

THE UNIVERSITY OF CHICAGO

THE GREEN BONDING HYPOTHESIS: HOW DO GREEN BONDS ENHANCE THE
CREDIBILITY OF ENVIRONMENTAL COMMITMENTS?

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To my parents.

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ABSTRACT

This paper proposes and provides evidence on a green bonding hypothesis, where green bonds act as a commitment device that subjects firms to institutions holding them accountable to their environmental promises. I find that green-bond issuers face higher climate change risks and opportunities but fewer financial constraints than do traditional-bond issuers. Moreover, consistent with green bonds acting as a commitment device, green-bond issuers increase emissions-target achievements and face more media scrutiny when their target progress decreases after issuing green bonds. In additional analyses, I find that when a municipality issues green bonds, the issuer experiences a reduction in financing costs for both traditional and green bonds issued on the same day, consistent with green bonds being an environmental commitment for an entity, rather than a security-level commitment.

CHAPTER 1

INTRODUCTION

From the climate change week protest led by Greta Thunberg to the call for a global carbon tax by world leaders at Davos 2020, climate change risk is materializing for high-carbon firms in a transition to a low-carbon economy. Firms that credibly show their commitment to being environmentally friendly can benefit from receiving more green opportunities and from being exposed to fewer climate change risks (e.g., Greening and Turban, 2000; Drozdenko et al., 2011; Krueger et al., 2020). The challenge for firms is how to demonstrate their environmental commitment without being seen as greenwashing. In particular, credible environmental commitments require a well-established institutional infrastructure to hold firms accountable for their claims.¹ Without environmental reporting standards and mandates, as well as enforcement institutions that validate the credibility of such reports, monitoring agencies cannot confirm whether firms' green promises are trustworthy. In the absence of regulation, private mechanisms may arise to fill this need for supporting institutions.

In this paper, I propose a green bonding hypothesis, where firms use financial innovations to bond to institutional oversight that facilitates credible environmental disclosure. In particular, green bonds are an example that is gaining popularity. Green bonds are public debt instruments where the issuer commits to using the proceeds on green projects that contribute to a firm's environmental objectives. To facilitate monitoring, green bonds come with three bonding mechanisms to hold firms accountable for their environmental claims. First, green-bond issuers commit to periodically report on the use of proceeds and their environmental impact in accordance with international standards. Second, institutions such as external reviewers and exchanges act as enforcement mechanisms. For example, exchanges with green-bond segments monitor the green-bond issuer's annual disclosures, and in cases

1. This is analogous to institutional complementarities in the financial reporting literature. Some of these institutional components are standard setting bodies, disclosure regulations, enforcement and oversight institutions, and litigation channels (Leuz, 2010).

of non-compliance, the exchange can choose to delist the bonds. Third, green-bond issuers subject themselves to public scrutiny from the media and from green investors. This intensified monitoring, along with periodic reporting and enforcement, makes it costly for firms to deviate from their environmental promises, potentially making green bonds a credible commitment device.

It is important to note that a green bond consists of more than issuing a bond and committing to use the amount of money raised on environmental projects. When issuing green bonds, firms also bond to oversight by institutions that hold them accountable. I refer to this bonding mechanism as the green bonding hypothesis. This is similar to the bonding hypothesis, where foreign firms with growth opportunities cross-list in the US as a commitment to limit insider expropriation (Coffee Jr, 2002; Doidge et al., 2004). By listing in the US, firms subject themselves to US GAAP disclosure requirements, enforcement and oversight from the SEC, and public monitoring from skilled financial analysts and market participants. Similarly, in the green bonding hypothesis, firms with higher environmental risks or opportunities issue green bonds to commit to lowering pollution. By issuing green bonds, firms subject themselves to public monitoring, enhanced disclosure requirements, and potential scrutiny.

In my empirical analysis, I first show that consistent with the green bonding hypothesis, firms are more likely to issue green bonds when they need to demonstrate their environmental commitment. Compared to traditional-bond issuers matched on size and industry, green-bond issuers face higher climate change risks (e.g., carbon-pricing regulation) and opportunities (e.g., revenue from low-carbon sources). Furthermore, green-bond issuers already use various other methods to show their environmental commitment: 82% of green-bond issuers publish audited sustainability reports, 55% release science-based emissions targets, and 46% tie manager compensation to Environmental, Social, and Governance (“ESG”) performance. This observation is consistent with green-bond issuers having high incentives to

demonstrate environmental credibility. I do not observe higher financial constraints among green-bond issuers, which suggests that funding may not be the primary reason for issuing green bonds. In fact, green-bond issuers have higher cash holdings, and pay more cash dividends.

Next I examine the credibility of green bonds as an environmental commitment device. If the green-bonding mechanisms are effective, green-bond issuers will find it costlier to deviate from their environmental promises. To test this hypothesis, I study the progress of a firm's emissions targets disclosed in the Carbon Disclosure Project ("CDP").² I create a measure of emissions-target achievement, calculated as the target progress divided by the time progress, which captures how on track a firm is in reaching its target (Engie Impact, 2019).³ Using a generalized difference-in-differences regression, I find that the emissions-target achievements of green-bond issuers increase by 20% after the issuance of green bonds, relative to firms that have not issued green bonds.

Because firms self-select into issuing green bonds, I do not claim that issuing green bonds causes an improvement in target achievement. Instead, the result is consistent with green bonds acting as an effective commitment device so that firms capable of achieving their targets can make credible commitments to be monitored by external institutions. Another concern is that the effects could be driven by an increase in green projects funded by green bonds, instead of by green bonding. Conceptually, if green bonding increases the marginal benefit of investing in green projects, the increase in green projects is also attributable to green bonds acting as an effective commitment device. However, there could be an endogeneity concern if firms time the issuance of green bonds with other environmental strategies; in such cases, the increased target achievement may not stem from the green bonds. To

2. CDP is the largest corporate environmental disclosure platform. Each year, around 2,000 firms globally provide detailed environmental information.

3. On average, a target lasts for 11 years, and I do not find significant changes in emissions targets around green-bond issuance.

mitigate this concern, I exploit the staggered introduction of green-bond segments on stock exchanges. The idea is that the timing of green bonds issued right after the introduction of green-bond segments is plausibly exogenous to the issuer’s other environmental activities. I keep treated firms as those that issued a green bond within one year of the introduction of a green-bond segment on the firm’s local stock exchange.⁴ The magnitudes of the estimated treatment effects are similar in this robustness test, but are only statistically significant at the 15% level.

In a cross-sectional analysis, I separate green bonds by their ties to enforcement institutions. Green-bond issuers choosing to get an external review or to list the green bonds on an exchange with a green-bond segment are bonding to stricter enforcement. Comparing between groups of green-bond issuers, I find that the target improvement is larger and only statistically significant for issuers of green bonds with external reviews or that are listed on green-bond segments on stock exchanges. This result is consistent with enforcement institutions contributing to the use of green bonds as a commitment device.

To explore one channel through which green bonds hold firms accountable to their environmental targets, I study the role of media monitoring and scrutiny. Green bonds are effective as a commitment device if after issuance, the media and other monitoring agencies penalize firms that deviate from their environmental promises. I use RavenPack data that link news articles to firms, and identify environmental articles using key words used in prior literature (Flammer, 2013; Moss et al., 2020). I find that after green-bond issuance, media articles related to the firm’s environmental performance increase by 27%. Further, for firms that experience a decrease in emissions-targets performance, media sentiment becomes more negative after the green-bond issuance. This finding provides suggestive evidence that green

4. While the largest green-bond segment is on the Luxembourg Stock Exchange, I use the headquarter country to determine local stock exchange because the introduction of green-bond segments is often accompanied by green finance initiatives by the local government. I also find significant increase in green-bond issuance subsequent to the introduction of green bond segments located in the headquarter country. I discuss more about these assumptions in Section 5.1.

bonds attract more public scrutiny over a firm's environmental performance, and hence can act as a credible environmental commitment device.

Finally, if green bonding is a reason for issuing green bonds, then any benefits should be realized at the entity-level and not only at the green-bond level. In other words, stakeholders should believe the firm as a whole is more environmentally responsible. I study this hypothesis in the setting of the US municipal bond market because of better data availability and because municipal issuers often issue both green and traditional bonds with the same structure on the same day. This feature allows me to compare the prices of green and traditional bonds issued simultaneously by the same entity (Larcker and Watts, 2020). I find that both traditional and green bonds issued on the same day have a treasury-adjusted yield that is 5 to 11 basis points lower than bonds with similar structures issued by the same issuer. Furthermore, similar effects apply to bonds issued after the first green-bond-issuance-date. This result is consistent with green bonds acting as a commitment device that benefits the issuer at the entity level.

The green bonding hypothesis proposes a framework for thinking about a firm's motives for issuing green bonds, field evidence may provide additional support to understand the endogenous issuance choice. To directly gauge firm motives for issuing green bonds, I send a survey to all green-bond issuers with a valid investor relations email (298 firms). From the 52 survey responses I received, 35 firms rank environmental commitment as a very relevant motive, compared to 12 for environmental project funding, and 10 for lower cost of capital. Overall the survey confirms that many green-bond issuers use green bonds to enhance the credibility of their environmental commitments.

While this paper studies the green bonding hypothesis using green bonds as the focal instrument, there are other ways to show environmental commitments. In a descriptive analysis, I find that the environmental scores of firms with green bonds are higher than firms with alternative green commitments, including CSR reports, audited CSR reports,

ESG committee, ESG compensation, and science-based targets. The environmental scores are also higher for alternative green commitments with more institutional oversight, such as having audited CSR reports and science-based emissions targets. One interesting observation is that the environmental scores are the highest for firms that both issue green bonds, and use any of the alternative green commitments. This finding suggests the different ways to show environmental commitments are complements. One potential explanation is that different environmental commitments involve a complementary set of institutions that together provide a more holistic institutional infrastructure to facilitate credible environmental disclosure.

I aim to make two contributions. First, this paper adds to our understanding of how firms can enhance their environmental credibility by proposing a green bonding hypothesis. Prior literature on corporate social responsibility (“CSR”) disclosure finds mixed evidence on the relation between disclosure and performance, with many arguing that such disclosures are mostly cheap talk (Ingram and Frazier, 1980; Cho and Patten, 2007; Clarkson et al., 2008). One challenge to demonstrating environmental commitment is the lack of supporting institutions that hold firms accountable. Christensen et al. (2019) and Grewal and Serafeim (2020), two recent surveys of the CSR disclosure literature, both point to the importance of institutional support, such as standard setters, auditors, and enforcement mechanisms, in the credible communication of CSR information. The evidence in this paper suggests that firms can bond to institutional oversight by issuing financial instruments, such as green bonds.

This need for supporting institutions is not unique to CSR, and has been studied widely in the financial reporting context. In particular, research on international accounting standards suggests that the harmonization of financial reporting is challenging when countries have different institutional infrastructure, such as legal and enforcement institutions (e.g., Ball et al., 2003; Daske et al., 2008; Leuz, 2010; Armstrong et al., 2010; Landsman et al., 2012;

Christensen et al., 2013). To fulfill this demand for comparable financial reporting, Leuz (2010) proposes a “Global Player Segment” where member firms face the same reporting rules and enforcement, and can be delisted as a sanction to hold firms accountable. This idea is similar to the green-bond segments, where exchanges act as enforcers.

Second, this paper adds to the literature on green bonds by arguing that green bonds are valuable as a commitment device because of the reporting, enforcement, and monitoring accompanying their issuance. My finding that green bonds have entity-level effects helps reconcile the mixed results in the literature on the premium of issuing green bonds over traditional bonds (Baker et al., 2018; Kapraun and Scheins, 2019; Flammer, 2021; Larcker and Watts, 2020). Comparing across issuers, Baker et al. (2018) find that green bonds have a lower yield, but in a different research design comparing traditional and green bonds issued by the same issuer on the same day, Larcker and Watts (2020) find no evidence of a premium. I find support for both results, as traditional and green bonds issued on the same day by the same issuer both receive lower yields. In addition to the green bond premium literature, there are two concurrent papers on corporate green bonds. Flammer (2021) and Tang and Zhang (2020) document a positive market response and higher institutional ownership after a firm issues green bonds.⁵ Flammer (2021) also finds an increase in environmental ratings and decrease in CO₂ emissions after a firm issues green bonds, and suggests that green bonds have signaling value. In comparison, my paper focuses on establishing the idea of green bonding, and discussing the role of green bonds as an environmental commitment device with green-bonding mechanisms.⁶ The green bonding hypothesis provides practical implications for the development of green bonds. If green bonds help firms demonstrate environmental credibility, then designing stricter institutional oversight and standards would enhance the value of this commitment device, and could attract more firms to issue green bonds.

5. The finding that shareholders benefit from green-bond issuance supports my hypothesis that green bonding benefits are realized at the firm level. I discuss this finding in greater details in Section 7.

6. I describe differences between a commitment device and signaling in Section 2.3

CHAPTER 2

THE GREEN BONDING HYPOTHESIS

In this section, I provide the conceptual underpinnings of the green bonding hypothesis. I start with existing problems that give rise to the need for commitment devices for environmental performance, and then I discuss specific mechanisms related to green bonds that allow them to act as a commitment device.

2.1 The rising stakeholder emphasis on climate change

In recent years, concerns about climate change have grown and stakeholders have increasingly pressured firms to internalize their environmental impact. While these stakeholder preferences translate to higher climate change risk exposure, they also create green opportunities for firms better at managing their environmental impact.

Governments have begun to introduce corporate regulation to address climate change. According to the World Bank's 2020 data, there are 60 carbon-pricing initiatives implemented or scheduled that cover 46 national jurisdictions and 21.3% of global greenhouse gas emissions (World Bank, 2020). Carbon taxes reduce the future earnings of firms with higher carbon emissions and thus lowers the net present value of these firms. Investors are also increasingly considering ESG in their investments (e.g., Hartzmark and Sussman, 2019; Krueger et al., 2020; Bolton and Kacperczyk, 2020). Investors representing over \$100 trillion in assets under management have signed the Principles for Responsible Investment (PRI, 2020). This is an example of investors having a taste for certain assets, and investors with these preferences demand a lower expected return for holding firms with better environmental performance (e.g., Fama and French, 2007; Friedman and Heinle, 2016; Pástor et al., 2020). Finally, growing evidence points to consumers and employees considering climate change when making purchase or career decisions (Greening and Turban, 2000; Laroche et al., 2001;

Drozdenko et al., 2011; Barrage et al., 2020; Homanen, 2018). Thus, stakeholder pressure translates to lost revenue and lower market value for firms with a poor environmental impact.

Firms that can manage their environmental impact and credibly communicate their environmental commitments can turn climate change risks into opportunities. Exposure to climate change risk increases the marginal benefit of investing in green projects that lower carbon emissions. Because of this shift in marginal benefit, some green projects become positive NPV, and more firms would communicate their environmental efforts in an attempt to capture these new opportunities. For example, Grewal (2019) finds that firms increasingly disclose about green opportunities in annual reports and sustainability reports. Another example is the emergence of the Carbon Disclosure Project (“CDP”), where by year 2019, over 2000 firms voluntarily provided disclosure about their environmental efforts and performance. Additionally, during the climate change week in September 2019 alone, over 50 firms announced their commitment to setting science-based emissions targets (UNFCCC, 2019).

However, the extent to which a firm’s environmental commitments are credible remains an open question. For example in January 2020, Microsoft released a statement titled, “Microsoft will be carbon negative by 2030” (Microsoft, 2020). Hours after the announcement, however, Microsoft’s corporate center in Fargo, North Dakota, began running on fossil fuel generators because of a cheaper energy arrangement with local electricity providers (Gold, 2020). As the media covering this story pointed out, meeting targets may be harder than setting them. In the next section, I discuss reasons that limit the credibility of firms’ environmental commitments.

2.2 The lack of credible commitments over environmental performance

Given rising stakeholder concerns about climate change, many firms attempt to communicate their efforts to manage their environmental impact. Existing literature, however, shows

little evidence that communication about firms' environmental efforts is trustworthy. In this section, I discuss how credibly disclosing environmental commitments is difficult where there are weak institutional structures that hold firms accountable to their environmental promises.

Prior literature documents mixed evidence on the credibility of CSR disclosures and commitments. When comparing environmental performance and environmental disclosure, Ingram and Frazier (1980) find no correlation, Cho and Patten (2007) find a negative correlation, and Clarkson et al. (2008) find a positive correlation. More recently, studies looking at global CSR initiatives find that signatory firms do not perform better in terms of CSR (Kim and Yoon, 2020; Raghunandan and Rajgopal, 2020). While inconclusive, there is limited evidence that firms' environmental commitments are credible.

One challenge in communicating an environmental promise is the lack of robust disclosure regulations and complementary institutional frameworks. In most countries, environmental disclosure is still voluntary, and even where a mandate exists, the disclosure requirements are relatively loose compared to well-established financial accounting rules.¹ Furthermore, Christensen et al. (2019)'s recent survey of the CSR disclosure literature suggests that institutional complementarities impose constraints on what CSR disclosure mandates can achieve. Without well-defined standards, it is difficult to determine which activities are green. Without strict enforcement, it is difficult to track firms' environmental performance after making environmental commitments. Without monitoring agents, it is difficult to hold firms accountable when environmental promises are violated.

This concern about weak institutional infrastructure is similar to one reason foreign firms cross-list in the US under the bonding hypothesis. Specifically, the bonding hypothesis suggests that foreign firms from countries with weaker financial regulation cross-list in the

1. Based on the Reporting Exchange, an online database of global CSR reporting requirements, as of end of 2020, there are 137 mandates related to climate action; only 51 mandates across 23 countries include well-defined metrics, and many only apply to specific sectors.

US as a way to commit to limiting insider expropriation of firm resources by subjecting themselves to the higher disclosure and regulatory standards in the US (Coffee Jr, 2002; Doidge et al., 2004).² Firms that cross-list forgo insider benefits in exchange for cheaper external financing to capture growth opportunities. These tend to be firms with growth opportunities, and subsequent to cross-listing, these firms are more likely to raise equity in their home countries, and receive a lower cost of capital (Doidge et al., 2004; Reese Jr and Weisbach, 2002; Hail and Leuz, 2009).

Analogously, in the green bonding hypothesis, firms benefit from polluting activities, but some firms commit to lower pollution in order to access green opportunities. Pollution is a negative externality where the cost of pollution is not borne by the firm. This means that the firm extracts private benefits from environmental resources without paying for the consequences. Some firms with green opportunities may find it beneficial to forgo this private benefit. This tradeoff is not beneficial to all firms, as access to green opportunities vary by firm and by industry. For example, an utilities firm facing carbon-pricing regulation or investor pressure may find it efficient to convert to renewable energy, but this conversion may be too costly for an oil and gas company. To benefit from green opportunities, firms need to forgo their private benefits from pollution, which is challenging to commit to without the institutional support that allows for credible disclosure.

To illustrate this tension, consider a scenario analogous to the model in Stein (1989), where managers face market pressure to boost short-term earnings. Consider an utilities firm with an opportunity to lower carbon tax if it reduces its carbon emissions. To cut emissions, the manager of the utilities firm can invest in a renewable energy plant, which is costly in the short run but value-enhancing in the long run. Thus, it is in the manager's

2. Coffee Jr (2002) describes a few bonding mechanisms that help cross-listed firms commit to limiting insider expropriation when cross-listed in the US market. First, cross-listed firms commit to provide more robust financial information under the US GAAP. Second, cross-listed firms subject themselves to the oversight and enforcement powers of the SEC. Third, the US market helps shareholders exercise effective legal remedies through litigation. Fourth, cross-listed firms are exposed to the scrutiny of "reputational intermediaries," such as US underwriters and analysts.

best interest to invest in this project, and she will communicate this plan to the market and commit to lowering carbon emissions. However, after making this promise, the manager has an incentive not to invest in this green project because it lowers short-term earnings, and because green projects are relatively unobservable without institutional frameworks to monitor them, the market cannot tell whether the firm’s lower earnings are due to the green project or poor fundamentals. Recognizing this incentive, the market is not convinced by the manager’s environmental target, and does not price the green opportunity. Using Stein (1989)’s language, the manager is trapped in a prisoner’s dilemma and the green opportunity is lost.

To realize the green opportunities, firms need to be held accountable for their environmental commitments. With the growing need for environmental change in a world with limited public regulation on monitoring environmental commitments, private mechanisms may arise in order to fulfill the demand for accountability. The green bond is one such market invention, and in the next section, I discuss the green-bonding mechanisms that make green bonds a credible commitment device.

2.3 Green bonds as a commitment device

In this section, I provide institutional details on how green bonds function as a commitment device through their green-bonding mechanisms. Formally, I define green bonding as the use of financial instruments to bond firms to institutional oversight of their environmental performance. These institutions provide reporting standards, enforcement, and monitoring in order to hold firms accountable to their environmental claims, making it costly to deviate.

According to the Green Bond Principles (“GBP”) issued by the International Capital Market Association, green bonds are “any type of bond instrument where the proceeds will be exclusively applied to finance or re-finance, in part or in full, new and/or existing eligible Green Projects and which are aligned with the four core components of the GBP” (ICMA,

2018). GBP states that these green projects should contribute to the firm’s environmental sustainability objectives and should provide clear environmental benefits. The Climate Bonds Initiative (“CBI”) provides a detailed green taxonomy that defines what constitutes a green project. Since firms can use general corporate cash to pay back green bonds, the financial credibility of green bonds is similar to that of conventional bonds. As such, we can think of a green bond as a conventional bond with a promise to spend a minimum amount on green projects.³ This promise is credible because the issuer is bonding to increased reporting, enforcement, and monitoring, which I refer to as the three green-bonding mechanisms.

The first green-bonding mechanism is the commitment to provide periodic reporting in accordance with international standards. GBP provides guidance on reporting practices for green-bond issuers, stating that “the annual report should include a list of the projects to which Green Bond proceeds have been allocated, as well as a brief description of the projects and the amounts allocated, and their expected impact” (ICMA, 2018). When issuing green bonds, firms often discuss their reporting commitments in the prospectus and in the green bond framework. For example, Appendix B shows that Apple’s green bond framework includes the following claim: “Throughout the term of the green bond, until the proceeds have been fully allocated to eligible projects, Apple commits to publishing annual updates of the allocation of the proceeds and impact of projects that have received allocations.” Apple also lists key performance indicators for its impact disclosure, including greenhouse gas emissions avoided, energy reduction, and water reduction. To provide additional credibility for these promises, Apple commits to an annual third-party compliance review of its green bond framework.

The second green-bonding mechanism is enforcement. There are two main institutions that fulfill this role: external reviewers and green-bond segments of stock exchanges. Exter-

3. While green bonds are project-level commitments, these projects are meant to support firm-level environmental goals, and the average amount of issuance is substantial relative to environmental expenditures. In an untabulated analysis with 30 green-bond issuers that voluntarily disclosure environmental expenditures, the average green-bond issuance amount is 25 times the average annual environmental expenditure.

nal reviewers provide a third-party opinion of how well the green bond commitments align with the GBP. For example, after reviewing Apple’s green bond documents, Sustainalytics concluded, “Apple’s green bond framework aligns with the four pillars of the Green Bond Principles 2015.” This is similar to the role of auditors that provide opinions on whether a financial report is compliant with GAAP. More specifically, external reviewers evaluate the ongoing reporting promises and the validity of the green projects. For example, Appendix C shows that PepsiCo’s external review discusses PepsiCo’s long-term emissions targets and provides the opinion that the green projects support the firm’s overall sustainability strategy. The enforcement by external reviewers increases confidence that the green bond proceeds will be spent on meaningful green projects and that the issuer will provide relevant disclosures in the future.

In addition to external reviewers, certain stock exchanges also act as enforcement institutions. While the GBP is a voluntary guideline for green-bond issuance, 18 stock exchanges have introduced green-bond segments in a staggered time frame, where listing on these segments require issuers to align with international green bond standards. For example, to be listed on the Luxembourg Green Exchange (“LGX”), firms must have external reviews over their compliance with an international green-bond standard and must provide annual reporting updates that are monitored by LGX. Failure to provide sufficient information will subject the green bonds to delisting. Thus, exchanges act as enforcement institutions that check a green-bond issuer’s continuing alignment with the GBP, and especially with their reporting commitments.

The third mechanism is the monitoring of the firm’s environmental performance by investors who purchase the green bonds and by the public media. Green bonds attract environmentally-conscious investors, and these investors likely monitor and exert pressure on the firm in regards to its environmental performance. One example is when green-bond issuer State Bank of India was considering financing a coal mine in Australia, its green-

bond holder Amundi sent a warning to the State Bank of India, stating Amundi will divest from the green bonds if the issuer finance the coal mine (Reuters, 2020). Similarly, green bonds generate attention from the media, with ongoing media coverage of the environmental performance of green-bond issuers. One example is the acquisition of energy firm Innogy by E.ON, where multiple news articles discussed concerns over the status of Innogy's existing green bonds. Following the acquisition, Sustainalytics issued an assurance letter about the transition and its implications for Innogy's green bond, providing confirmation that the green bond framework remained valid. Innogy and E.ON's efforts to keep the green-bond commitments, as well as the public monitoring of the bond's status, suggest there may be high reputational costs of breaching the green commitments.

In sum, firms that issue green bonds are bonding to oversight by standard setters like GBP and CBI, enforcement from external reviewers and exchanges that have green-bond segments, and monitoring and scrutiny from public media and green investors. These institutions work together to hold firms accountable to their environmental claims.

I refer to green bonds as a commitment device, where the bonding mechanisms make it costly for firms to deviate from their environmental promises ex-post. Alternatively, the bonding mechanisms of green bonds can also be used for signaling, where a low type firm with poor environmental performance may find it more costly to fulfill the promise and hence more likely to receive the reputational damage from public scrutiny. The similarity between signaling and commitment device is that the source of costly signaling is the same as what makes it costly to deviate from a commitment device ex-post. However, the friction being solved is different. In a standard signaling model, signaling solves the problem of information asymmetry about firm type, where in this setting, type can be defined as environmental friendliness, or capability to carry out green projects (Spence, 1978). In contrast, a commitment device is needed when there is a commitment problem, where there is incentives to deviate from a promise ex-post. In the case of concerns about greenwashing, the issue is that

managers have incentives to deviate from their environmental promise when facing earnings pressure. As such, I refer to green bonds as a commitment device throughout this paper.

2.4 Other ways of green bonding

While this paper studies the green bonding hypothesis in the setting of green bonds, the hypothesis can be applied to other instruments fulfilling a similar role. For example, firms can issue CSR reports, set science-based emissions targets, and link environmental performance to management compensation. I conduct a descriptive comparison of the various alternative environmental commitments in Section 8.2. Relative to these alternative methods, green bonds involve more standardized institutional frameworks and more robust enforcement.

Another question to consider is that if what people truly care about is the environmental impact of a firm, why are green bonds linked to the amount spent on green projects instead of on environmental outcomes? One reason is that the market is more experienced at monitoring monetary transactions, and that environmental outcomes are less timely. This is analogous to the relevance-reliability tradeoff; while the monetary input may be less relevant than environmental outcomes, monetary transactions are easier to measure reliably and monitor.

In fact, as the market evolves and environmental metrics mature, an output-based green bonding instrument has emerged. The International Capital Market Association released the Sustainability-Linked Bond Principles in June 2020. The principles define sustainability-linked bonds as “any type of bond instrument for which the financial and/or structural characteristics can vary depending on whether the issuer achieves predefined Sustainability/ESG objectives” (ICMA, 2020). As of October 2020, four firms have issued sustainability-linked bonds (Broughton, 2020). This group includes Suzano, a firm that also issued a green bond in 2016. Suzano’s 2020 sustainability-linked bond comes with a commitment to lower greenhouse gas intensity by 10.9% before 2026; a failure to reach this target will result in a

25 basis point increase in their interest rate. As this is a relatively new instrument, future studies can examine the green-bonding mechanism in the sustainability-linked bond, the choice of metrics, and the determinants of the interest-rate penalty.

CHAPTER 3

HYPOTHESIS DEVELOPMENT

To provide empirical evidence on the green bonding hypothesis, I next discuss four sets of testable hypotheses.

First, if firms issue green bonds as a commitment device, these firms should have a stronger incentive to demonstrate environmental credibility. Specifically, these firms likely face higher opportunities and risks over climate change, and can benefit more from green bonding. Additionally, firms that want to show their environmental commitments would likely have used other commitment methods before the emergence of green bonds; these methods include adopting an emissions target or providing environmental disclosures. This motive to show environmental credibility suggests that it is less likely that firms issue green bonds because they face financial constraints to funding environmental projects. Thus, I test the following hypothesis for the determinants of green-bond issuance:

Hypothesis 1a: *Green-bond issuers face higher risks and opportunities from climate change.*

Hypothesis 1b: *Green-bond issuers have used other methods to show their environmental commitment.*

Hypothesis 1c: *Green-bond issuers do not face higher financial constraints.*

Second, if green bonds are effective as a commitment device, green-bond issuers should find it costlier to deviate from their environmental promises. Specifically, if institutional oversight holds green-bond issuers accountable to their spending promises, green projects should contribute to the achievement of environmental targets. Additionally, green bonds should attract monitoring directly on the issuers' environmental targets, since many green-bond issuers discuss how the green projects facilitate the achievement of long-term emissions targets (e.g., PepsiCo in Appendix C). However, if green bonding is not effective, green bonds may be just another form of greenwashing. This leads to my second hypothesis that firms

achieve more of their greenhouse gas emissions targets after the green-bond issuance:

Hypothesis 2a: *Emissions-target achievements are higher after the issuance of green bonds.*

To shed some light on the potential mechanisms of the disciplining effect, I exploit cross-sectional variations in the reporting and enforcement commitments in the green bonds. For reporting, I test if green bonds with impact-reporting commitments in their green bond framework increase target achievement more than those that do not. For enforcement, I test if green bonds issued with an external review and listed on exchanges with green-bond segments increase target achievement more than those that do not. This yields the following hypothesis:

Hypothesis 2b: *The green bonding effects are larger for firms with reporting or enforcement commitments in their green bond framework.*

Third, I study one channel through which green bonds hold firms accountable to their environmental commitments: media scrutiny. In particular, I study if media monitoring of a firm's environmental performance increases after green-bond issuance. If the green-bond issuance attracts media monitoring, as the Innogy acquisition example suggests, then news coverage of the environmental performance of the green-bond issuer should increase. Further, if the media scrutinizes firms with poor environmental performance, news sentiment may become more negative. I test the following hypothesis:

Hypothesis 3a: *Media coverage over a firm's environmental performance increases after the issuance of green bonds.*

Hypothesis 3b: *Media sentiment is more negative for green-bond issuers with lower emissions-target achievement.*

Fourth and finally, if green bonds enhance the firm's environmental commitment, any resulting financial benefits should be realized on the firm level. In other words, if stakeholders reward the firm for being environmentally responsible, the benefit will not only be realized on

the green bonds, but also on the issuer's other debt and equity securities. This may explain why Tang and Zhang (2020) and Flammer (2021) find a positive equity-market response to the announcement of green-bond issuance. Furthermore, this reasoning could reconcile the mixed results in the green-bond premium literature (Baker et al., 2018; Kapraun and Scheins, 2019; Flammer, 2021). Using the US municipal bonds setting, Baker et al. (2018) find that green bonds have a lower yield than similar bonds issued by other municipalities, while Larcker and Watts (2020) find a premium of zero in a research design comparing traditional and green bonds issued by the same issuer on the same day. One way to reconcile the difference is that the value of the green bond goes to an issuer, so other bonds issued by the same issuer also benefit from the lower yield.

To test this hypothesis, I follow prior literature and use the setting of US municipal bonds. The benefit of this setting is that many issuers issue green and traditional bonds with the same maturity and structure on the same day. This feature is exploited in the research design of Larcker and Watts (2020). Furthermore, the US municipal bonds market includes more green bonds than the rest of the world combined, and this enhances comparability and power when studying the pricing of green bonds. Since the green bonding hypothesis also applies to local governments wanting to demonstrate environmental credibility, I test the following hypothesis to show that the benefit of green bonds is entity-level:

Hypothesis 4: *The green bond 'premium', if any, applies to both the green bonds and to the green-bond issuer's other bonds.*

CHAPTER 4

WHO ISSUES GREEN BONDS?

4.1 Data

To create a database of green bonds, I use data from Bloomberg and the Climate Bonds Initiative (“CBI”). From Bloomberg, I retrieve all self-labelled green bonds with a Bloomberg classification of “Corporate.” From CBI, I retrieve all green bonds with a bond type of “Financial corporate” or “Non-financial corporate.” While Bloomberg provides a more comprehensive database of green bonds, the CBI database only contains bonds that meet CBI’s green bond taxonomy. I then use ISIN of all green bonds in either Bloomberg or CBI to retrieve bond details from Bloomberg. The bond details include issuer identity, issuance amounts in US dollar, bond coupon, issuance dates, announcement dates, maturity dates, and listed exchanges. For the green bonds from CBI, CBI also provides data on external reviews and the use of proceeds of the green bonds. Additionally, CBI provides summary sheets for green-bond issuers with publicly available information about the first green-bond issuance. I scrape these summary sheets to classify firms based on their reporting commitments.

Through February 2020, there are a total of 1,205 corporate green bonds in the Bloomberg and CBI databases. Table 1 Panel A provides summary statistics of the green bonds in my sample. On average, green bonds have a coupon rate of 3% (excluding float-rate bonds), a maturity of 7 years (excluding perpetual bonds), and an issuance amount of US\$282 million. 34% of green bonds are issued by public firms, which translates to 250 public firms. 24% of green bonds are listed on a green-bond segment managed by a stock exchange. Among the 941 green bonds with CBI data, 73% receive an external review or certification. Among the 232 first green-bond issuances with CBI summary sheets, 72% include impact reporting in the green bond framework.

Since my analysis relies on corporate environmental data at the firm level, I link the green bonds data to firms in the Carbon Disclosure Project (“CDP”) database. CDP is the largest environmental disclosure platform, gathering environmental information requests from over 500 institutional investors with combined assets of US\$106 trillion (CDP, 2020). Firms voluntarily respond to specific climate-change questions on an annual basis. Most data is available from 2011 and includes specific information on emissions targets and progress, as well as climate change risks and opportunities. I identify green-bond issuers in the CDP data by matching firm’s ticker and country to those of green bond issuers retrieved from Bloomberg, which resulted in 132 unique green-bond issuers.

4.2 Incentives to issue green bonds

To study the determinants of green-bond issuance, I use the universe of firms in the CDP database because this captures the majority of firms with environmental data in the world. To better compare to green-bond issuers, I use firms that issued traditional bonds as the control group in this determinants test. Using Bloomberg, I identify 1255 firms in the CDP database that issued green or traditional bonds, among which 132 are green-bond issuers.

Table 1 Panel B shows the breakdown by GICS sectors and is ranked based on the ratio of green-bond issuers to all bond issuers. While the industry with the highest number of green-bond issuers is financial (followed by utilities and industrial), utilities has the highest proportion of green-bond issuers at around 31%. No energy firm issued green bonds. Industries with more green-bond issuers tend to have business activities that qualify as green projects under green-bond standards. Financial institutions qualify when the proceeds from their green bonds are used to finance loans that meet green requirements. Firms in the utilities and industrials sectors often use green-bond proceeds on renewable energy or on energy-efficiency investments. Real estate firms often use green-bond proceeds on green buildings. These descriptive statistics are consistent with green bonds used by industries

with more green opportunities.

To further examine firm’s incentives to issue green bonds in hypothesis 1, I use the following proxy. I proxy for a firm’s exposure to climate change risk from carbon-pricing legislation in the firm’s home country using the 2020 Carbon Pricing Dashboard released by the World Bank. I proxy for a firm’s green opportunities with revenue from low-carbon sources, based on firm responses to CDP from 2016 to 2019.¹ I proxy for a firm’s effort to provide environmental commitments with data from Thomson Reuters. I include an indicator for having audited CSR reports and include the environmental score from Asset4, which captures the extent of firms’ environmental disclosures.² I proxy for a firm’s financing needs with balance sheet cash and cash dividends. Conceptually, firms facing financial constraints have lower amounts of cash and are less likely to pay dividends.³ Financial variables are collected from Datastream and Worldscope. For Asset4 and Datastream data, I take the average from 2010 to 2019 to maximize sample availability.

Table 1 Panel C separately describes the financial, environmental, and ESG variables used in the determinants analysis by green- and non-green-bond issuers. Overall, green-bond issuers are larger in scale and have superior environmental reporting. The average market capital of green-bond issuers is almost double that of non-green-bond issuers. Over 90% of green-bond issuers also provide CSR reports. Since green-bond issuers are on average larger in size, to create a better benchmark for green bond firms, I use coarsened exact matching (“CEM”) and match on firm size and industry. The matching process reduces the multivariate L1 distance from 0.5498 to 0.1764.

1. In Appendix G Panel A, I show results using other proxies for risks and opportunities, such as using firm’s self-identification with transitional climate change risks and opportunities in CDP responses.

2. In Appendix G Panel B, I show results for other environmental efforts, such as the use of science-based emissions targets and ESG-linked compensation.

3. Measures of financial constraint are heavily debated in the literature (Farre-Mensa and Ljungqvist, 2016). In Appendix G Panel C, I include leverage and debt-to-cash ratio and find that green-bond issuers are more levered. However, it is unclear from prior literature whether higher leverage is a sign of financial constraint, or reflects the capability to raise more debt.

Figure 1 plots the average value of key determinant variables for green- and traditional-bond issuers based on CEM. The first column shows that on average, green-bond issuers face more climate change risks and opportunities. Green-bond issuers are more likely to be in countries with carbon-pricing regulation and are more likely to have revenue from low-carbon sources. The second column shows that green-bond issuers have already attempted to show environmental credibility in other ways. Green-bond issuers are more likely to publish audited CSR reports and have a higher Asset4 environmental score, which reflects the extent of environmental disclosure a firm makes. The third column shows that green-bond issuers do not face more financial constraints than the control group. In contrast, green-bond issuers have higher balance sheet cash and cash dividends, which suggests funding needs are likely not the primary reason for issuing green bonds.

Table 3 shows the key determinants of being a green-bond issuer using the CEM sample in OLS regressions.⁴ The results in Table 3 confirm most of the findings in the figures. While the coefficient on logged cash is not significant, the higher raw amount in figure 1 suggests that the logarithm may have smoothed out some larger cash balances. Overall, these descriptive statistics are consistent with firms issuing green bonds for reasons other than green project financing, and with green-bond issuers having higher incentives to prove their environmental commitment.

4. Results are similar when using probit rather than OLS regressions.

CHAPTER 5

EMISSIONS TARGET PERFORMANCE AFTER GREEN BOND ISSUANCE

5.1 Main analysis

To study if green bonds are effective as a commitment device, I test if emissions-target achievement increases after green-bond issuance. Every year starting in 2011, firms responding to CDP provide information on their emissions targets and progress, which includes details on emission scope, target reduction percentage, base year, target year, and the percentage of target achieved. Table 2 Panel A shows summary statistics for these target variables. On average, a target lasts 11 years and has an annual target reduction of 2.3 percent. Since a target lasts for 11 years on average, there are limited observations on firms missing targets. Instead, I measure target achievement by how “on track” a firm is in terms of reaching their target (Engie Impact, 2019). I create a target achievement score for each target-year using data from the CDP:

$$\text{Target achievement}_{i,t} = \text{Target progress}_{i,t} / \text{Time progress}_{i,t}$$

Target and time progress are defined as follows:

$$\text{Target progress}_{i,t} = \text{Current emissions reduction}_{i,t} / \text{Total emissions-reduction target}_i$$

$$\text{Time progress}_{i,t} = \text{Years passed}_{i,t} / \text{Duration of target}_t$$

For example, DTE Energy’s target is to reduce emissions by 20% from 2010 to 2020. In 2015, they achieved an aggregate reduction of 16%. Thus, for 2015, the target progress is 80% (16/20), the time progress is 50% (5/10), and the target achievement score is 1.6 (80/50). Note that a value of 1 means that a firm is on track to achieving their target,

assuming an equal rate of improvement every year. The average target achievement is 1.35. Since this data on emissions targets are from firm responses to CDP surveys, they are prone to errors across the years. As such, I winsorize the target achievement and average annual target at the 1st and 99th percentile. Results are similar but weaker in statistical power when I truncate the variables.

Using *Target achievement* as the outcome variable, I estimate the following generalized difference-in-differences model:

$$Target\ achievement_{i,t} = \beta_0 + \beta_1 Green\ bond_i \times Post_{i,t} + \sum \beta_j Fixed\ effects + Controls + \epsilon \quad (1)$$

The dependent variable is annual target achievement. *Green Bond_i* is an indicator that takes the value of ‘1’ for firms that issued a green bond.¹ *Post_{i,t}* is an indicator that takes the value of ‘1’ for observations after the issuance year of green bonds. β_1 is the coefficient of interest, which captures how target achievement changes after the issuance of green bonds for green-bond issuers. I include firm fixed and year fixed effects.² Since firm fixed effects control for time-invariant firm-level variations, I include controls for time-varying firm-level variables that may affect target achievement around green-bond issuance. I include *Asset (log)* and *Market Value (log)* to control for the size of the firm, which may affect the visibility of the firm’s emissions targets; *Market-to-Book* to control for growth opportunities; and *Average Annual Target* to control for difficulty of reaching the emissions targets (Ioannou et al.,

1. Since the target is related to greenhouse gas emissions, I exclude green bonds with an use-of-proceed that is unrelated to energy, such as water and waste. Additionally, while banks issue green bonds to finance external projects that lower emissions, some of the bank’s emissions targets relate to the targets of their portfolio. Thus, I keep banks in the analysis. The main result remains similar when excluding banks, but with a lower significance level of 13%.

2. Some firms have multiple targets, but including firm-target fixed effects is not feasible because it is difficult to track the same target over years. In untabulated analysis, I find similar results using average target achievement for each firm-year, and using only the target with the longest duration for each firm-year.

2016).³ Standard errors are clustered at the industry level.

Table 4 shows the change in target achievement after the green-bond issuance. In column 1, the interaction term is positive and significant, suggesting firms enhance their target achievement after the issuance of green bonds. This effect remains similar when I include control variables in column 2. The coefficient on *Green Bond* \times *Post* in column 2 translates to a 20% (0.270/1.346) increase in target achievement after the green-bond issuance.

Figure 2 plots the coefficients by years relative to the green-bond issuance, where 0 represents the year of green-bond issuance. The plot provides some support of the parallel-trends assumption, the target achievements of treated and control observations have similar trends before the issuance of green bonds. Starting the first year after green-bond issuance, the target achievement of issuers increases. The results are consistent with green bonds being an effective commitment device that holds firms accountable to their environmental targets.

One concern in this analysis is the endogeneous timing of green bonds. If the issuance of green bonds is timed with other environmental efforts, such as a change in strategy introduced by a new CEO, then the target effects may not stem from the green-bond issuance. To mitigate this concern, I exploit the staggered introduction of green-bond segments on 18 exchanges. The introduction of green-bond segments often relate to green finance initiatives by local governments. For example, the Japan Exchange Group introduced the green-bond segment after the Japan Ministry of the Environment published a guideline for issuing green bonds. Furthermore, in various cases, the first green bonds being listed are municipal green bonds, such as the City of Cape Town green bond on the Johannesburg Stock Exchange. As such, the introduction of green-bond segments is plausibly exogenous to firm-specific reasons to engage in environmental activities.

3. As plotted in Appendix H, I do not find significant changes in the average annual target around green-bond issuance. In other words, green-bond issuers did not change emissions targets when issuing green bonds.

I repeat the main analysis keeping only the firms that issued a green bond within one year after the introduction of a green-bond segment on the local exchange. I define local exchange based on the firm’s headquarter country disclosed in CDP. While firms may choose to list their green bonds in foreign exchanges with more green bonds, such as the Luxembourg Stock Exchange, their decision to issue green bonds are likely affected when their local stock exchange introduce green-bond segments, especially when accompanied with support from local governments. Appendix F lists the 18 exchanges and plots green-bond issuance around the month that local exchanges introduced green-bond segments. The figure shows a sharp increase in green-bond issuance starting the month of introduction, which provides some support for the relevance of green-bond segments in driving green-bond issuance.

Table 4 columns 3 and 4 show the result of this robustness test using green bonds issued within 1 year of the introduction of green-bond segments on the local stock exchange. The effects are only significant at the 15% level, but the magnitude remains similar. This provides some support that the associations are not driven by other confounding firm activities, since the timing of these issuances is likely driven by the decisions of local exchanges to introduce green-bond segments.

5.2 Cross sectional analysis

To further pin down the green-bonding mechanism, I perform a cross-sectional analysis that splits green-bond firms by their ties to green bonding institutions. When firms issue these bonds, they can also choose the level of engagement with the green bonding institutions. Summary statistics in Table 2 Panel A shows that 74% of green-bond issuers have an external review from third parties like Sustainalytics, and 19% have green bonds listed on exchanges with green-bond segments. To facilitate monitoring of environmental performance, almost all firms commit to annual reports on the use of proceeds, and 78% commit to annual reporting on the environmental impacts in their green bond frameworks. If institutions hold firms

accountable to their promises, then the firms more confident about reaching their targets will select stricter oversight, and the increase in target achievement after green-bond issuance should be larger.

Table 5 shows the cross-sectional tests on target achievements. In these tests, I use green-bond issuers only, and keep firms with available information for the tested variable. In column 1, the coefficient on *Post* remains positive, statistically significant, and translates to a 17% (0.235/1.413) increase in target achievement after green bond issuance. To explore the enforcement mechanism of green bonding, I split green-bond issuers on exchange listings and with external reviews in columns 2 and 3. The results show that the increase in target achievement is positive and significant only for green-bond issuers with external reviews and listed on exchanges with green-bond segments. In column 2, the coefficient on *Green Bond Exchange* is statistically significant and indicates a 30% (0.419/1.413) increase in target achievement, while the coefficient on *No Green Bond Exchange* is not statistically significant and indicates a 14% (0.194/1.413) increase in target achievement. F-test shows the difference between the two coefficients is marginally statistically significant at the 15% level. In column 3, the coefficient on *External Review* is statistically significant and indicates a 17% (0.243/1.446) increase in target achievement, while the coefficient on *No External Review* is not statistically different from zero. However, F-test for the difference between the two coefficients is not statistically significant.

To examine the reporting mechanism of green bonding, I split green-bond issuers on their reporting commitments. Reporting commitment is based on summary sheets from CBI's website, where CBI analysts search for publicly available information about the first green bond for each issuer. Since all firms with available data provide report on the use of proceeds, I perform cross-sectional analysis using the promise to report on environmental impact. The results in Table 5 column 4 show that the increase in target achievement is positive and significant only for firms with impact reporting. The caveat here is the small

sample size due to the limited observations where CBI summary sheets are available.

CHAPTER 6

PUBLIC SCRUTINY AFTER GREEN BOND ISSUANCE

In this section, I use media analysis to study if green-bond issuance exposes a firm to greater public scrutiny over their environmental performance. I use RavenPack data from 2011 to 2019 that link each news article to the related firm. I identify 120 green-bond issuers in the RavenPack database by matching on ticker and country. I exclude press releases and keep only news articles published by the media. I identify articles related to environmental performance by searching for keywords in the news title; I select keywords by referencing Flammer (2013) and Moss et al. (2020).¹ The keywords are as follows: environmental, green, renewable, recycling, emission, carbon, global warming, climate change, pollution, and contamination. I exclude firms with a name that includes any of the keywords. The summary statistics of the media data can be found in Table 2 Panel B. On average, a firm receives 5 environmental news articles in a year. The average news sentiment is 51, which is close to the neutral score of 50.

To study changes in news coverage, I replace the dependent variable in equation 1 with environmental news count. As the news count is positively skewed, I take the natural logarithm of one plus news count. Furthermore, I study the media sentiment related to each news article, and test if the sentiment becomes more positive (negative) for firms with higher (lower) target achievement after the green-bond issuance. I use the following equation for this test:

$$\begin{aligned} \text{News sentiment}_{i,t} = & \beta_0 + \beta_1 \text{Target achievement}_{i,t} \times \text{Post}_{i,t} \\ & + \beta_2 \text{Target achievement}_{i,t} + \beta_3 \text{Post}_{i,t} + \sum \beta_j \text{Fixed effects} + \epsilon \quad (2) \end{aligned}$$

1. I did not include the following words from Flammer (2013), as they are less relevant to green bond environmental issues: oil spill, hazardous waste (toxic waste), and ecosystem preservation. I did not include the following words from Moss et al. (2020), as they result in more generic articles: sustainability and technology.

The dependent variable is the average news sentiment for firm i in year t . News sentiment is created using RavenPack’s proprietary analysis techniques, where a score of 50 is neutral, a score above 50 is positive, and a score below 50 is negative. $Target\ achievement_{i,t}$ is firm i ’s emissions-target achievement in year t , measured as in section 5. $Post$ is an indicator that takes the value of ‘1’ starting the issuance year of green bonds. β_1 is the variable of interest, and captures the correlation of news sentiment with target achievement after the issuance of green bonds. β_1 will be positive and significant if news sentiment is higher (lower) for firms with better (worse) environmental performance. I include firm and year fixed effects, and cluster standard errors by industry.

Table 6 shows results for the media analysis. In column 1, the coefficient on $Post$ is positive and significant, supporting the hypothesis that green-bond issuance generates more media attention on a firm’s environmental performance. The coefficient means that on average, green-bond issuers receive 27% more media coverage related to its environmental performance after issuing the green bond. Figure 3 plots the media count for each year relative to the green-bond issuance. The trend before the issuance of green bonds is similar between treated and control observations, providing some support for the parallel-trends assumption. Starting the year of green bond issuance, average news count increases. One concern is that the media coverage may simply reflect the green-bond issuance. In Table 6 column 2 and Figure 4, I exclude news articles explicitly mentioning green bonds in the title, and the increase in the news count the year after the bond issuance remains significant. I manually look at news articles after the green-bond issuance, and find that green bonds are often mentioned in articles about the firm’s other environmental activities.

In columns 3 to 5, I report how news sentiment changes with regards to emissions-target achievement after the issuance of green bonds. The number of observations reduces, as only those with media coverage are included. Column 3 shows that overall, the change in sentiment around green-bond issuance is not significantly different from zero. In column

4, when target achievement is interacted with green-bond issuance, there is some suggestive evidence that news sentiment decreases after green-bond issuance, but the effect is mitigated if target achievement is higher. However, due to the limited number of observations with both media and targets data, the power of this analysis is low, and the coefficient on the interaction term is only statistically significant at the 12% level. To increase power, I split green-bond issuers into those with a higher or lower target achievement after green-bond issuance, relative to before the issuance. Column 5 shows that news sentiment is significantly lower only for green-bond issuers with lower target achievement. Relative to the average news sentiment of 50.664 (50 is neutral), firms with lower target achievement receive a lower news sentiment by around 1.658 points, which translates to a decrease of 3%. Taken together, this analysis provides some evidence that after issuing green bonds, firms face higher media coverage and scrutiny, which may help hold firms accountable to their environmental commitments.

CHAPTER 7

THE GREEN BOND PREMIUM AT THE ENTITY LEVEL

One testable hypothesis is that if green bonds are a commitment device on environmental performance, then any resulting benefit should be realized at the entity-level, not just at the security-level. To test this, I study if green and traditional bonds issued on the same day receive a lower yield. I am able to conduct this analysis in the US municipal bonds market because many local governments issue both green and traditional bonds on the same day (Larcker and Watts, 2020).

Municipal bonds issuance data come from Mergent. Following Larcker and Watts (2020), I keep fixed rated bonds for better comparison, and exclude bonds that are not tax-exempt to mitigate differential tax effects. The current analysis includes bonds issued between 2013 and 2020. I keep green bonds issued after 2014 for a minimum two years of pre-period. The summary statistics of the municipal bond issuance can be found in Table 2 Panel C. The average municipal bond has a yield of 2.3%, a coupon rate of 3.5%, a maturity of 10 years, an issuance amount of US\$3 million, and a credit rating of AA on Moody’s scale. There are 0.6% of green bonds and 0.2% of traditional bonds issued by the same issuer on the same day as green bonds, which translate into 3,732 and 1,399 bonds, respectively.

I estimate the following difference-in-differences model:

$$Yield_{i,t} = \beta_0 + \beta_1 Green\ Bond_{i,t} + \beta_2 Same\text{-}Day\ Traditional\ Bond_{i,t} + \sum \beta_j Fixed\ effects + Controls + \epsilon \quad (3)$$

The dependent variable is the yield to maturity at issuance, adjusted by treasury rate, for a bond from issuer i on day t . $Green\ Bond_{i,t}$ is an indicator that takes the value of ‘1’ for green bonds. $Same\text{-}Day\ Traditional\ Bond_{i,t}$ is an indicator that takes the value of ‘1’ for traditional bonds issued by the same issuer on the same day the issuer issued a green bond.

Depending on the specification, the control variables include credit rating, issuance amount, and maturity. Credit rating is scaled so that a credit rating of AAA gets a 22, and lower ratings receive a lower value. Fixed effects include issuer fixed effects and date fixed effects. In more robust specifications, I include issuer-maturity fixed effects. I cluster standard errors by issuer.

If green bonds provide entity-level commitment, hypothesis 4 predicts that both β_1 and β_2 are negative, and not significantly different from each other. Conceptually, by including issuer fixed effects, β_1 and β_2 capture how the yield of green and traditional bonds issued on the same day compares to the yield of the issuer's other bonds. If the benefit of green bonding is realized on the entity, both β_1 and β_2 should be negative.

Table 7 reports the results on the yields of US municipal bonds. In all specifications, the yield of green and traditional bonds issued on the same day are negative and statistically significant, and the F-test in all specifications show that the coefficients of β_1 and β_2 are not statistically different. This result is robust to including issuer-maturity fixed effects in columns 3 and 4. Depending on the specification, bonds issued on the day of green-bond issuance receive a yield that is 5 to 11 basis points lower on average.

In columns 1 and 3, *Green Bonds* represent all green bonds issued, whereas in columns 2 and 4, I define *Green Bonds* as the first green bonds issued by the issuer, and add an indicator for bonds issued subsequent to the first green-bond-issuance-date. The negative and significant coefficient on both green and traditional bonds issued after the first green-bond-issuance-date suggests the entity-level effect lasts, and is consistent with green bonding being a credible and permanent change.

The results are consistent with the benefit of green bonds being realized at the entity-level. While the existence of a green bond premium shows the financial benefits of green bonding, this premium may not be the main benefit. An estimate of the annual savings based on a premium of 8 basis points applied to the average corporate bond issuance of

US\$280 million is US\$224,000. In contrast, the event studies in Tang and Zhang (2020); Flammer (2021) find cumulative abnormal returns from 0.5 to 1.4% at the announcement of green-bond issuance. If we take the average at 1%, multiplying this number by the average market value of corporate green-bond issuers is equal to US\$200,000,000. Converting this to annual savings based on the average bond maturity of 7 year is equal to US\$28,571,429. Overall, this back-of-the-envelope calculation shows that the benefit of issuing green bonds is potentially much larger than that of the green bond premium; this is consistent with green bonds acting as a commitment device that helps firms benefit from a stronger environmental commitment.

CHAPTER 8

ADDITIONAL ANALYSES

8.1 Survey

In this section, I provide survey evidence supporting the green bonding hypothesis.¹ This hypothesis suggests that firms issue green bonds in order to enhance the credibility of their environmental commitments; survey responses from green-bond issuers provide more direct evidence. The goal of the survey is to understand firms' motives in issuing green bonds, as well as firms' exposure to environmental scrutiny after issuance.

I sent surveys to the public relations departments of the green-bond issuers. Since investors interested in green bonds likely communicate with firms' public relations, the public relations representative should understand the firm's green bond, or be able to forward any relevant questions to the appropriate team. I reference the survey design and implementation in Hail et al. (2019), which also surveys public relations departments. For each green-bond issuer, I collect contact information for the public relations representative on Capital IQ, Factset, and Eikon. If information for the issuer is not available, I use the information for the parent firm, if available.

I conduct the survey on Qualtrics, and limit the length to approximately five minutes (based on Qualtrics' estimate) in order to encourage participation. I pre-tested the survey and incorporated feedback from several academics and practitioners, including from the University of Chicago Survey Lab professionals, who specialize in survey design and execution. The full survey is attached in Appendix D. It contains 9 questions related to green bonds and 5 administrative questions at the end. The survey provides field evidence that complements the archival data, but surveys can be subjective or even misleading if the design induces a response bias. For example, one concern could be that participants choose the

1. The survey received expedited approval from the IRB.

environmental commitment motive because the research design makes it look like the right answer. To avoid such a bias, I include two design features. First, before asking about motives, I ask if the cost of borrowing for green bonds is lower than for traditional bonds. The answer to this question is more objective, and provides indirect evidence on green bond motives without inducing a bias. Second, before asking participants to rate the relevance of pre-defined motives, I include the open question: “Briefly, what is the main reason for issuing the green bond?” This allows me to validate green bond motives before participants see the motive options.

In total, I emailed the survey to 205 issuers and 93 parent firms. Among the 298 emails, 17 emails bounced back, and most of these were Chinese companies with invalid investor relations email addresses. From the remaining 281 surveys, I received 52 responses, giving me a response rate of 19%. Appendix E lists the response summaries for all survey questions. Responses to the administrative questions show that there are firms first issuing green bonds in each year from 2014 to 2020, with the highest representation in 2018 and 2019. 30 participants are from the finance department, and 12 are in investor relations. In untabulated summary, the 52 survey participants are from 26 countries, representing a diverse group of green-bond issuers.

Table 8 lists survey results on the motives for green-bond issuance. Panel A shows that 14 of the 50 firms that responded to question 3 believe the cost of borrowing for green bonds is lower than for traditional bonds. Thus, it is unlikely that most firms issue green bonds because they believe that green bonds are a cheaper source of financing. In question 4, an optional question on the reason they provide to question 3, most of the 14 firms from the previous question believe that the lower cost of borrowing stems from high investor demand for green bonds (untabulated). Furthermore, 4 firms believe the cost of borrowing for green bonds would be higher than for traditional bonds, partly because of the additional fees associated with issuing and reporting.

Question 5 asks respondents their main reason for issuing green bonds. Since this is an open question with unique answers and references to firm names, for confidentiality reasons I do not release the individual responses. I manually read all responses and group them by motive in Panel B. Some firms give multiple reasons for green-bond issuance, which suggests that the motives are not mutually exclusive. Supporting the green bonding hypothesis, most firms issue green bonds to show their commitment to the environment or to sustainability. Furthermore, 17 answers highlight the firm's ongoing environmental efforts, as well as the fact that green bonds reinforce such efforts. 14 firms say green bonds attract new investors. 12 firms issue green bonds for funding, pricing, liquidity, or diversification reasons. Some answers in question 5 directly speak to the green bonding hypothesis. For example, one firm says they need to "tangibly evidence our commitment to sustainability." Another answer highlights the "transparency and second party opinion" of green bonds, while another claims that green bonds "draw market attention to the company."

To directly compare the different motives, question 6 asks firms to rank the relevance of a few pre-defined motives for issuing green bonds. These motives are chosen from media articles about green-bond issuance. The responses from the open question help validate that the pre-defined motives capture firms' main reasons for issuing green bonds. From the 50 responses, 35 find environmental commitment very relevant, and 31 find attract investors very relevant. 10 find a lower cost of capital very relevant, while 18 find it not relevant. In an untabulated analysis, I create a relevance score for each motive, where not relevant is '0,' and very relevant is '3.' A t-test finds no significant difference between the relevance of environmental commitment and of attract investors, but both are significantly higher than the remaining three motives.

Table 9 lists the survey results for changes in environmental monitoring after green-bond issuance. Panel A shows that from the 52 responses, 30 respondents report that their firm saw an increase in inquiries about the firm's environmental performance. Among these 30

firms, 26 say that inquiries come from green-bond issuers, 16 from equity market shareholders or external reviewers, and 12 from the public media. This result provides additional evidence consistent with that by issuing green bonds, firms bond to increased monitoring that helps discipline their environmental performance.

8.2 Alternative environmental commitments

In addition to issuing green bonds, firms have been showing environmental commitments in various other ways. In this section, I examine how green bonds differ and relate to these alternative green commitments. Table 10 shows the correlation and summary statistics of the most commonly-used environmental commitments among CDP firms, as well as their average environmental score between 2010 and 2019 taken from the determinants analysis. Panel B ranks the frequency of these green commitments, with CSR report being the most frequently used, followed by having an ESG committee, having an audited CSR report, linking ESG to management compensation, setting a science-based target, and issuing green bonds.

Two observations emerge from this analysis. First, relative to other green commitments, green bonds have the lowest frequency and firms with green bonds have the highest environmental score. In contrast, almost all firms in this sample issue CSR reports and have ESG committees, but the average environmental score for these firms are the lowest. This finding reflects that fewer firms use green bonds to show environmental commitment and that those that do are the better performers. Conceptually, this separation can be explained by the stronger bonding mechanisms of green bonds. While there are voluntary disclosure standards for CSR reports, such as SASB and GRI, they are relatively loosely-enforced, with many firms only partially aligning with the standards. Audited CSR reports provide more assurance over this alignment, and this may explain the higher environmental score and lower frequency of audited CSR reports. ESG compensation is used by fewer firms than audited

CSR reports, but reading into some of the compensation schemes, most does not follow any external standards or have any enforcement agencies in place. Finally, Science-based targets also involve bonding mechanisms by allowing firms to validate that their emissions target aligns with a two-degree scenario, and hence is also used by fewer firms with higher environmental scores. Yet relative to green bonds, science-based targets do not have enforcement beyond setting the target, such as the annual reporting updates used in the green bond frameworks.

The second observation is that all the green commitments are positively and significantly correlated, and that green bond issuers that also use these alternative green commitments have a even higher environmental score. This observation suggests that the various green commitments are complements instead of substitutes in showing environment commitment. For example, issuing green bonds are highly correlated with having an audited CSR report and setting a science-based target. While setting science-based targets provides assurance over the meaningful of the emissions targets, green bonds provide credibility over the monetary inputs to achieve these targets, and audited CSR report facilitate monitoring over the target achievement. Each commitment involves a different set of institutions and together they form an institutional infrastructure that oversees firm's environmental performance.

CHAPTER 9

CONCLUSION

This paper proposes a green bonding hypothesis where firms use green bonds as a commitment device to enhance their environmental credibility. Green-bond issuers bond to oversight from institutions that hold firms accountable for their environmental promises through enhanced reporting, enforcement, and monitoring. Archival and field evidence supports the motive that firms issue green bonds to demonstrate environmental credibility.

Consistent with green bonds as an effective commitment device, firms' emissions target achievements increase after green-bond issuance. The effects are stronger for issuers subject to stronger bonding commitments such as external reviews or listing on exchanges with green-bond segments that require ongoing reporting. Further, media analysis shows that green-bond issuers receive higher media coverage, as well as a more negative sentiment for lower environmental target achievement. Finally, evidence from the US municipality setting shows that issuing green bonds benefits the issuer as an entity, which is consistent with green bonds as a commitment device. Future studies can tap into other entity-level benefits of green bonding, such as by studying consumer and employee responses.

While this paper discusses the green bonding hypothesis in the green bond setting, this hypothesis extends beyond the use of green bonds. Green bonds are a first step in the direction of institutions holding firms accountable to their environmental commitments. As the market evolves, new financial instruments likely emerge that provide stronger bonding frameworks, such as the sustainability-linked bonds discussed briefly in section 2.4. Future research can compare the different methods for achieving green bonding. Further, as more institutions develop to support environmental disclosure, such as the science-based targets and the upcoming EU green taxonomy, future research can study how different institutions support each other to foster credible environmental disclosure (Campbell et al., 2020; Commission, 2020).

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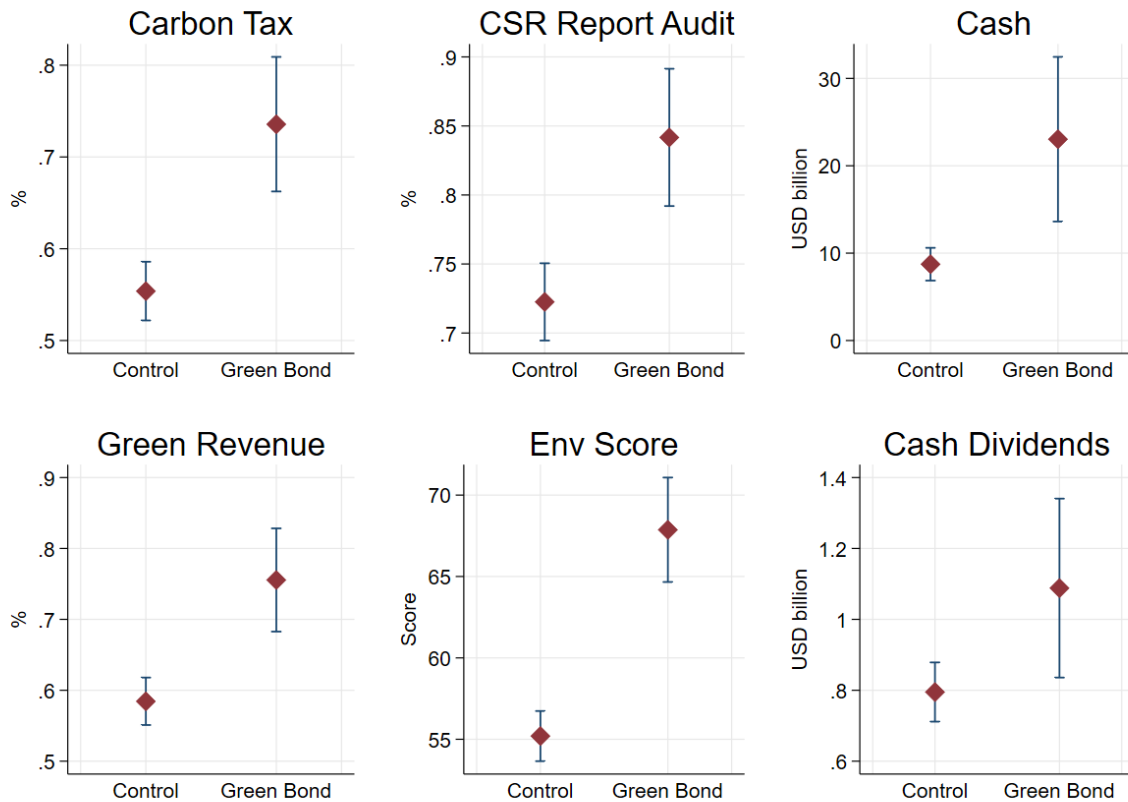
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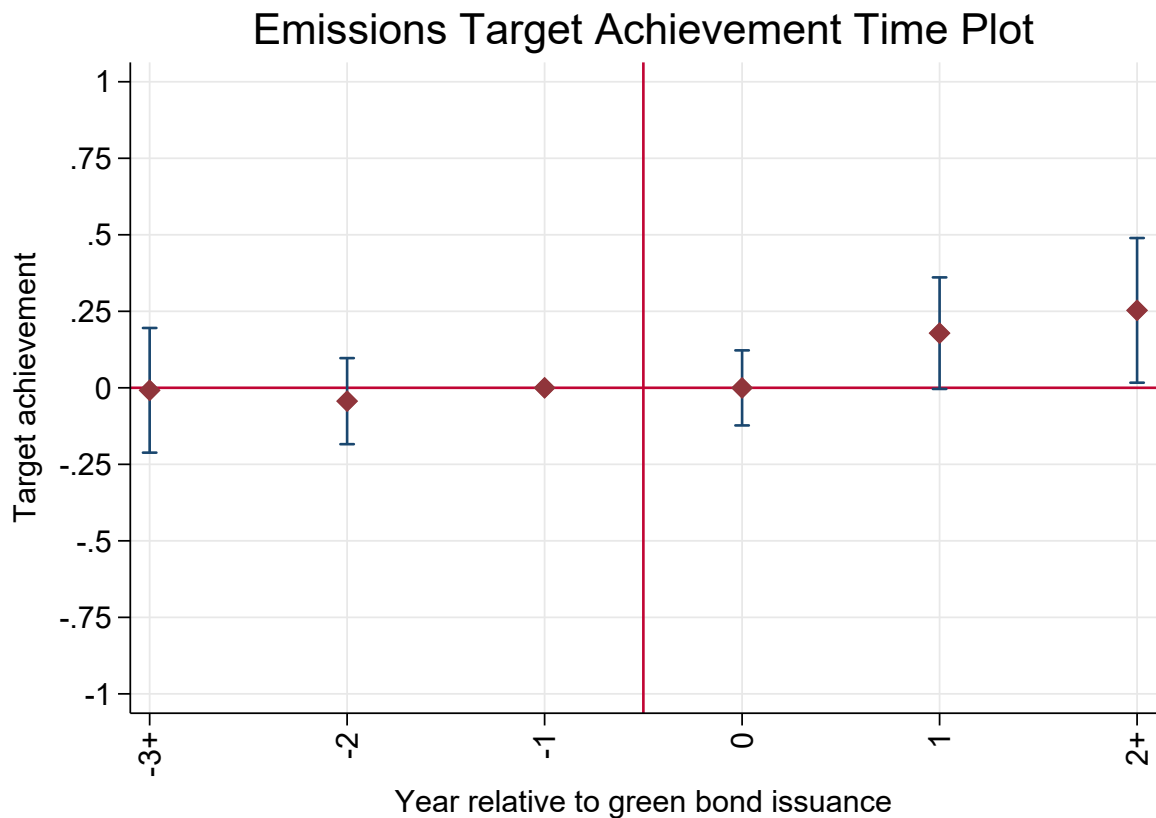
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Figure 1: Determinants of Green-Bond Issuance



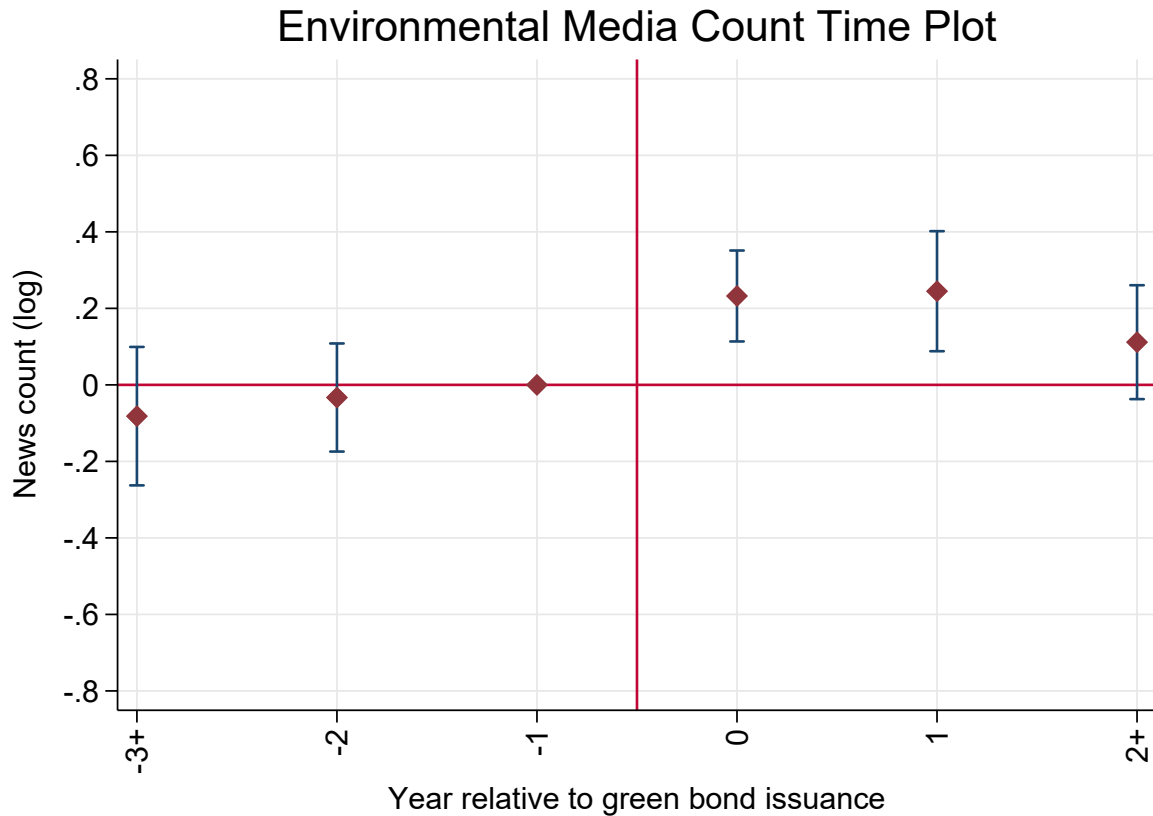
This figure plots the key determinant variables of green bonds. Each subfigure plots the average value for green-bond issuers and for the control group created using coarsened exact matching on industry and size. *Carbon Tax* is ‘1’ if a firm’s headquarter is located in a country with a carbon tax, based on data from the World Bank. *Green revenue* is ‘1’ if a firm self-reports low-carbon revenue in CDP. *CSR Report Audit* is ‘1’ if a firm has an audited sustainability report, based on data from Asset4. *Env Score* is the environmental pillar score created by Asset4. *Cash* and *Cash Dividends* are the balance sheet cash and cash dividends paid in billion USD, respectively, based on data from Datastream.

Figure 2: Emissions Target Performance around Green-Bond Issuance



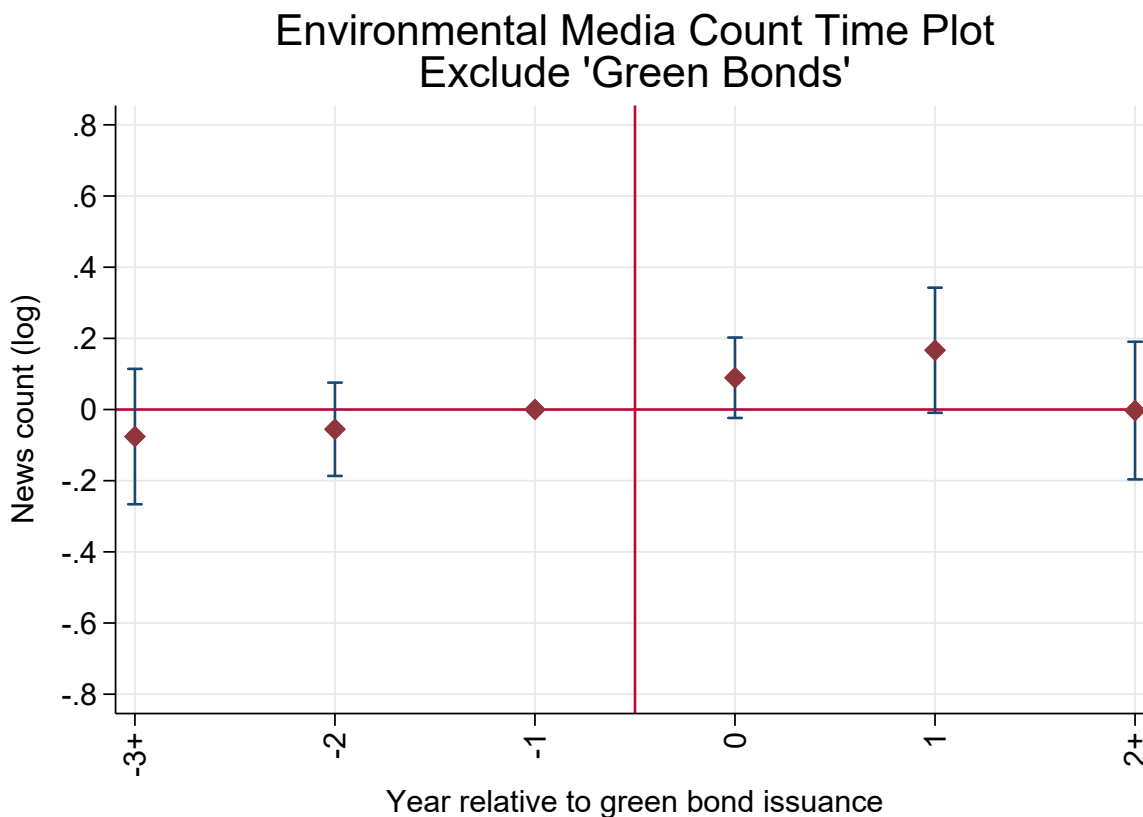
This figure plots the coefficient and 95% confidence interval for the main regression investigating the effect of green-bond issuance on emissions-target achievement in event time. *Target achievement* captures a firm's progress in achieving their emissions targets, defined as $Target\ achievement_{i,t} = Target\ progress_{i,t} / Time\ progress_{i,t}$. I replace the post indicator with the year relative to the green-bond-issuance year. I omit the indicator for year t-1, the year before the green-bond issuance, which serves as the benchmark period with a coefficient and standard error of zero. I control for size, market-to-book, and average annual target. I include firm fixed effects and year fixed effects. Standard errors are clustered by industry.

Figure 3: Media Coverage around Green-Bond Issuance



This figure plots the coefficient and 95% confidence interval for the main regression investigating the effect of green-bond issuance on media coverage in event time. *News count* captures the average number of news items related to a firm's environmental performance. I replace the post indicator with the year relative to the green-bond-issuance year. I omit the indicator for year $t-1$, the year before the green-bond issuance, which serves as the benchmark period with a coefficient and standard error of zero. I include firm fixed effects and year fixed effects. Standard errors are clustered by industry.

Figure 4: Media Coverage around Green-Bond Issuance: Exclude Mentions of Green Bonds



This figure plots the coefficient and 95% confidence interval for the main regression investigating the effect of green-bond issuance on media coverage in event time. *News count* captures the average number of news items related to a firm's environmental performance, but excludes any that mentions green bonds. I replace the post indicator with the year relative to the green-bond-issuance year. I omit the indicator for year $t-1$, the year before the green-bond issuance, which serves as the benchmark period with a coefficient and standard error of zero. I include firm fixed effects and year fixed effects. Standard errors are clustered by industry.

Table 1: Green Bonds Summary Statistics

<i>Panel A: Green Bonds Summary Statistics</i>						
	Count	Mean	Std. dev.	P25	P50	P75
Coupon	1,187	2.984	2.447	0.875	2.543	4.583
Maturity	1,186	7.224	6.197	4.000	5.000	10.000
Amount Issued (mil USD)	1,205	282.415	460.791	14.485	89.575	401.846
Public Firm	1,205	0.343	0.475	0.000	0.000	1.000
Green Bond Exchange	1,205	0.243	0.429	0.000	0.000	0.000
Climate Bonds Initiative	1,205	0.781	0.414	1.000	1.000	1.000
External Review	941	0.733	0.442	0.000	1.000	1.000
Impact Reporting	232	0.716	0.452	0.000	1.000	1.000

<i>Panel B: Green Bond Issuers by Industry</i>			
	All Firms	Green Bond Firms	Ratio
Utilities	88	27	0.31
Financials	206	49	0.24
Real Estate	69	16	0.23
Industrials	224	21	0.09
Communication Services	64	4	0.06
Consumer Staples	97	5	0.05
Information Technology	99	3	0.03
Consumer Discretionary	133	3	0.02
Materials	141	3	0.02
Health Care	65	1	0.02
Energy	69		0.00
Total	1,255	132	0.11

(Continued)

Table 1 (continued)

Panel C: Bond Issuers Summary Statistics

	Green			Non-Green			T-test Diff	
	Firms	Mean	Std.dev.	Firms	Mean	Std.dev.		p-value
Financial								
Market Value (USD mil)	132	34,925	68,032	1,130	19,573	36,293		0.000
Market-to-Book	132	1.911	3.221	1,110	2.663	12.740		0.500
Cash (USD mil)	132	24,653	58,338	1,130	3,418	9,683		0.000
Cash Dividends (USD mil)	132	1,200	1,681	1,130	526	1,105		0.000
Debt to Cash	132	10.141	23.992	1,130	6.376	14.016		0.008
Leverage	132	272.541	411.286	1,130	121.067	461.011		0.000
Asset (USD mil)	132	329,244	580,784	1,130	47,293	146,216		0.000
Long-Term Debt (USD mil)	132	36,743	56,419	1,130	6,905	17,134		0.000
Environmental								
Carbon Pricing Regulation	132	0.758	0.430	1,130	0.569	0.495		0.000
Environmental Performance Index	132	72.137	8.821	1,119	70.753	10.184		0.135
Low-Carbon Revenue	132	0.735	0.443	1,130	0.492	0.500		0.000
Physical Risk	132	0.875	0.273	1,130	0.774	0.371		0.002
Transition Risk	132	0.922	0.225	1,130	0.818	0.346		0.001
Physical Opportunity	132	0.802	0.342	1,130	0.639	0.426		0.000
Transition Opportunity	132	0.921	0.228	1,130	0.802	0.352		0.000
Science-based Target	132	0.545	0.500	1,130	0.340	0.474		0.000
CSR								
CSR Report	132	0.942	0.161	1,130	0.847	0.289		0.000
CSR Report Audit	132	0.816	0.326	1,130	0.584	0.448		0.000
Asset4 Environmental Score	132	68.744	19.127	1,130	54.815	22.636		0.000
ESG Committee	132	0.919	0.194	1,130	0.803	0.328		0.000
ESG Compensation	132	0.462	0.438	1,130	0.369	0.414		0.015

This table presents the summary statistics for green bonds. Panel A shows the descriptive statistics of corporate green bonds. Panel B shows the number of green-bond issuers compared to the total number of firms in the CDP database that issued any bond. Panel C shows the descriptive statistics for the financial, environmental, and CSR metrics for green- and non-green-bond issuers. See Appendix A for the variable definitions.

Table 2: Summary Statistics

<i>Panel A: Targets Analysis Summary Statistics</i>						
	Count	Mean	Std. dev.	P25	P50	P75
Target Achievement	14,260	1.356	1.160	0.740	1.125	1.667
Average Annual Target	14,260	2.298	2.609	0.820	1.750	2.857
Target Duration	14,260	10.973	9.141	5.000	8.000	13.000
Time Progress	14,260	54.960	28.761	30.000	53.333	80.000
Target Progress	14,260	62.906	37.901	27.000	75.000	100.000
Green-Bond Issuer	14,260	0.122	0.328	0.000	0.000	0.000
Green Bond Exchange	1,744	0.192	0.394	0.000	0.000	0.000
External Review	1,502	0.743	0.437	0.000	1.000	1.000
Impact Reporting	540	0.780	0.415	1.000	1.000	1.000
Asset (log)	14,260	16.627	1.685	15.497	16.455	17.591
Market Value (log)	14,260	9.155	1.395	8.170	9.131	10.110
Market-to-Book	14,260	2.655	3.104	1.090	1.720	2.980
Observations	14,260					

<i>Panel B: Media Analysis Summary Statistics</i>						
	Count	Mean	Std. dev.	P25	P50	P75
News Count	1,080	4.981	11.253	0.000	1.000	4.000
News Sentiment	581	50.664	3.596	50.000	50.667	52.000
Target Achievement	707	1.467	1.038	0.913	1.248	1.850
Target Achievement Lower	738	0.573	0.495	0.000	1.000	1.000
Observations	1,080					

<i>Panel C: Municipal Bonds Summary Statistics</i>						
	Count	Mean	Std. dev.	P25	P50	P75
Yield	601,222	2.326	0.987	1.600	2.330	3.050
Treasury-Adjusted yield	601,222	0.272	0.557	-0.080	0.220	0.583
Maturity (years)	601,222	9.762	6.214	5.000	9.000	14.000
Coupon	601,222	3.508	1.168	3.000	3.400	5.000
Issuance Amount (USD mil)	601,222	2.949	19.900	0.295	0.695	1.965
Credit Rating	601,222	19.730	1.735	19.000	20.000	21.000
Green Bonds	601,222	0.006	0.079	0.000	0.000	0.000
Same-Day Traditional bonds	601,222	0.002	0.048	0.000	0.000	0.000
Observations	601,222					

This table presents descriptive statistics for the emission-targets, media, and municipal-bonds analyses. See Appendix A for the variable definitions.

Table 3: Determinant of Green Bonds

	Green bonds as dependent variable					
	(1)	(2)	(3)	(4)	(5)	(6)
	Env Opps	Env Risks	CSR Audit	Env Score	Cash	Cash Div
Low-Carbon Revenue	0.081*** (3.34)					
Carbon Pricing Regulation		0.097*** (3.21)				
CSR Report Audit			0.105*** (3.49)			
Asset4 Environmental Score				0.003** (2.69)		
Cash (log)					0.018 (0.92)	
Cash Dividends (log)						0.010** (2.21)
N	966	966	966	966	966	966
Adj. R-squared	0.012	0.019	0.016	0.029	0.009	0.005
Clusters	Industry	Industry	Industry	Industry	Industry	Industry

t statistics in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

This table presents the key determinants of green-bond issuance. The sample consists of firm-level observations for those issuing green or traditional bonds that also report to the CDP. Coarsened exact matching is used to match green- and traditional-bond issuers on size and industry. *Green bond* is a binary variable identifying green-bond issuers. *Low-Carbon Revenue* is ‘1’ for firms that report revenue from low-carbon sources in the CDP survey. *Carbon pricing regulation* is ‘1’ for firms in countries with carbon-pricing legislation. *CSR Report Audit* is ‘1’ for firms with an audited CSR report. *Asset4 Environmental score* is the environmental score from Asset4, and is calculated from the weighted averages of environmental disclosures. The score ranges between 0 and 100. *Cash (log)* is the log of 1 plus the firm’s balance sheet cash from Datastream. *Cash Dividends (log)* is the log of 1 plus the firm’s cash dividends from Datastream.

Table 4: Target Achievement after Green-Bond Issuance

	Target Achievement as dependent variable			
	(1) All	(2) All	(3) Within 1 Year of Exchange	(4) Within 1 Year of Exchange
Green Bond \times Post	0.276** (2.60)	0.270** (2.58)	0.308 (1.51)	0.306 (1.52)
Asset (log)		-0.148* (-1.76)		-0.115 (-1.36)
Market Value (log)		0.031 (0.57)		0.026 (0.43)
Market-to-Book		-0.000 (-0.03)		0.004 (0.56)
Average Annual Target		-0.019*** (-2.91)		-0.013* (-1.89)
N	13,969	13,969	12,542	12,542
Adj. R-squared	0.199	0.200	0.202	0.202
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Clusters	Industry	Industry	Industry	Industry

t statistics in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

This table shows the results from estimating the regression $Target\ achievement_{i,t} = \beta_0 + \beta_1 Green\ Bond_i \times Post_{i,t} + \sum \beta_j Fixed\ Effects + Controls + \epsilon$. *Target achievement* captures a firm's progress in achieving their emissions target, defined as $Target\ achievement_{i,t} = Target\ progress_{i,t} / Time\ progress_{i,t}$. The coefficient on *Green Bond* \times *Post* represents the change in target achievement after green-bond issuance. Columns 1 and 2 include all sample firms in the GDP database. Columns 3 and 4 include firms without green bonds and firms that issued green bonds within 1 year from the introduction of a green-bond segment in the local stock exchange. I include firm fixed effects and year fixed effects, and cluster standard errors at the industry level.

Table 5: Target Achievement after Green-Bond Issuance: Cross-Sectional Analysis

	Target Achievement as dependent variable			
	(1) All Green Bonds	(2) Exchange Listed	(3) External Review	(4) Impact Reporting
Post	0.235** (2.07)			
Green Bond Exchange		0.419*** (2.97)		
No Green Bond Exchange		0.194 (1.63)		
External Review			0.243** (2.10)	
No External Review			-0.002 (-0.01)	
Impact Reporting				0.699** (2.40)
No Impact Reporting				-0.169 (-0.45)
N	1,724	1,724	1,483	530
Adj. R-squared	0.192	0.192	0.200	0.132
F-test		0.104	0.419	0.044
Controls	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Clusters	Industry	Industry	Industry	Industry

t statistics in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

This table shows cross-sectional results from estimating the regression $Target\ achievement_{i,t} = \beta_0 + \beta_1 Post_{i,t} + \sum \beta_j Fixed\ Effects + Controls + \epsilon$. *Post* is split into two groups based on the enforcement and monitoring features of the green bond. Column 1 repeats the main regression with only firms issuing green bonds. Column 2 splits by firms listing the green bond on stock exchanges with green-bond segments. Column 3 splits by firms with external reviews on their green bond. These data are only available for green-bond issuers in the CBI database. Column 4 splits by firms with an environmental impact reporting commitment in their green bond framework. These data are only available for firms with CBI summary reports. *Target achievement* captures a firm's progress in achieving their emissions target, defined as $Target\ achievement_{i,t} = Target\ progress_{i,t} / Time\ progress_{i,t}$. I include firm fixed effects and year fixed effects, and cluster standard errors at the industry level.

Table 6: Environmental Media Coverage after Green-Bond Issuance

	(1)	(2)	(3)	(4)	(5)
	News Count (log)	Non-Green- Bonds News Count (log)	News Sentiment	News Sentiment	News Sentiment
Post	0.236*** (3.93)	0.125*** (2.28)	0.061 (0.09)	-1.307 (-1.08)	0.619 (1.47)
Target Achievement				-0.204 (-0.58)	
Post × Target Achievement				0.725 (1.29)	
Post × Target Lower					-1.658** (-2.56)
N	1,062	1,062	555	401	376
Adj. R-squared	0.776	0.774	0.061	0.030	0.046
Firm FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Clusters	Industry	Industry	Industry	Industry	Industry

t statistics in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

This table shows the change in media coverage on a firm's environmental performance after green-bond issuance. Columns 1 to 3 estimate the main regression in model 1, where the outcome variables are environmental news count and news sentiment. Columns 4 and 5 show how news sentiment changes with emissions-target achievements after green-bond issuance. *Target achievement* captures a firm's progress in achieving their emissions target, defined as $Target\ achievement_{i,t} = Target\ progress_{i,t}/Time\ progress_{i,t}$. *Target Lower* is a binary variable equal to '1' for firms whose target achievement decreased after green-bond issuance. I include firm fixed effects and year fixed effects, and cluster standard errors at the industry level.

Table 7: Municipal Green Bonds Premium

	Treasury-Adjusted Yield as dependent variable			
	(1)	(2)	(3)	(4)
	All Green Bonds	First Green Bond	All Green Bonds	First Green Bond
Green bonds	-0.083*** (-2.76)	-0.053** (-2.02)	-0.070** (-2.37)	-0.047* (-1.66)
Same-day Traditional bonds	-0.113*** (-3.37)	-0.066** (-2.12)	-0.105*** (-3.51)	-0.072** (-2.35)
Bonds after First Green Bond Date: Green		-0.124*** (-2.87)		-0.098** (-2.52)
Bonds after First Green Bond Date: Traditional		-0.048** (-2.58)		-0.040** (-2.26)
N	598471	598471	446904	446904
Adj. R-squared	0.668	0.668	0.675	0.675
F-test	0.372	0.699	0.230	0.414
Issuer FE	Yes	Yes	No	No
Issuer X Maturity FE	No	No	Yes	Yes
Day FE	Yes	Yes	Yes	Yes
Control	Yes	Yes	Yes	Yes
Cluster	Issuer	Issuer	Issuer	Issuer

t statistics in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

This table shows results from the municipal green bonds premium analysis. The dependent variable is the treasury-adjusted yield to maturity at issuance for US municipal bonds. *Green Bonds* is '1' for all green bonds in columns 1 and 3, and for the first green bonds by an issuer in columns 2 and 4. *Same-Day Traditional Bonds* is '1' for traditional bonds from green-bond issuers on the same day the issuer issues *Green Bonds*. *Bonds after First Green Bond Date* is '1' for green or traditional bonds issued after the first green-bond-issuance-date for an issuer. Control variables include credit rating and issuance amount (log), and also include maturity for columns 1 and 2. Issuer and day fixed effects are included in columns 1 and 2. Issuer-maturity and day fixed effects are included in columns 3 and 4. Standard errors are clustered at the issuer level.

Table 8: Green Bond Survey Results: Motives

<i>Panel A: Q3 Did your firm believe the cost of borrowing for green bonds would be...</i>					
	N	Percent	Cumulative		
			Percent		
Do not know	2	4.00	4.00		
Higher than traditional bonds	4	8.00	12.00		
Lower than traditional bonds	14	28.00	40.00		
Same as traditional bonds	30	60.00	100.00		
Total	50	100.00			

<i>Panel B: Q5 What is the main reason for issuing the green bond? (open question)</i>					
	Total	N	Mean	SD	
Show commitment to environment or sustainability	52	33	0.63	0.49	
Reinforce commitment to environment or sustainability	52	17	0.33	0.47	
Attract green investors	52	14	0.27	0.45	
Financing reasons	52	12	0.23	0.43	

<i>Panel C: Q6 How relevant are the following motives for issuing green bonds?</i>					
	Not relevant	Somewhat relevant	Quite relevant	Very relevant	
Environmental Commitment	0	2	15	35	
Environmental Project Funding	10	16	13	12	
Lower Cost of Capital	18	9	13	10	
Attract Investors	0	6	14	31	
Shareholder Demand	14	22	9	6	
Other	0	0	2	4	

This table shows the survey results for green-bond-issuance motives. While there are 52 total survey responses, 50 firms responded to questions 3 and 5. Panel A shows the results for question 3, which is a multiple choice question about a firm’s belief for the cost of borrowing for green bonds. Panel B shows the most common responses to the open question “What is the main reason for issuing the green bond?” The common responses are manually grouped based on reading the written responses. Panel C shows how firms rank the relevance of different green-bond-issuance motives.

Table 9: Green Bond Survey Results: Environmental Inquiries

<i>Panel A: Q9 Since your firm issued the green bond, how has the frequency of inquiries about your firm's environmental performance changed?</i>				
	N	Percent	Cumulative Percent	
Fewer inquiries	0	0.00	0.00	
Do not know	7	13.46	13.46	
No change	15	28.85	42.31	
More inquiries	30	57.69	100.00	
Total	52	100.00		

<i>Panel B: Q10 Which parties initiated more environmental performance inquiries?</i>				
	Total	N	Mean	SD
Green bond investors	30	26	0.87	0.35
Equity market shareholders	30	16	0.53	0.51
External reviewers	30	16	0.53	0.51
Public media	30	12	0.40	0.50
Other	30	1	0.03	0.18

This table shows the survey results on environmental inquiries. There are 52 responses to these questions. Panel A shows the results for question 9, which is a multiple choice question on the change in inquiries about a firm's environmental performance. From the 30 firms that chose "more inquiries," Panel B shows the response for which party initiated more inquiries.

Table 10: Alternative Green Commitments

Panel A: Correlation

	(1)	(2)	(3)	(4)	(5)	(6)
(1) CSR Report	1.000					
(2) ESG Committee	0.513***	1.000				
(3) CSR Report Audit	0.453***	0.349***	1.000			
(4) ESG Compensation	0.146***	0.204***	0.063***	1.000		
(5) Science-based Target	0.193***	0.196***	0.267***	0.071***	1.000	
(6) Green Bonds	0.093***	0.095***	0.149***	0.051**	0.124***	1.000

* $p < .10$, ** $p < .05$, *** $p < .01$

Panel B: Summary Statistics

Green Commitments	No		Yes		Green Bond Issuers	
	N	E-score	N	E-score	N	E-score
CSR Report	132	14.617	1921	53.288	142	68.035
ESG Committee	247	24.316	1806	54.423	140	68.145
CSR Report Audit	767	35.540	1286	59.904	128	69.682
ESG Compensation	1015	46.708	1038	54.804	84	74.198
Science-based Target	1427	45.686	626	62.461	77	70.091
Green Bonds	1909	49.547	144	67.424	144	67.424

This table presents the correlation and summary statistics of firms with various green commitments among firms in the CDP sample. Panel A shows the correlation matrix. Panel B shows the number of firms and the average Asset4 environmental score for three groups. The columns under *No* and *Yes* are firms without and with the corresponding green commitment on the left, respectively. The last group under *Green Bond Issuers* are the firms with both the corresponding green commitment and green bonds.

Appendices

APPENDIX A

VARIABLE DEFINITION

Variable	Description	Data Source
Green Bond	An indicator variable equal to 1 if the firm issued a green bond	Bloomberg, CBI
Green Bonds Descriptive Statistics		
Coupon	The coupon rate of the bond in percentage (excluding float-rate bonds)	Bloomberg
Maturity	Years to the maturity date at issuance (excluding perpetual bonds)	Bloomberg
Amount Issued (USD mil)	The issuance amount of the bond, in USD millions	Bloomberg
Public Firm	An indicator variable equal to 1 if the bond issuer is a public firm	Bloomberg
Green Bond Exchange	An indicator variable equal to 1 if the bond is listed on exchanges with green-bond segments	Bloomberg
Climate Bonds Initiative	An indicator variable equal to 1 if the bond is included in the Climate Bonds Initiative (“CBI”) database	CBI
External Review	An indicator variable equal to 1 if the bond is certified or externally reviewed	CBI
Impact Reporting	An indicator variable equal to 1 if the bond issuer’s green bond framework includes reporting environmental impacts	CBI
Determinants Analysis		
Market Value (USD mil)	The total market capitalization, in USD millions	Worldscope
Market-to-Book	The market to book ratio	Worldscope
Cash (USD mil)	The amount of cash and cash equivalents on balance sheet, in USD millions	Datastream
Cash Dividends (USD mil)	The amount of cash dividends paid, in USD millions	Datastream
Debt to Cash	The ratio of long-term debt to cash	Datastream
Leverage	The ratio of long-term debt to equity	Datastream
Asset (USD mil)	Total assets, in USD millions	Datastream
Long-Term Debt (USD mil)	The amount of long-term debt outstanding, in USD millions	Datastream

(Continued)

Appendix A, continued

Variable	Description	Data Source
Carbon Pricing Regulation	An indicator variable equal to 1 if the firm's headquarter country has a carbon-pricing legislation	World Bank
Environmental Performance Index	An index that captures how close countries are to established environmental policy targets	Yale
Low-Carbon Revenue	An indicator variable equal to 1 if the firm has revenue from low-carbon sources	CDP
Physical Risk	An indicator variable equal to 1 if the firm considers physical climate change risks	CDP
Transition Risk	An indicator variable equal to 1 if the firm considers transition climate change risks	CDP
Physical Opportunity	An indicator variable equal to 1 if the firm considers physical climate change opportunities	CDP
Transition Opportunity	An indicator variable equal to 1 if the firm considers transition climate change opportunities	CDP
Science-Based Target	An indicator variable equal to 1 if the firm issued a science-based emissions target	CDP
CSR Report	An indicator variable equal to 1 if the firm published CSR reports	Asset4
CSR Report Audit	An indicator variable equal to 1 if the firm published audited CSR reports	Asset4
Asset4 Environmental Score	The firm's environmental score	Asset4
ESG Committee	An indicator variable equal to 1 if the firm has an ESG committee	Asset4
ESG Compensation	An indicator variable equal to 1 if the firm ties ESG to executive compensation	Asset4
Targets Analysis		
Target Achievement	A score for the achievement progress of emissions targets, calculated as $Target\ progress_{i,t} / Time\ progress_{i,t}$	CDP
Average Annual Target	The average annual emissions-reduction target, calculated as total emissions-reduction target divided by target duration	CDP
Target Duration	The number of a years an emissions target last for	CDP
Time Progress	The percent of years passed in the duration of an emissions target	CDP

(Continued)

Appendix A, continued

Variable	Description	Data Source
Target Progress	The percent of total emissions-reduction target completed	CDP
Media Analysis		
News Count	The number of environmental news articles related to a firm in a year	RavenPack
News Sentiment	The RavenPack news sentiment of a news article	RavenPack
Municipal Bonds Analysis		
Yield	Yield to maturity at the issuance of the bond	Mergent
Treasury-Adjusted Yield	Yield minus the treasury yield of the same maturity at issuance	Mergent, US Treasury
Maturity	The number of years between issuance and maturity	Mergent
Coupon	The coupon rate of the bond	Mergent
Issuance Amount	The offering amount at issuance, in USD	Mergent
Credit Rating	The average long-term rating assigned by Fitch, Moodys, and S&P at issuance. Scaled such that a credit rating of AAA gets a value of 22	Mergent
Same-Day Traditional Bond	An indicator variable equal to 1 if the bond is not a green bond, and is issued on the same day the issuer issued a green bond	Mergent

This table provides the descriptions and sources of variables used in this paper.

APPENDIX B

APPLE GREEN BONDS

2.2.3 Reporting

Throughout the term of the green bond, until the proceeds have been fully allocated to eligible projects, Apple commits to publishing annual updates of the allocation of the proceeds and impact of projects that have received allocations. The annual allocation and expected impact evaluation will be reported as a separate green bond report. These updates will be published on the company’s website at investor.apple.com.

Apple may include its green bond report either by reference or as an appendix in its annual Environmental Responsibility Report.

Key Performance Indicators	
Renewable Energy	<ul style="list-style-type: none"> • Renewable energy installed capacity (kW or MW) • Energy produced from renewable sources (kWh or MWh) • GHG emissions avoided (in CO2e tons)
Energy Efficiency	<ul style="list-style-type: none"> • Energy saved aggregate (kWh) • Energy saved due to building retrofits or design (kW)
Water	<ul style="list-style-type: none"> • Water use savings (gallons)
Waste	<ul style="list-style-type: none"> • Waste diverted from landfills (tons or % diversion) • Waste recycled or composted (tons)
Resource Use	<ul style="list-style-type: none"> • Bio-based material use (% of material in product) • Recycled content use (% material in product)

This appendix has selected passages from Apple’s green bond framework overview and external review by Sustainalytics.

APPENDIX C

PEPSICO GREEN BONDS

Panel A Green Bond External Review

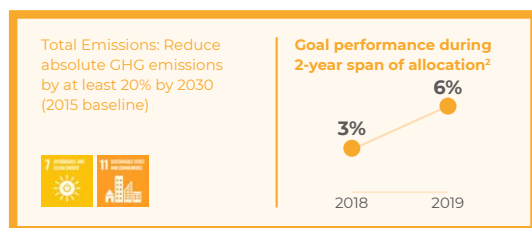
- Lower Carbon Emissions: reducing absolute Scope 1, 2 and 3 greenhouse gas (GHG) emissions across the value chain by at least 20% by 2030. In 2018, PepsiCo reduced Scope 3 emissions by approximately 2.2 million metric tons, making 7% progress towards its goal. In addition, the Company decreased Scope 1 and 2 emissions by 6.4%, representing 32% progress towards its goal.

Considering PepsiCo's ongoing sustainability commitments as well as its quantitative and time-bound targets, Sustainalytics is of the opinion that PepsiCo is well-positioned to issue green bonds and that the eligible categories specified under the Framework will support the Company's overall sustainability strategy.

Panel B Green Bond Report

PepsiCo Provides Update on US\$1 Billion Green Bond
10/13/2020

- **Approximately \$200 million to procure recycled polyethylene terephthalate (rPET) plastic for the Company's North American beverage packaging, avoiding approximately 210,000 metric tons of greenhouse gas emissions;**
- **More than \$110 million to help transition the company-owned fleet to lower-carbon models;**
- **\$98 million to build a green R&D facility in Valhalla, New York, featuring 681 solar panels, among other innovations; and**
- **\$9 million to improve water-use efficiency in the Company's plants, including a project at a PepsiCo snack plant in Vallejo, Mexico, a high-water-risk location, which implemented new water treatment technologies resulting in 70% water reuse rates.**



This appendix has selected passages from PepsiCo's green bond documents. Panel A is an extract from the green bond external review by Sustainalytics. Panel B is an extract from the 2020 green bond report and the associated press release.

APPENDIX D

GREEN BONDS SURVEY



Main survey

The Green Bond Survey

We are researchers at the **University of Chicago** studying the issuance of **green bonds**. Since your firm issued a green bond, we are interested in learning more about your firm's experience through a short **5-minute-survey**. Your insights will be very helpful for this research, and for a better understanding of green bonds. We will share with you a summary of the findings after the research analysis. Individual responses are purely for research purposes, and will be kept **confidential**. Should you have any questions, please do not hesitate to email us at shirley.lu@uchicago.edu.

Your participation is voluntary, and by clicking , you agree to participate in the survey.

If you have any questions about your rights as a participant in this research, feel you have been harmed, or wish to discuss other study-related concerns with someone who is not part of the research team, you can contact the University of Chicago Social & Behavioral Sciences Institutional Review Board (IRB) Office by phone at (773) 702-2915, or by email at sbs-irb@uchicago.edu. The study number of this survey is IRB20-0470.

Which year did your firm issue the first green bond?

Who initiated the idea of issuing a green bond? (choose all that apply)

- Board of Directors
- C-suite
- Sustainability department
- Finance department
- Shareholders
- Other:

Before the issuance, did your firm believe the cost of borrowing for green bonds would be higher or lower than for traditional bonds?

Note: traditional bonds defined as regular bonds with otherwise similar terms, e.g., on maturity, collateral, and issuance amount etc.

- Higher than traditional bonds
- Same as traditional bonds
- Lower than traditional bonds
- Do not know
- Did not consider

Please share with us your view on why green bonds may have a lower cost of borrowing than traditional bonds. (optional)

Please share with us your view on why green bonds may have a higher cost of borrowing than traditional bonds. (optional)

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Briefly, what is the main reason for issuing the green bond?

Page 4/8

For your firm, how relevant are the following motives for issuing green bonds?

	Not relevant	Somewhat relevant	Quite relevant	Very relevant
Show commitment to environmental efforts	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

	Not relevant	Somewhat relevant	Quite relevant	Very relevant
Get funding for environmental projects	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Receive a lower cost of borrowing than traditional bonds	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Attract a wider investor base	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Demand from existing shareholders	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other: <input type="text"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Reporting

Page 5/8

Which reporting commitments does your firm include in the green bond framework? (choose all that apply)

- No reporting commitments
- Periodic reporting on the use of proceeds
- Periodic reporting on the environmental impacts
- Other:

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Does the environmental impact reporting include any of the following categories?

	Yes	No
Greenhouse gas emissions	<input type="radio"/>	<input type="radio"/>
Renewable energy usage	<input type="radio"/>	<input type="radio"/>

	Yes	No
Energy usage	<input type="radio"/>	<input type="radio"/>
Water usage	<input type="radio"/>	<input type="radio"/>
Green buildings	<input type="radio"/>	<input type="radio"/>
Other:		
<input style="width: 150px; height: 20px;" type="text"/>	<input type="radio"/>	<input type="radio"/>

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Since your firm issued the green bond, how has the frequency of inquiries about your firm's environmental performance changed?

- More inquiries
- No change
- Fewer inquiries
- Do not know

Which parties initiated more environmental performance inquiries? (choose all that apply)

- Green bond investors
- Equity market shareholders
- Public media
- External reviewers of the green bond (e.g., Sustainalytics or other external reviewers)
- Other:

Ending questions

Thank you for your responses. Below we have a few administrative questions:

Which description below best describes your department?

- Sustainability department
- Finance department
- Investor relations
- Other:

What is your job title?

Would you be interested in receiving a summary of the findings? If so, may we get a contact email? (will be kept confidential)

Can we contact you in the future with any follow up questions? If yes, what is the best way to contact you if different from the contact above? (will be kept confidential)

Phone number

Email

LinkedIn

**If you have any other comments about green bonds,
please share them here:**

This is the end of the survey, thank you for participating! If you have any questions or comments, feel free to share with us at shirley.lu@uchicago.edu.

Powered by Qualtrics

APPENDIX E

GREEN BONDS SURVEY RESPONSE

Q1: Which year did your firm issue the first green bond?

	N	pct	cumpct
2014	8	16.00	16.00
2015	2	4.00	20.00
2016	3	6.00	26.00
2017	6	12.00	38.00
2018	12	24.00	62.00
2019	17	34.00	96.00
2020	2	4.00	100.00
Total	50	100.00	

Q2: Who initiated the idea of issuing a green bond?

	count	N	mean	sd
Board of Directors	52	12	0.23	0.43
C-suite	52	6	0.12	0.32
Sustainability	52	13	0.25	0.44
Finance	52	40	0.77	0.43
Shareholders	52	1	0.02	0.14
Other	52	12	0.23	0.43

Q3: Did your firm believe the cost of borrowing for green bonds would be...

	N	pct	cumpct
Do not know	2	4.00	4.00
Higher than traditional bonds	4	8.00	12.00
Lower than traditional bonds	14	28.00	40.00
Same as traditional bonds	30	60.00	100.00
Total	50	100.00	

Q6: How relevant are the following motives for issuing green bonds?

	Not relevant	Somewhat relevant	Quite relevant	Very relevant
Environmental Commitment	0	2	15	35
Environmental Project Funding	10	16	13	12
Lower CoC	18	9	13	10
Attract Investors	0	6	14	31
Shareholder Demand	14	22	9	6
Other	0	0	2	4

Q7: Which reporting commitments does your firm include in the green bond framework?

	count	N	mean	sd
Use of Proceeds	52	45	0.87	0.34
Environmental Impacts	52	37	0.71	0.46
No Reporting Commitments	52	1	0.02	0.14
Other	52	7	0.13	0.34

Q8: Does the environmental impact reporting include any of the following categories?

	Yes	No
Greenhouse Gas	31	4
Renewable Energy	21	9
Energy Usage	22	10
Water Usage	10	17
Green Building	22	11
Other	6	0

Q9: Since your firm issued the green bond, how has the frequency of inquiries about your firm's environmental performance changed?

	N	pct	cumpct
Fewer inquiries	0	0.00	0.00
Do not know	7	13.46	13.46
More inquiries	30	57.69	71.15
No change	15	28.85	100.00
Total	52	100.00	

Q10: Which parties initiated more environmental performance inquiries?

	count	N	mean	sd
Green bond investors	30	26	0.87	0.35
Equity market shareholders	30	16	0.53	0.51
External Reviewers	30	12	0.40	0.50
Public Media	30	16	0.53	0.51
Other	30	1	0.03	0.18

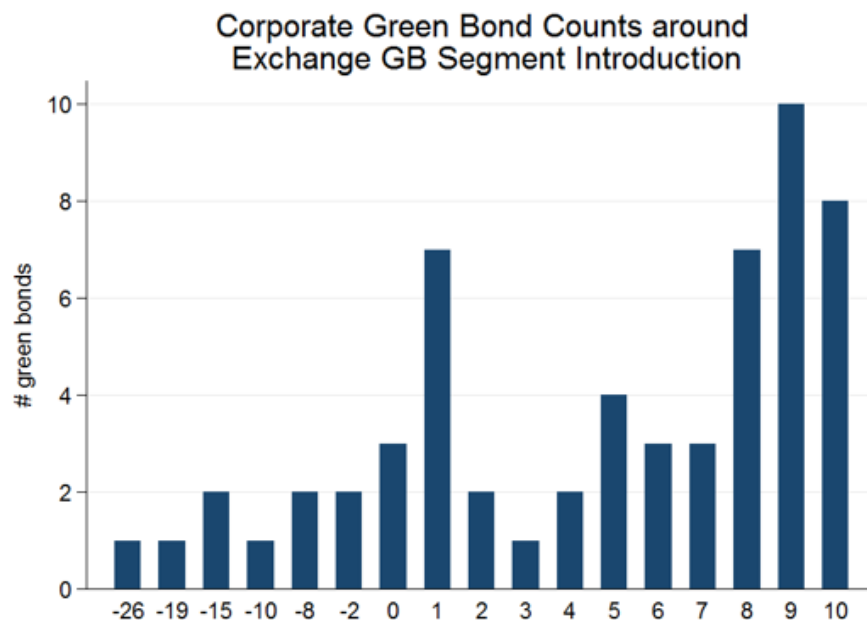
Q11: Respondent Department

	N	pct	cumpct
Finance department	30	57.69	57.69
Investor relations	12	23.08	80.77
Other:	8	15.38	96.15
Sustainability department	2	3.85	100.00
Total	52	100.00	

APPENDIX F

STAGGERED ADOPTION OF GREEN-BOND SEGMENTS

Name of Stock Exchange	Type of Dedicated Section	Launch Date
Oslo Stock Exchange	Green bonds	January 2015
Stockholm Stock Exchange	Sustainable Bonds	June 2015
London Stock Exchange	Green bonds	July 2015
Shanghai Stock Exchange	Green bonds	March 2016
Mexico Stock Exchange	Green bonds	August 2016
Luxembourg Stock Exchange	Luxembourg Green Exchange	September 2016
Borsa Italiana	Green and Social Bonds	March 2017
Taipei Stock Exchange	Green bonds	May 2017
Johannesburg Stock Exchange	Green bonds	October 2017
Japan Exchange Group	Green and Social Bonds	January 2018
Vienna Exchange	Green and Social Bonds	March 2018
Nasdaq Helsinki	Sustainable Bonds	May 2018
The International Stock Exchange	Green bonds	November 2018
Frankfurt Stock Exchange	Green bonds	November 2018



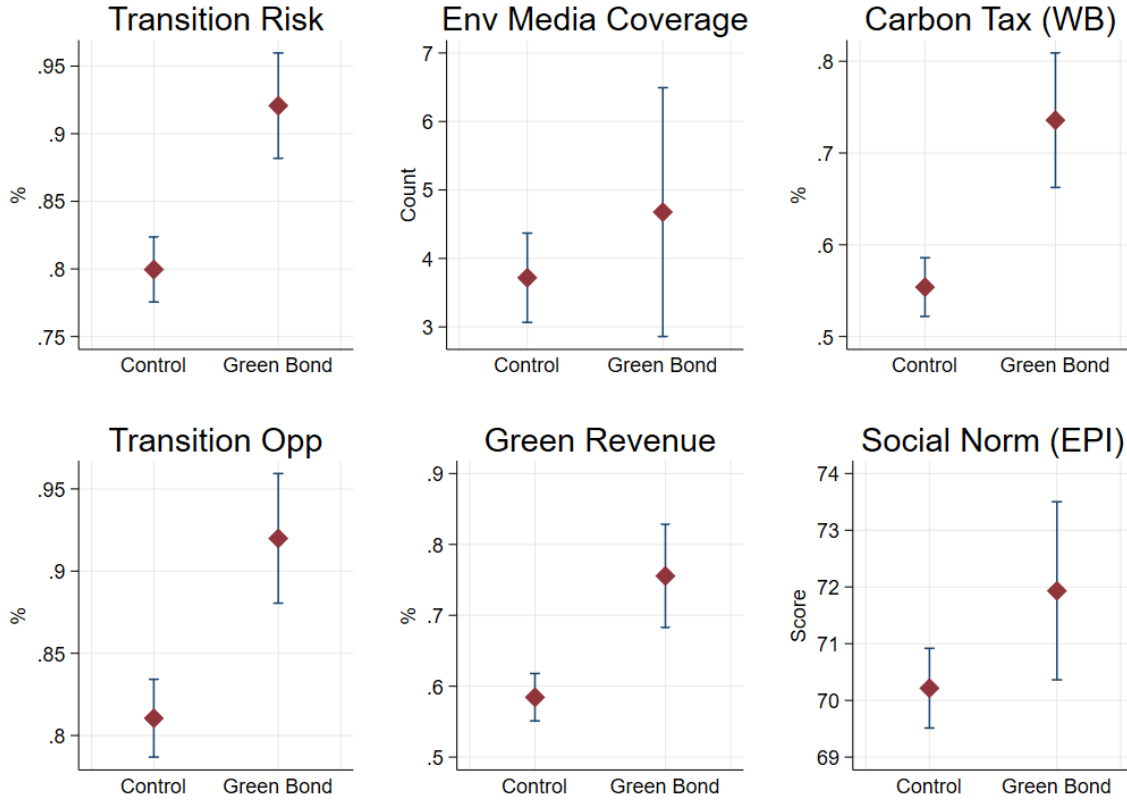
This appendix shows the exchanges with green-bond segments. The list of exchanges are sourced from CBI website: <https://www.climatebonds.net/green-bond-segments-stock-exchanges>. The figure plots the number of green bonds issued in relation to the month the local stock exchange introduced a green-bond segment.

APPENDIX G

DETERMINANTS OF GREEN-BOND ISSUANCE

Figure A1: Determinants of Green-Bond Issuance

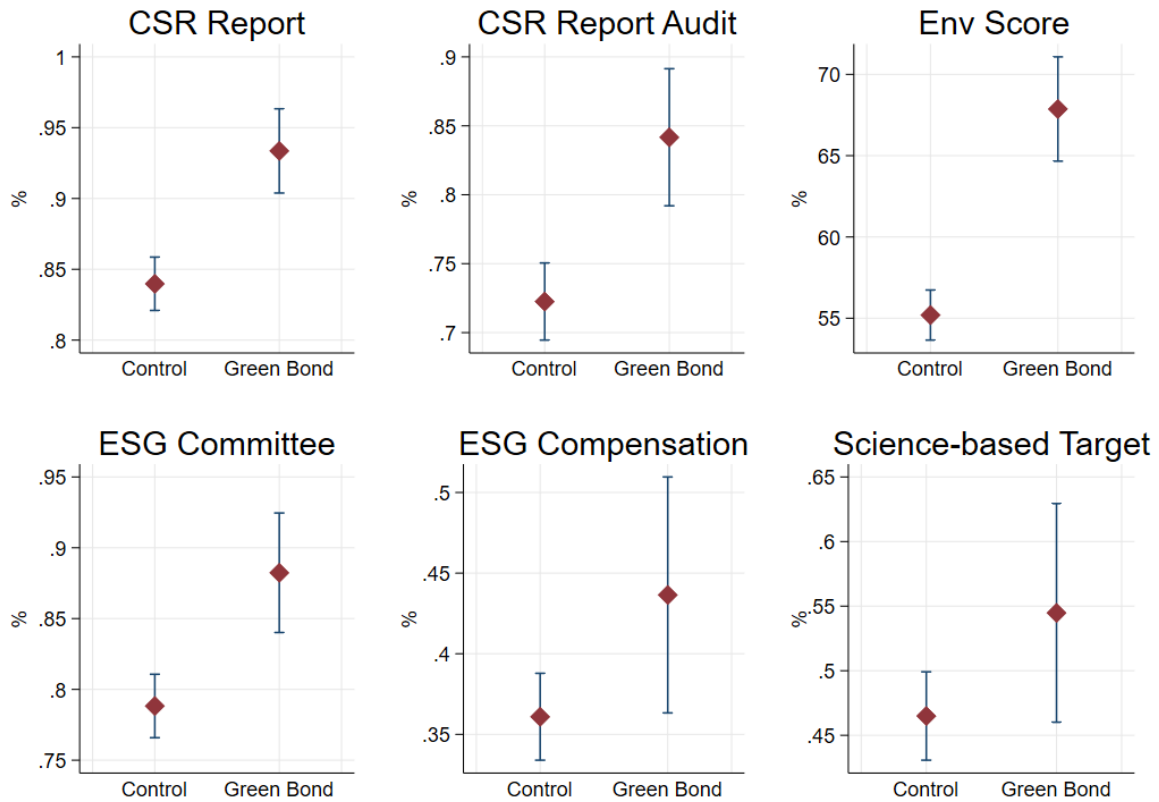
Panel A: Climate Change Risks and Opportunities



This figure plots the key determinant variables of green bonds. Each subfigure plots the average value for green-bond issuers and the control group created using coarsened exact matching on industry and size. *Transition risk* and *Transition Opp* are ‘1’ if the firm self-reported risk and opportunity, respectively, in CDP. *Green revenue* is ‘1’ if a firm self-reports low-carbon revenue in CDP. *Env Media Coverage* is a firm’s average annual number of media mentions related to environmental performance, based on Ravenpack data. *Carbon Tax* is ‘1’ if a firm’s headquarter is located in a country with carbon tax, based on data from the World Bank. *Social Norm* is the firm’s headquarter country’s environmental performance index, created by Yale.

Figure A1: Determinants of Green-Bond Issuance (continued)

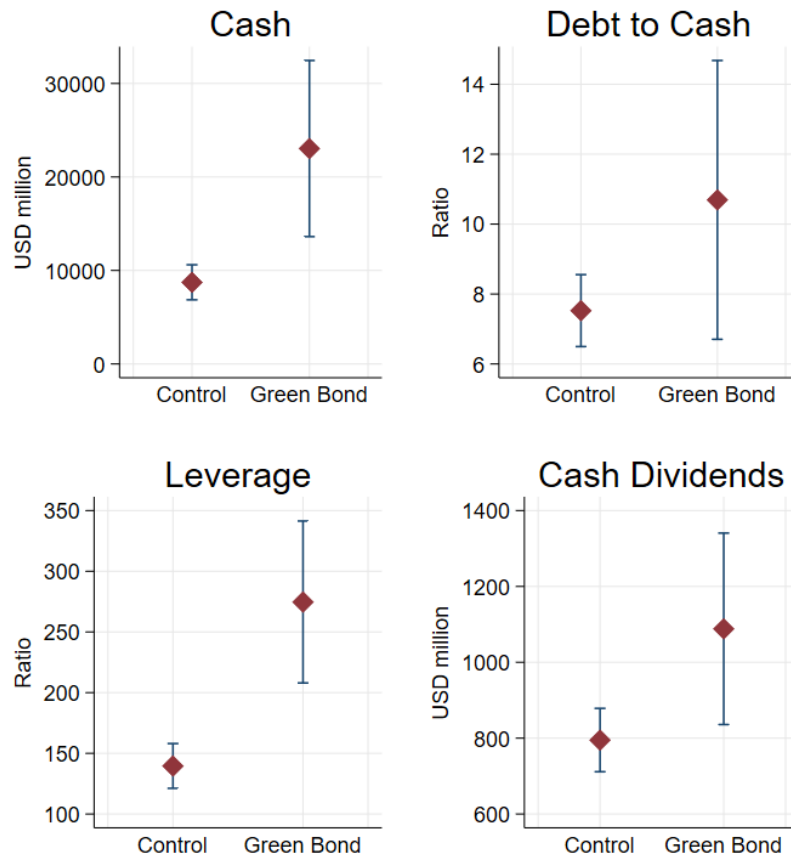
Panel B: Existing Environmental Efforts



This figure plots the key determinant variables of green bonds. Each subfigure plots the average value for green-bond issuers and the control group created using coarsened exact matching on industry and size. *CSR Report*, *CSR Report Audit*, *ESG Committee* and *ESG Compensation* are '1' if the firm has this information in Asset4. *Env Score* is the environmental pillar score created by Asset4. *Science-based Target* is '1' if a firm sets an emissions target that aligns with the science-based target initiative in the CDP data.

Figure A1: Determinants of Green-Bond Issuance (continued)

Panel C: Financial Constraint

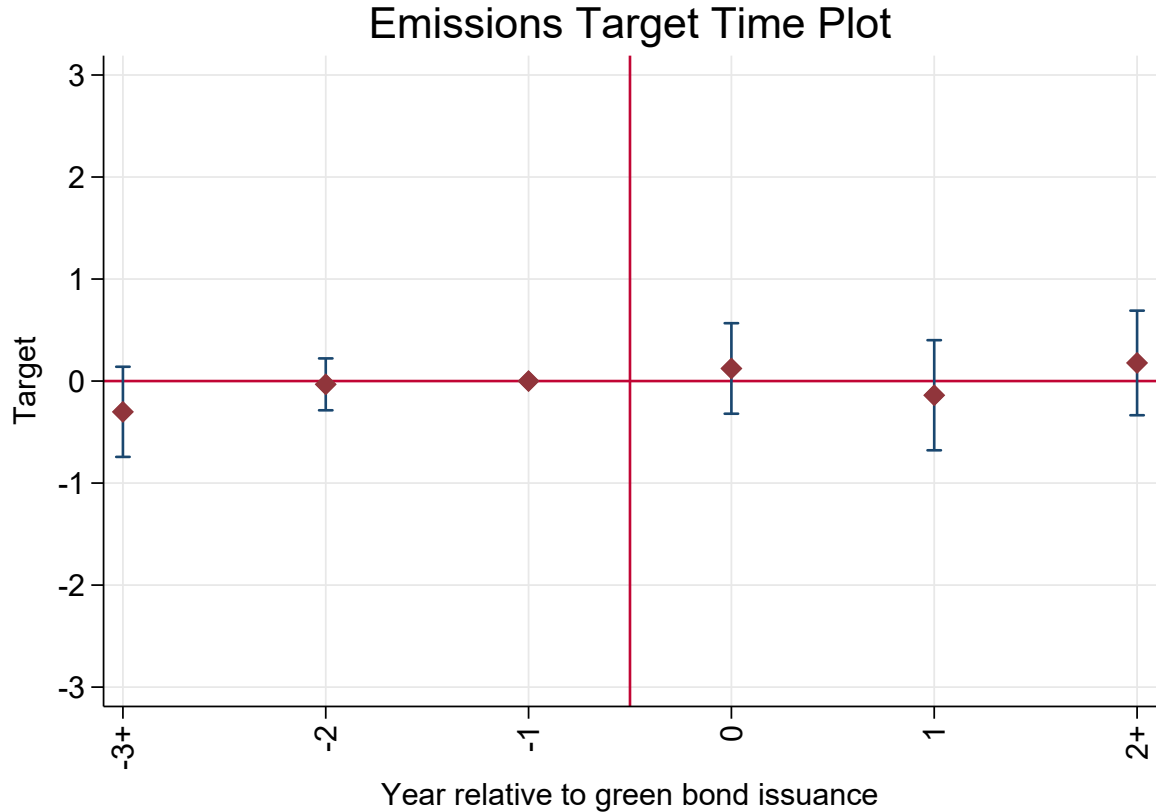


This figure plots the key determinant variables of green bonds. Each subfigure plots the average value for green-bond issuers and the control group created using coarsened exact matching on industry and size. The financial variables are the averages from between 2010 and 2019 from Datastream. *Cash* is the balance sheet cash amount in USD. *Debt to Cash* is the long-term debt to cash ratio. *Leverage* is the debt to equity ratio. *Cash Dividends* is the amount of cash dividends in USD.

APPENDIX H

EMISSIONS TARGET AROUND GREEN-BOND ISSUANCE

Figure A2: Emissions Target around Green-Bond Issuance



This figure plots the coefficient and 95% confidence interval for the main regression investigating the effect of green-bond issuance on emissions target in event time. *Emissions target* captures a firm's average annual emissions-reduction target. I replace the post indicator with the year relative to the green-bond-issuance year. I omit the indicator for year t-1, the year before the green-bond issuance, which serves as the benchmark period with a coefficient and standard error of zero. I control for size and market-to-book. I include firm fixed effects and year fixed effects. Standard errors are clustered by industry.