In signaling theory, a signal is credible if it is costly to mimic by firms with less desirable characteristics (Riley, 1979; Spence, 1973).

The issuance of corporate green bonds can be interpreted through the lens of signaling theory. Investors often lack sufficient information to evaluate the company's commitment to the environment (e.g., Lyon and Maxwell, 2011; Lyon and Montgomery, 2015). From the investors' perspective, this creates a need to (credibly) distinguish between those companies that are committed towards the environment versus those that are not.

By issuing green bonds, companies can signal their commitment towards the environment. This signal is likely to be credible, for the following reasons. First, by issuing green bonds, companies commit substantial amounts of money to green projects (among public firms, the average size of corporate green bonds is $0.26B). Second, green bonds are often certified by independent third parties (approved by the Climate Bond Standard Board) to guarantee that the proceeds are indeed used to finance the green projects that are outlined in the bond prospectus. Complying with the standards requires substantial managerial effort and resources, which is costly to the issuer.[6,7] What is more, non-compliance with certification is costly as well. In the event of non-compliance (so-called "green default"), the issuer needs to notify the Board of the Climate Bonds Initiative within one month of becoming aware of the non-compliance. The Board would then suggest corrective actions for compliance to be restored. If compliance is not restored within a reasonable timeframe, the Board would then revoke the certification of the green bond (see Climate Bonds Initiative, 2018).[8]

[6] In a recent interview with the *Financial Times*, Hiro Mizuno, chief investment officer of Japan's Government Pension Investment Fund—the world's largest pension fund—highlights that green bonds are "costly and complicated and cumbersome" for issuers (*Financial Times*, 2019).

[7] The certification standards ("Climate Bond Standards") are described in Climate Bonds Initiative (2018). 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 Climate Bond 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 Climate Bond Standards.

[8] As the green bond market is still in an early stage, there are only few instances of "green defaults." That being said,

In sum, the issuance of green bonds may serve as a credible signal of the company's commitment to the environment. This signaling role of corporate green bonds is often mentioned in anecdotal accounts. For example, referring to Unilever's £250M green bond issue, Unilever CFO 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" (*Financial Times*, 2014).

The signaling argument offers several testable implications. First, the previous literature has shown that shareholders respond positively to companies' engagement towards the environment. Several event studies document positive abnormal returns in response to companies' eco-friendly behavior (e.g., Flammer, 2013; Klassen and McLaughlin, 1996; Krueger, 2015). Similarly, Flammer (2015) finds that the stock market responds positively to the adoption of close-call shareholder proposals advocating the pursuit of eco-friendly policies.[9] Accordingly—to the extent that the issuance of green bonds signals a credible commitment towards the environment—one would expect the stock market to respond positively to the issuance of green bonds. Moreover, the stock market response is likely to be stronger for green bonds that are certified (i.e., green bonds for which the signal is more credible) and for first-time issuers (i.e., issuers that have not yet used this signaling device).

Second, another implication is that, following the issuance of green bonds, issuers would improve their environmental performance (e.g., the volume of CO_2 emissions). Indeed, if green

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as the example of the Spanish oil company Repsol illustrates, non-compliance with the standards can have important consequences. In May 2017, a controversy arose around Repsol's €500 million "green" bond that was deemed non-compliant with the Climate Bond Standards. On the day of the controversy, Repsol's stock price dropped by about 1%. The bond was subsequently excluded from green bond indices, with major reputation losses for Repsol (*Environmental Finance*, 2017).

[9] As mentioned in Section 1, the rationale behind the positive stock market response is that eco-friendly behavior is beneficial to firms, at least in the long run. This is consistent with the literature that documents a positive relationship between ESG and performance (e.g., Eccles, Ioannou, and Serafeim, 2014; Edmans, 2011, 2012; Flammer, 2015; Flammer, Hong, and Minor, 2019; Guenster et al., 2011) and a negative relationship between ESG and risk (e.g., Godfrey, Merrill, and Hansen, 2009; Hoepner et al., 2019).

bonds signal a credible commitment towards the environment, this should ultimately translate in improved environmental performance. Note that this argument need not imply that green bonds *cause* improvements in environmental performance. In fact, the green bond amounts are likely too small compared to the size of the respective issuers to bring about significant improvements at the firm level (among public firms, the average green bond issue is \$0.26B compared to the average issuer's asset size of \$33.5B). Instead, the argument is that, by issuing green bonds, companies signal a (credible) commitment towards the environment. As this commitment materializes in eco-friendly behavior, companies' environmental performance improves. Some of these improvements, but not necessarily all of them, may be due to the projects that are financed by the green bond proceeds.

Third, another implication is that, following the issuance of green bonds, ownership by long-term and green investors would be expected to increase. Indeed, as companies signal their commitment towards the environment by issuing green bonds, they would be expected to become more attractive for an investor clientele that is sensitive to the environment.

All these empirical predictions are supported by the data (see Sections 5 and 6). Before turning to the empirical analysis, I discuss alternative rationales for issuing green bonds.

2.2. Greenwashing

Another potential rationale is that green bonds may represent a tool of greenwashing. "Greenwashing"—that is, the practice of making unsubstantiated or misleading claims about the company's environmental commitment—is a widespread phenomenon (e.g., Berrone, Fosfuri, and Gelabert, 2017; Lyon and Montgomery, 2015; Marquis, Toffel, and Zhou, 2016). Greenwashing comes in many flavors. For example, companies may use selective disclosure, dubious eco-labels, misleading visual imagery (e.g., the display of biodiversity symbols on the product), and misleading narratives (for details, see Lyon and Montgomery, 2015).

As discussed in Section 2.1, issuing green bonds is costly to firms, and hence need not represent a suitable greenwashing strategy. If the aim is to engage in greenwashing, other means—such as those listed above—are likely more appealing. Nevertheless, practitioners have raised concerns about a potential greenwashing motive underlying the issuance of green bonds. For example, referring to the rapid growth of the green bond market, 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. Instead, the green bond market relies on private governance regimes such as the certification standards described in the previous section. These private governance regimes do not have the same enforcement mechanisms as public regulation.[10]

If indeed the greenwashing motive prevails, one would not expect any improvement in environmental performance following the issuance of corporate green bonds. The results of this study are inconsistent with this prediction, as I find that environmental performance increases post issuance (see Section 6).

2.3. The cost of capital

Another rationale for issuing green bonds could be the cost of capital. Specifically, if green bond investors are willing to accept lower yields for the greater good of fighting climate change, green bonds may represent a cheaper source of financing.[11] This, in turn, would predict a positive stock

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

[11] This prediction can be obtained from Fama and French's (2007) taste-based framework. If mean-variance investors have a "taste" for holding green assets (or, more broadly, assets from which they derive non-pecuniary benefits), green assets will trade at a premium compared to non-green assets. Intuitively, as investors derive utility from holding the green assets, they are willing to settle for lower expected returns.

market response, as equityholders benefit from the cheaper source of debt financing.

Nevertheless, the findings of this paper are inconsistent with the cost of capital argument, as I find no evidence that corporate green bonds trade at a premium compared to non-green bonds (see Section 7).[12]

3. 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 "Green bond indicator" is "Yes"). I exclude bonds whose issuer's BICS (Bloomberg Industry Classification System) is "Government".[13] 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.[14]

The above criteria yield a total of 1,189 corporate green bonds issued from January 1, 2013 until December 31, 2018. 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.

3.1. Corporate green bonds over time

In Table 1, I report the evolution of corporate green bonds over the years (the corresponding

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[12] This finding of no pricing difference is consistent with industry practice (e.g., Chiang, 2017) and the recent work by Larker and Watts (2019), who find no evidence for a green bond premium among municipal bonds. See Section 7 for details.

[13] 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.

[14] The dataset includes special purpose entities such as Mexico City Airport Trust that issued 8 green bonds between September 29, 2016 and September 20, 2017 (in amount of $12B). Those are coded as "corporates" in Bloomberg, and have non-government BICS codes (e.g., Mexico City Airport Trust has BICS code "Transportation and logistics"). Nevertheless, their inclusion is immaterial for the results. The main analysis is conducted with green bonds of publicly traded firms, and none of them are special purpose entities.

statistics are plotted in Figure 1). This table shows the rapid growth in corporate green bonds over the past few years. While the total amount issued in 2013 was $5B (corresponding to 16 bonds), it soared to $95.7B (corresponding to 396 bonds) in 2018. This trend is likely to continue in future years, given the growing popularity of sustainable finance (Morgan Stanley, 2017).[15]

------Insert Table 1 and Figure 1 about here------

3.2. Corporate green bonds across industries and countries

Table 2 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). In Section 4.2, 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)).

------Insert Table 2 about here------

Table 3 provides a breakdown by countries. As is shown, green bonds are especially prevalent in China, the U.S., and Europe (the Netherlands, France, and Germany being the larger issuers in dollar terms).

------Insert Table 3 about here------

3.3. Summary statistics at the bond level

In column (1) of Table 4, I provide summary statistics on the 1,189 corporate green bonds. It is

[15] Note that Tesla issued 140 green bonds between October 15, 2014 and January 14, 2016 (out of which 131 were issued in 2015). This explains the 2015 spike in the number of green bonds observed in Table 1 and Figure 1.

not uncommon that a given company issues several green bonds on a given day—the 1,189 green bonds correspond to 775 unique issuer-days, 526 unique issuer-years, and 400 unique issuers.[16]

------Insert Table 4 about here------

As can be seen, corporate green bonds are fairly large—the average issuance amount is \$253.4M. About 65.6% are certified by independent third parties.[17] The average maturity is 7.7 years. 75.3% of the bonds are fixed-rate with an average coupon of 3.7%. Finally, the median credit rating is A- (based on Standard & Poor's rating scale), A3 (based on Moody's rating scale), and A- (based on Bloomberg's composite rating).[18]

In columns (2) and (3), I distinguish between green bonds that are issued by private firms (624 bonds, corresponding to 231 unique issuers) and public firms (565 bonds, corresponding to 169 unique issuers). Not surprisingly, public firms issue larger bonds. Moreover, these bonds tend to have longer maturities, and are more likely to be fixed-rate bonds. In the remainder of this paper, I restrict the sample to the green bonds of public firms, since detailed firm-level data (e.g., stock market data, accounting data, etc.) are available that can be used to study how firm-level outcomes evolve following the issuance of green bonds.

4. Firm-level data

4.1. Data sources

The firm-level data are obtained from several sources, which are described below.[19]

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[16] In Table 4, *#Green bond issuer-days* refers to the number of unique days on which a given firm issues green bonds (summed across all firms); *#Green bond issuer-years* refers to the number of unique years in which a given firm issues green bonds (summed across all firms); and *#Green bond issuers* refers to the number of unique firms.
[17] 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).
[18] Bloomberg's rating is a composite of the ratings from four ratings agencies—DBRS, Fitch, Moody's, and Standard & Poor's. See Bloomberg (2015) for details.
[19] In Section 6, I introduce additional data that will be used in the finer-grained analysis.

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 book value of common stock) 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 of total assets. To mitigate the impact of outliers, all ratios are winsorized at the 1^{st} and 99^{th} percentiles of their empirical distribution.

Stock market data. The stock market data are obtained from the daily stock file of Compustat North America and 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*). 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 standardized 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 financially material for companies in the industry (*environment materiality*).[20, 21]

4.2. Summary statistics at the issuer level

The 565 green bonds of public firms correspond to 225 unique firm-year observations (since some companies issue multiple green bonds in a given year). In column (1) of Table 5, I provide summary statistics for the characteristics described above. The statistics are recorded in the fiscal year that ends before the green bond's issue date.

------Insert Table 5 about here------

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). Again, the statistics are recorded in the fiscal year that ends prior to the bond issue. I identify bond issuers from Bloomberg's fixed income database. For each characteristic, I 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). Moreover, green bond issuers have higher environmental ratings (and higher ESG ratings).

[20] 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.

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

Finally, since the last characteristic—environment materiality—is at the industry level, I adjust the comparison group by taking the average across all comparison firms in the same country and year, excluding those operating in the same 2-digit SIC industry as the green bond issuer. 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 companies are more likely to issue green bonds when green projects are beneficial to them.

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

5.1. 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). In keeping with Krueger (2015), I account for the possibility that some information may have been known to the public prior to the announcement by including the 5 previous trading days, and account for the possibility of a staggered response by including the following 10 trading days—i.e., the baseline event window is [-5, 10]. To see if there is any run-up in stock prices before and after the event window, I also consider the time intervals [–20, –11] and [–10, –6] prior to, and the time intervals [11, 20] and [21, 60] 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.[22]

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:

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

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 time intervals [–20, –11], [–10, –6], [11, 20], and [21, 60] in addition to the event window [–5, 10].

5.2. Event study results

The event study results are reported in Table 6. The sample includes all 384 issuer-day observations. 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 event window [–5, 10] is 0.49% and significant at the 5% level. All other intervals before and after this event window yield CARs that are small and insignificant, which indicates that the results are not driven

[22] 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).

by unrelated trends around the event date. The positive CARs suggest that the stock market respond positively to the issuance of green bonds.

------Insert Table 6 about here------

This finding speaks to the large literature in corporate finance that 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 signal of the company's commitment to the environment. 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, 2015).

In Table 7, I examine which characteristics drive the announcement returns. First, in Panel (A), I find that the stock market reaction is large and significant for certified green bonds, while it is small and insignificant for non-certified green bonds. As discussed in Section 2.1, 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 represent a more credible signal of the company's commitment towards the environment. As such, the stronger stock market response is consistent with the signaling argument.

------Insert Table 7 about here------

In Panel (B), I find that the abnormal returns are large and significant for first-time issuers, but small and insignificant for seasoned issuers. This finding is again consistent with the signaling argument. After the first-time issue, the market has learned about the firm's commitment to green projects. As a result, the information content of subsequent issues might be closer to that of conventional bond issues, which have been shown to yield insignificant abnormal returns (see Eckbo, Masulis, and Norli, 2007).[23]

Finally, in Panel (C), I document that the abnormal returns are only significant in industries where the natural environment is financially material to the firms' operations. While this test does not speak directly to the signaling argument, it helps validate the underlying assumption that shareholders value companies' commitment towards the environment. Indeed, to the extent that shareholders are sensitive to companies' eco-friendly behavior, one would expect a stronger stock market response in industries where the natural environment is material to the companies' financial performance. The findings are consistent with this argument.[24]

5.3. Robustness

In Table 8, I present a series of robustness checks that address potential concerns. In what follows, I briefly describe each of them.

------Insert Table 8 about here------

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.

[23] Note that there is only limited overlap between certified green bonds and first-time green bonds. The correlation between these two characteristics is 28.9%.

[24] I caution that the differences across groups in Table 7 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.

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.[25]

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.

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 financials. 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 (in fact, larger) after excluding financial firms.

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[25] 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.

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 384 event dates considered in the baseline. There are 42 event dates with other relevant announcements. As is shown, my results are robust to their exclusion.

Median CAR. 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 (0.34% compared to the mean CAR of 0.49%). Importantly, it remains significant at the 5% level.

Excluding countries with green bond subsidies. China, Hong Kong, and Singapore provide subsidies for issuing green bonds, which could affect the stock market response. In row 9, I show that my results are robust to excluding issuers from these countries.

6. Corporate green bonds and firm-level outcomes

In this section, I examine how firm-level outcomes evolve following the issuance of green bonds. I first describe the outcome variables and the methodology. I then present the results.

6.1. Data and methodology

6.1.1. Firm outcomes

Environmental performance. I use two measures of environmental performance. The first measure is the environmental rating from ASSET4. A caveat of this measure is the subjective nature of ESG ratings (e.g., Berg, Koelbel, and Rigobon, 2019; Chatterji, Durand, Levine, and Touboul, 2016). For example, it could be that ASSET4 analysts perceive the issuance of green bonds as good environmental practice, and upgrade the company's environmental rating accordingly. In this scenario, finding an increase in the ASSET4 environmental rating post issuance could capture the green bond itself as opposed to tangible improvements in environmental performance. However, note that the issuance of green bonds does not enter the assessment grid used by ASSET4 to determine the rating (see Thomson Reuters, 2017). As such, there is no mechanical link between the issuance of green bonds and higher environmental ratings.

To further mitigate this issue, I use a second measure of environmental performance: the ratio of CO_2 emissions (in tons) from ASSET4 divided by the book value of assets.[26,27] CO_2 emissions are (more) objectively measured. Moreover, this metric is easier to interpret compared to the environmental rating that blends several dimensions of corporate environmental behavior.

Ownership structure. For U.S. companies, I characterize their equity ownership using holding data from Thomson Reuters. By tracking changes in ownership, I can examine whether the issuance of green bonds help attract specific investor clienteles.[28] I use four measures of ownership. *Institutional ownership* is the percentage of shares owned by institutional investors. The other three 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. I construct this measure in two different ways, depending on how I identify long-term investors. First, I use the duration measure of Cremers and Pareek (2016, equation (2) on p. 292)—which captures the holding horizon of investors—and code an investor as long-term if the duration measure is above the median across all investors (*duration*). Second, I use the churn ratio of Gaspar, Massa, and Matos (2005, equation (1) on p. 143)—which captures the frequency at which investors rebalance their

[26] More precisely, I use item ENERDP023 from ASSET4 ("total CO_2 and CO_2 equivalent emissions in tons").
[27] I winsorize this ratio at the 1st and 99th percentiles of its empirical distribution.
[28] 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).

portfolios—and code an investor as long-term if the churn ratio is below the median across all investors (*churn ratio*). 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.[29]

6.1.2. 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. In doing so, 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.

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 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 225 public 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

[29] 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.

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.[30]

This matching procedure is designed to ensure that control firms are highly similar 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.[31] 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).

To illustrate the similarity between treated and control firms, Table 9 reports descriptive statistics for the 14 matching characteristics (Panel A) and several non-matching characteristics (Panel B). Levels (e.g., log(assets)) are measured in the year preceding the green bond issuance, while pre-trends (e.g., Δ log(assets)) are measured in the two-year window preceding the green

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

[31] 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).

bond issuance. For each characteristic, the table reports means, medians, and standard deviations for the 225 treated firms and the 225 matched control firms.[32, 33] 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 0.22 to 0.93). Neither can the null of equal medians (with *p*-values from 0.14 to 0.97).[34] 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.

------Insert Table 9 about here------

6.1.3. Difference-in-differences specification

To examine how firm-level outcomes evolve following the issuance of corporate green bonds, I estimate a difference-in-differences specification using all firm-year observations of the treated and matched control firms from 2010-2018.[35] Specifically, I estimate the following regression:

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

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., CO_2 emissions, institutional ownership, etc.); α_i are firm fixed effects; $\alpha_c \times \alpha_t$ are country by year fixed effects; $\alpha_s \times \alpha_t$ are industry by year fixed effects; *Green bond* is a dummy variable ("treatment dummy") that equals one if firm i has issued a green

[32] The ESG ratings from ASSET4 are available for 157 out of the 225 firms. For companies without ASSET4 coverage, the matching is done based on the other four characteristics (i.e., eight matching variables).
[33] The number of observations varies depending on data availability.
[34] In particular, the fact that treated and control firms have a similar level of CO_2 emissions (and a similar pre-trend in CO_2 emissions) mitigates concerns that firms that have emission problems issue green bonds for reputational purposes.
[35] 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.

bond by year *t* and zero otherwise; *ε* is the error term.[36] 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 change in *y* following the green bond issue accounting for contemporaneous changes in *y* at otherwise comparable firms that do not issue green bonds.

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 responses, and formally test for pre-trends in the data. In the following, I estimate both specifications for each outcome variable.

6.2. Results

6.2.1. Environmental performance

In Table 10, I find that environmental performance goes up substantially in the long run. The ASSET4 environment rating goes up by 7 percentage points, which corresponds to an increase by 8.7% (given the mean of 80.1 from Table 9). Similarly, emissions are reduced by 13 tons of CO_2 per $1M of assets, a reduction by 12.9% (given the mean of 101.1 from Table 9). These results indicate that companies improve their environmental performance following the issuance of green

[36] 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.

bonds.[37] These findings are consistent with the signaling argument, as they suggests that corporate green bonds do signal subsequent improvements in environmental performance. Importantly, this is inconsistent with a greenwashing motive for green bonds, according to which companies issue green bonds without any intention to improve their environmental footprint.

------Insert Table 10 about here------

6.2.2. Ownership structure

In Table 11, I examine how ownership structure evolves following the issuance of green bonds. In columns (1)-(2), I find that institutional ownership increases slightly, but not significantly. Importantly, in columns (3)-(8), I find that the share of i) long-term investors and ii) green investors increases significantly (by 1.8% to 2.2% for long-term investors; by 2.9% for green investors).

------Insert Table 11 about here------

These findings indicate that the issuance of green bonds helps attract an investor clientele that values the long-term and the natural environment. Again, this is consistent with the signaling argument—by issuing green bonds, companies can (credibly) signal their commitment to the environment. This, in turn, increases the companies' appeal for investors who are sensitive to the environment.

6.2.3. Certification

In Table 12, I revisit the results of Tables 10 and 11 to examine the role of certification. Specifically, 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—regardless of the outcome variable—the estimates are large and significant for certified green bonds, while they are small

[37] As mentioned above, these improvements are unlikely to be directly driven by the projects that are financed by the green bond proceeds, as those are an order of magnitude smaller compared to the size of the issuer (see Section 2.1).

and insignificant for non-certified green bonds. These findings are again consistent with the signaling argument—certification is a costlier signal and hence reflects a stronger commitment towards the natural environment.[38]

------Insert Table 12 about here------

7. Is there a premium for corporate green bonds?

7.1. Green versus brown bonds of the same issuer

Some prior work on green bonds—Karpf and Mandel (2017), Baker et al. (2018), and Zerbib (2019)—has focused on the pricing of green bonds and whether green bonds trade at a discount compared to non-green (i.e., "brown") bonds. These studies focus primarily on municipal bonds (Zerbib's sample also includes sovereign bonds and a small set of corporate bonds). Their findings are mixed. Karpf and Mandel (2017) find a green bond discount (i.e., a positive yield differential for green bonds) of about 8 basis points; Zerbib (2019, p. 40) finds a "small, albeit significant" green bond premium of 2 basis points; Baker et al. (2018) find a green bond premium of about 6 basis points.

In a recent article, Larcker and Watts (2019) revisit these studies. They argue that "the mixed evidence from prior studies is the result of methodological design misspecifications that produce biased estimates" (p. 8). Specifically, they note that Karpf and Mandel (2017) compare taxable and non-taxable securities (i.e., they ignore the role of taxation in the municipal securities market), which biases the estimates towards finding a green bond discount. They further argue that Baker et al.'s (2018) pooled fixed-effects regression insufficiently accounts for differences

[38] Note that, unlike in Table 7, I do not distinguish between first-time and seasoned issuers. The reason is that the green bond dummy (i.e., the treatment dummy) in equation (1) switches to one (and remains one) as of the first year in which the company issues a green bond.

between green and brown bonds, which biases the analysis towards finding a green bond premium.[39] To carefully examine the possibility of a green bond premium (or discount), Larcker and Watts (2019) use a very tight matching methodology, in which they match each green bond to a quasi-identical brown bond of the *same issuer*. When using this refined matching, they find that the green bond premium is essentially zero.

While the above literature focuses primarily on the pricing of municipal green bonds, little is known about corporate green bonds. To shed light on the latter, I apply Larcker and Watts' (2019) methodology in my sample of corporate green bonds. I proceed as follows. First, out of the 565 corporate green bonds issued by public firms, I restrict the sample to bonds with non-missing information on the offering yield (item "yield at issue" in Bloomberg's fixed income database). A total of 152 bonds have this information, corresponding to 65 unique issuers. For each of these 65 issuers, I extract from Bloomberg's fixed income database all brown bonds (i.e., bonds for which item "Green bond indicator" is "No"), that have non-missing information on the offering yield and were issued between January 1, 2010 and December 31, 2018. This yields a total of 1,690 brown bonds by the 65 issuers (and hence an average of 26 brown potential brown bond matches per issuer).

I then match each green bond to the most comparable brown bond of the same issuer. The matching is done in two steps. First, I require that the credit rating be the same (based on Bloomberg's composite credit rating). I then pick the nearest neighbor (using the Mahalanobis distance) based on four characteristics: i) log(issuance amount), ii) maturity, iii) coupon, and iv)

[39] More precisely, Larcker and Watts (2019) note (p. 21): "There are several concerns with the methodological approach used by Baker et al. (2018) models. This approach requires the fixed effects to be especially effective controls. It is easy to imagine a situation where the fixed effects will be inadequate. For example, green issuers (which tend to be significantly larger) may outperform non-green issuers over the sample period. Even when controlling for rating-maturity-issuance month fixed effects and issuer fixed effects, a greenium would be observed in this setting when it does not actually exist."

the number of days in between the green and brown bond issuance. By design, this matching procedure provides for each green bond a matched brown bond by the same issuer that is as similar as possible except for the "greenness."

The results are provided in Table 13.[40] As can be seen, for a given issuer, there is no noticeable difference between the yields of green vs. brown bonds. The median difference is exactly zero (*p*-value = 1.000). The mean difference is small in economic terms (0.019%) and statistically insignificant (*p*-value = 0.942). This is consistent with Larcker and Watts' (2019) finding of nearly identical pricing for green and brown (municipal) bonds. This also implies that my finding of a positive stock market reaction is unlikely to be driven by a cost of capital argument (i.e., companies accessing a cheaper source of capital).

------Insert Table 13 about here------

7.2. Discussion of the no pricing difference

The finding of no green bond premium warrants some discussion. First, is this finding consistent with industry practice? Intuitively, one might expect that green bond investors are willing to trade off financial returns for societal benefits. Yet, as it turns out, this is *not* the prevailing view among industry practitioners. For example, participants responding to a survey by the State Treasure Office of California on green bonds unanimously stated that "their firms would not accept a lower yield for a green bond" (Chiang, 2017). This was further confirmed by Larcker and Watts (2019) in their interviews of several traders, portfolio managers, and investment bankers, who all shared that sentiment (p. 8). I also conducted my own interviews of industry practitioners, including two fixed income analysts at asset management firms, a green bond research analyst at a leading

[40] Appendix Table 1 shows the covariate balance for the matching characteristics, confirming that there is no significant difference between the green bonds and matched brown bonds.

financial institution, and the director of the sustainable division of one of the world's largest banks. They unanimously stated that they would not invest in green bonds if the returns were not competitive.

Naturally, this raises the question of *why* there is no green bond premium. Larcker and Watts (2019) provide a detailed discussion of this question, and conclude that the most likely explanation is that the green projects are profitable enough to generate competitive returns. They note on p. 5: "[…] Rather, it is much more likely that asset prices are a function of the impact of ESG and CSR on future firm profitability and risk." This rationale is consistent with the large (and growing) literature that documents a positive relationship between ESG and performance (e.g., Eccles, Ioannou, and Serafeim, 2014; Edmans, 2011, 2012; Flammer, 2015; Flammer, Hong, and Minor, 2019; Guenster, Bauer, Derwall, and Koedijk, 2011) and a negative relationship between ESG and risk (e.g., Godfrey, Merrill, and Hansen, 2009; Hoepner, Oikonomou, Sautner, Starks, and Zhou, 2019). The results of this study lend further support to this argument, as they indicate that shareholders perceive a (credible) commitment towards eco-friendly behavior as value-enhancing.

Finally, it is worth highlighting that the market for corporate green bonds is still at a relatively early stage. As mentioned in Section 1, the market for corporate green bond represents only a tiny share of the overall corporate bond market (the issuance of corporate green bonds was $95.7 billion in 2018, while the size of the worldwide bond market is estimated at $102.8 trillion in 2018, see SIFMA, 2019). As such, my finding of no pricing differential need not generalize to future years. In particular, it could very well be that the existing corporate green bonds take advantage of the "low-hanging fruits" of eco-friendly behavior—that is, green projects that are profitable enough to sustain competitive returns. Yet, as the market expands (and the set of profitable green projects may eventually become scarce), it is possible that green bond investors may ultimately settle for a lower yield compared to non-green bonds.

8. Conclusion

This paper sheds light on corporate green bonds, a relatively new instrument in sustainable finance. I first document several stylized facts on corporate green bonds: i) corporate green bonds have become more prevalent over time; ii) corporate green bonds are more prevalent in industries in which the environment is material to the firm's operations (e.g., energy); and iii) corporate green bonds are especially prevalent in China, the U.S., and Europe.

I then examine how the stock market responds to the issuance of corporate green bonds. I find that the stock market responds positively to the announcement of green bond issuance. The response is stronger for green bonds that are certified by independent third parties and first-time issuers. Moreover, I find that, following the issuance of green bonds, companies improve their environmental performance (i.e., higher environmental ratings and lower CO_2 emissions) and experience an increase in ownership by long-term and green investors.

Overall, my results are consistent with a signaling argument: by issuing green bonds, companies credibly signal their commitment towards the environment. The stock market responds positively to this signal, consistent with prior work that finds a positive link between eco-friendly behavior and stock market outcomes (e.g., Flammer, 2013; Klassen and McLaughlin, 1996; Krueger, 2015). As this commitment materializes, companies show improved environmental performance, and become more attractive for an investor clientele that is sensitive to the environment.

In contrast, my findings are inconsistent with the view that green bonds are merely a tool of greenwashing. If that were the case, one would not observe improvements in environmental performance following the issuance of green bonds. My results are also inconsistent with a cost of capital argument, according to which green bonds would provide a cheaper source of debt financing, as I find no pricing difference between green bonds and quasi-identical brown bonds by the same issuer. This finding of no pricing difference for corporate green bonds is consistent with Larker and Watts' (2019) finding of no pricing difference in the market for green municipal bonds.

This study calls for future research. First, since corporate green bonds are a new financial instrument, 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 implications 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, an important (but difficult) question pertains to the optimal design of the governance of the green bond market. The current regime is mainly in the form of private governance (through certification by independent third parties). Yet, this need not be the optimal governance regime compared to, e.g., a combination of private *and* public governance. Making ground on these questions is an exciting avenue for future research.

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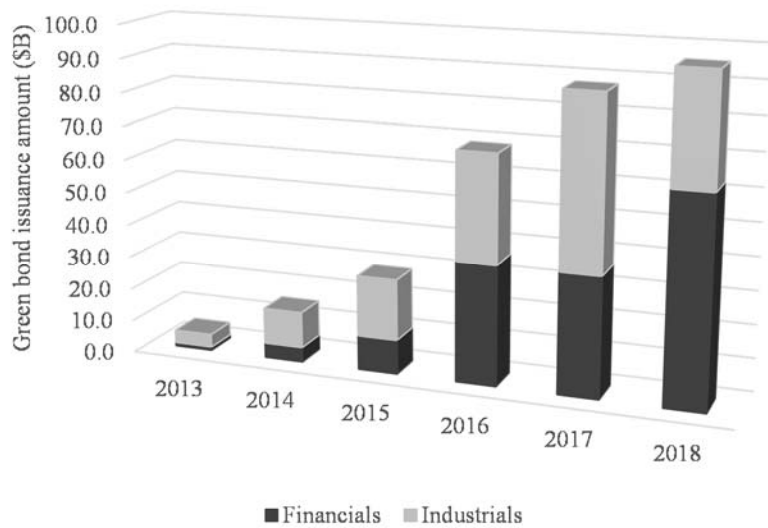
Figure 1. Evolution of corporate green bonds

This figure plots the total issuance amount of corporate green bonds (Panel A) and the number of green bonds issued (Panel B) on an annual basis, using all corporate green bonds from 2013-2018.

Panel A. Issuance of corporate green bonds (in $B)



Panel B. Number of corporate green bonds issued

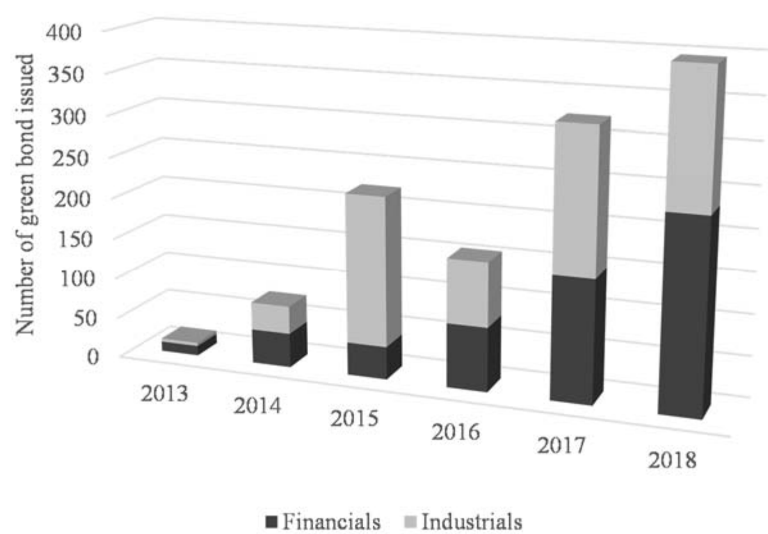


Table 1. Corporate green bonds over time

This table reports the total issuance amount (in $B) as well as the number of corporate green bonds issued on an annual basis, using all corporate green bonds from 2013-2018.

Year	# Bonds	$ Amount (billion)
2013	16	5.0
2014	76	15.4
2015	222	28.7
2016	156	68.7
2017	323	87.8
2018	396	95.7
Total	1,189	301.2

Table 2. Corporate green bonds by industry

This table reports the total issuance amount (in $B) as well as the number of corporate green bonds by industry, using all corporate green bonds from 2013-2018. Industries are partitioned according to Bloomberg's BICS (Bloomberg Industry Classification System) codes.

Industry	# Bonds	$ Amount (billion)
Financials	554	151.0
Banking	322	117.3
Real estate	178	22.0
Others	54	11.7
Industrials	635	150.3
Utilities	112	53.1
Power generation	149	34.7
Renewable energy	223	14.9
Transportation and logistics	25	13.8
Waste and environment services and equipment	28	8.5
Forest and paper products manufacturing	10	3.7
Automobiles manufacturing	8	3.5
Travel and lodging	15	3.4
Communications equipment	2	2.5
Food and beverage	3	1.3
Containers and packaging	2	1.0
Consumer products	4	0.7
Electrical equipment manufacturing	4	0.6
Others	50	8.7
Total	1,189	301.2

Table 3. Corporate green bonds by country

This table reports the total issuance amount (in $B) as well as the number of corporate green bonds by country, using all corporate green bonds from 2013-2018.

Country	# Bonds	$ Amount (billion)
China	190	75.1
Netherlands	46	33.2
United States	194	31.5
France	157	30.8
Germany	57	19.4
Mexico	9	12.2
Sweden	140	11.6
United Kingdom	25	10.8
Luxembourg	20	8.9
Spain	17	7.6
Hong Kong	31	7.4
Japan	37	6.7
Australia	15	5.4
Italy	10	4.6
Norway	20	4.4
India	17	4.2
Brazil	6	3.4
Canada	10	3.4
Denmark	4	2.1
Austria	5	1.7
South Korea	5	1.7
United Arab Emirates	3	1.6
Taiwan	21	1.6
Singapore	10	1.2
Others	140	10.9
Total	1,189	301.2

Table 4. 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)). *#Green bond issuer-days* refers to the number of unique days on which a given firm issues green bonds (summed across all firms); *#Green bond issuer-years* refers to the number of unique years in which a given firm issues green bonds (summed across all firms); and *#Green bond issuers* refers to the number of unique firms. *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 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, Moody's, and Bloomberg's rating scales, respectively).

	All	Private	Public
	(1)	(2)	(3)
# Green bonds	1,189	624	565
# Green bond issuer-days	775	391	384
# Green bond issuer-years	526	301	225
# Green bond issuers	400	231	169
Amount (in $M)	253.4	245.5	262.0
	(421.0)	(329.5)	(503.3)
Certified (1/0)	0.656	0.684	0.625
	(0.475)	(0.465)	(0.485)
Maturity (years)	7.7	7.4	8.1
	(29.5)	(5.5)	(42.3)
Fixed-rate bond (1/0)	0.753	0.732	0.775
	(0.432)	(0.443)	(0.418)
Coupon (for fixed-rate bonds)	0.037	0.038	0.036
	(0.022)	(0.022)	(0.022)
Credit rating			
S&P rating (median)	A–	BBB+	A–
Moody's rating (median)	A3	A3	A2
Bloomberg's composite rating (median)	A–	BBB+	A–

Table 5. 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*, and *governance 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 refer to the average across all bond issuers (but not green bond issuers) in the same 2-digit SIC industry, country, and year as the green bond issuer. In column (3), the statistics refer to the average across all bond issuers (but not green bond issuers) in the same country and year, but excluding those operating in the same 2-digit SIC industry as the green bond issuer. Column (4) reports the *p*-value of the difference-in-means test. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

	N	Green bond issuers	(Non-green) bond issuers in same country, industry, and year	(Non-green) bond issuers in same country and year, but different industries	*p*-value (diff. in means)
		(1)	(2)	(3)	(4)
Log(assets)	225	10.470	8.942	–	0.000***
		(2.460)	(1.003)		
Return on assets	225	0.056	0.059	–	0.378
		(0.040)	(0.029)		
Tobin's Q	225	1.179	1.196	–	0.704
		(0.404)	(0.311)		
Leverage	225	0.331	0.355	–	0.138
		(0.178)	(0.108)		
Environment rating (ASSET4)	157	80.097	62.315	–	0.000***
		(19.659)	(17.058)		
Social rating (ASSET4)	157	74.370	58.334	–	0.000***
		(25.282)	(18.698)		
Governance rating (ASSET4)	157	60.498	47.630	–	0.008***
		(29.313)	(23.456)		
Environment materiality (SASB, industry level)	225	1.742	–	1.298	0.000***
		(1.715)		(0.815)	

Table 6. 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 $N = 384$ green bond issuance events (corresponding to the 384 unique issuer-day observations from Table 4). *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

Event time	CAR	Std. Err.
[–20, –11]	-0.129	0.157
[–10, –6]	0.051	0.245
[–5, 10]	0.489**	0.241
[11, 20]	-0.029	0.218
[21, 60]	-0.122	0.645

Table 7. Cross-sectional heterogeneity

This table reports the average CAR[-5, 10] from Table 6 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 first-time and seasoned issues of green bonds. Panel C distinguishes between green bond issuers operating in industries with above- versus below-median SASB scores of environment materiality. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

	CAR[–5, 10]	Std. Err.
Panel A. Certified vs. non-certified		
Certified green bonds (N = 192)	0.710**	0.292
Non-certified green bonds (N = 192)	0.268	0.535
Panel B. First-time issue vs. seasoned issue		
First-time green bond issue (N = 169)	0.798**	0.322
Seasoned green bond issue (N = 215)	0.246	0.512
Panel C. Financial materiality of the environment		
SASB score above median (N = 172)	0.699***	0.143
SASB score below median (N = 212)	0.318	0.303

Table 8. Robustness

This table reports alternative ways of computing CAR[-5, 10] from Table 6. In row 1, the MSCI All-Country World Equity Index is used in lieu of country-specific market indices. In row 2, the global three-factor model of Fama and French (1993) is used instead of the market model. In row 3, returns are industry-adjusted by subtracting the average return across all stocks on a given trading day in the same country and same 2-digit SIC industry. In row 4, standard errors are computed using the "crude dependence adjustment" (CDA) of Brown and Warner (1980, 1985). Row 5 reports the precision-weighted average CAR. Row 6 excludes financials. Row 7 excludes event dates on which companies make other relevant announcements such as the announcement of equity issues, (regular) bond issues, or quarterly earnings. Row 8 reports the median CAR. Row 9 excludes issuers from countries that provide subsidies for issuing green bonds (China, Hong Kong, and Singapore). *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

	CAR[–5, 10]	Std. Err.
1. Global market model based on MSCI world index	0.481**	0.230
2. Global three-factor model of Fama and French	0.511**	0.252
3. Industry-adjusted CARs	0.496**	0.221
4. Cross-sectional correlation	0.489**	0.244
5. Precision-weighted CARs	0.530**	0.217
6. Excluding financials	0.569***	0.170
7. Excluding confounding events	0.527**	0.256
8. Median CARs	0.336**	0.128
9. Excluding countries with green bond subsidies	0.452**	0.226

Table 9. Matching

This table presents descriptive statistics comparing treated and matched control firms. Levels (e.g., log(assets)) are measured in the year preceding the bond issue (t – 1), while pre-trends (e.g., Δ log(assets)) are measured in the two-year window preceding the bond issue (changes from t – 2 to t – 1). The variables in Panel A are described in Table 5; those in Panel B are described in Tables 10 and 11. 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)
Panel A. Matching characteristics							
Log(assets)	Green bond	225	10.470	10.065	2.460	0.781	0.688
	Matched control	225	10.359	9.891	2.106		
Return on assets	Green bond	225	0.056	0.056	0.040	0.666	0.529
	Matched control	225	0.054	0.053	0.040		
Tobin's Q	Green bond	225	1.179	1.037	0.404	0.870	0.901
	Matched control	225	1.186	1.033	0.369		
Leverage	Green bond	225	0.331	0.321	0.178	0.909	0.929
	Matched control	225	0.333	0.318	0.179		
Environment rating (ASSET4)	Green bond	157	80.10	90.25	19.66	0.385	0.714
	Matched control	157	78.13	89.13	22.68		
Social rating (ASSET4)	Green bond	157	74.37	85.98	25.28	0.820	0.564
	Matched control	157	73.80	82.94	23.31		
Governance rating (ASSET4)	Green bond	157	60.50	68.09	29.31	0.458	0.305
	Matched control	157	58.00	65.08	28.69		
Δ Log(assets)	Green bond	225	0.045	0.030	0.071	0.884	0.319
	Matched control	225	0.043	0.044	0.065		
Δ Return on assets	Green bond	225	0.002	0.001	0.013	0.222	0.383
	Matched control	225	0.003	0.002	0.011		
Δ Tobin's Q	Green bond	225	0.023	0.010	0.076	0.901	0.409
	Matched control	225	0.022	0.014	0.068		
Δ Leverage	Green bond	225	0.006	0.004	0.028	0.662	0.144
	Matched control	225	0.007	0.008	0.021		
Δ Environment rating (ASSET4)	Green bond	157	3.83	0.87	10.46	0.648	0.308
	Matched control	157	3.32	1.17	8.10		
Δ Social rating (ASSET4)	Green bond	157	3.93	1.68	9.67	0.647	0.320
	Matched control	157	3.46	2.01	6.44		
Δ Governance rating (ASSET4)	Green bond	157	2.09	1.51	7.35	0.625	0.935
	Matched control	157	1.68	1.55	8.73		

Table 9. Matching
(continued)

		Obs.	Mean	Median	Std. Dev.	p-value (diff. in means)	p-value (diff. in medians)
Panel B. Other characteristics							
CO_2 emissions	Green bond	132	101.14	13.66	184.63	0.931	0.953
	Matched control	132	98.23	13.67	186.69		
Institutional ownership	Green bond	34	0.405	0.381	0.419	0.731	0.935
	Matched control	34	0.422	0.386	0.427		
Ownership by long-term investors (duration)	Green bond	34	0.191	0.112	0.252	0.826	0.705
	Matched control	34	0.193	0.105	0.236		
Ownership by long-term investors (churn rate)	Green bond	34	0.176	0.087	0.253	0.625	0.634
	Matched control	34	0.170	0.085	0.244		
Ownership by green investors	Green bond	34	0.038	0.015	0.043	0.802	0.923
	Matched control	34	0.037	0.015	0.048		
Δ CO_2 emissions	Green bond	132	-0.35	-0.01	7.98	0.652	0.940
	Matched control	132	-0.82	-0.01	7.35		
Δ Institutional ownership	Green bond	34	0.005	0.003	0.116	0.836	0.970
	Matched control	34	0.004	0.003	0.129		
Δ Ownership by long-term investors (duration)	Green bond	34	0.001	0.002	0.033	0.843	0.592
	Matched control	34	0.002	0.003	0.036		
Δ Ownership by long-term investors (churn rate)	Green bond	34	0.003	0.002	0.031	0.778	0.726
	Matched control	34	0.002	0.002	0.027		
Δ Ownership by green investors	Green bond	34	0.006	0.004	0.041	0.574	0.911
	Matched control	34	0.005	0.004	0.034		

Table 10. Environmental performance following the issuance of green bonds

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. *Environment rating* is described in Table 5. *CO_2 emissions* is the ratio of CO_2 emissions (in tons) from ASSET4 divided by the book value of assets in U.S. dollars. The sample includes all firm-year observations of the treated and matched control firms from 2010-2018. 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.

	Environmental performance			
	Environment rating		CO_2 emissions	
	(1)	(2)	(3)	(4)
Green bond	6.118**		-10.898***	
	(2.438)		(4.101)	
Green bond (pre-issue year)		1.333		1.083
		(2.502)		(4.229)
Green bond (short-term, 1 year)		4.079		-7.667
		(2.663)		(4.879)
Green bond (long-term, 2+ years)		7.034**		-12.977**
		(3.286)		(5.325)
Firm fixed effects	Yes	Yes	Yes	Yes
Country-year fixed effects	Yes	Yes	Yes	Yes
Industry-year fixed effects	Yes	Yes	Yes	Yes
Observations	1,466	1,466	1,196	1,196
R-squared	0.88	0.88	0.90	0.90

Table 11. Ownership structure following the issuance of green bonds

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. *Institutional ownership* is the percentage of shares owned by institutional investors. *Ownership by long-term investors (duration)* is the percentage of shares owned by institutional investors whose holding duration (computed as in Cremers and Pareek, 2016, equation (2) on p. 292) is above the median across all investors. *Ownership by long-term investors (churn rate)* is the percentage of shares owned by institutional investors whose churn rate (computed as in Gaspar, Massa, and Matos, 2005, equation (1) on p. 143) is below the median across all investors. *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 2010-2018. 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 investors				Green investors	
	Institutional ownership		Ownership by long-term investors (duration)		Ownership by long-term investors (churn rate)		Ownership by green investors	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Green bond	0.011		0.017**		0.014**		0.025**	
	(0.010)		(0.007)		(0.006)		(0.011)	
Green bond (pre-issue year)		-0.001		0.001		0.000		0.002
		(0.010)		(0.006)		(0.004)		(0.008)
Green bond (short-term, 1 year)		0.010		0.011		0.004		0.014
		(0.011)		(0.008)		(0.007)		(0.012)
Green bond (long-term, 2+ years)		0.011		0.022**		0.018**		0.029**
		(0.013)		(0.009)		(0.007)		(0.013)
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	361	361	361	361	361	361	361	361
R-squared	0.80	0.80	0.62	0.62	0.56	0.56	0.70	0.70

Table 12. Certification

This table presents variants of the regressions in Tables 10 and 11, interacting *Green bond* with dummy variables that distinguish between green bonds that are certified by independent third parties and green bonds that are not. The sample includes all firm-year observations of the treated and matched control firms from 2010-2018. 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.

	Environment rating	CO_2 emissions	Institutional ownership	Ownership by LT investors (duration)	Ownership by LT investors (churn rate)	Ownership by green investors
	(1)	(2)	(3)	(4)	(5)	(6)
Green bond × certified	7.656***	-14.392***	0.012	0.020**	0.018**	0.034***
	(2.737)	(5.154)	(0.013)	(0.010)	(0.008)	(0.014)
Green bond × non-certified	2.224	-2.051	0.010	0.012	0.007	0.015
	(2.445)	(4.476)	(0.011)	(0.009)	(0.008)	(0.012)
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country-year fixed effects	Yes	Yes	–	–	–	–
Industry-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,466	1,196	361	316	316	361
R-squared	0.88	0.90	0.80	0.62	0.56	0.70

Table 13. Is there a premium on corporate green bonds?

This table reports the mean and median of *yield at issue* for green bonds and matched non-green bonds of the same issuer. The matching is described in Section 7.1. The two rows at the bottom report the difference-in-means and difference-in-medians tests, along with the corresponding *p*-values. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

	Yield at issue		
	N	Mean	Median
Green bond	152	3.654	3.600
Matched non-green bond	152	3.673	3.600
Difference		-0.019	0.000
p-value (difference)		0.942	1.000

Appendix Table 1. Covariate balance for the within-issuer matching of green bonds to non-green bonds

This table presents descriptive statistics comparing green bonds and matched non-green bonds of the same issuer. The matching is described in Section 7.1. *Log(amount issued)* is the natural logarithm of the issuance amount. *Maturity* is the maturity of the green bond (in years). *Coupon* is the coupon rate. 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)
Log(amount issued)	Green bond	152	17.909	18.302	2.177	0.792	0.592
	Matched non-green bond	152	17.844	18.174	2.080		
Maturity (years)	Green bond	152	7.604	7.509	0.775	0.174	0.997
	Matched non-green bond	152	7.727	7.510	0.792		
Coupon	Green bond	152	0.037	0.036	0.025	0.961	1.000
	Matched non-green bond	152	0.036	0.036	0.023		