Green Bonds: Environmental Performance and Capital Market Response

Avis Devine*
York University

Nils Kok†
Maastricht University

Halil Özgür‡
Concordia University

Erkan Yönder§
Concordia University

8th February, 2024

Abstract

Green bonds are growing in popularity, both as a financial tool and a path toward responsible investing. This brings a demand for measurement of both financial and environmental performance of these instruments. Yet analysis of the latter is largely missing, and that which exists is noisy, due to vague green bond commitments and difficulty in measuring outcomes in general corporations. We capitalize on the uniquely clean nature of REIT green building investments to measure the environmental performance of green bonds, and then analyze the response of capital markets to green bond issuance. Using highly rigorous modeling techniques, we find evidence that green bond issuance leads to enhanced environmental performance for a firm, within a two year horizon. We further find that capital markets appear to evaluate green bond issuers as lower risk investments, offering bond spread discounts to green bond issuers as well as increased access to equity.

KEYWORDS:
Capital Structure, Green Bonds, Commercial Real Estate, REITs, ESG, Green Building

*Schulich School of Business, York University, 4700 Keele St, Toronto, ON M5E1Z5 Canada adevine@schulich.yorku.ca

†Department of Finance, Maastricht University, PO Box 616, Maastricht, 6200 MD, the Netherlands. n.kok@maastrichtuniversity.nl

‡John Molson School of Business, Concordia University, 1455 de Maisonneuve West, Montréal, Québec H3G 1M8, Canada. halillozgurr@gmail.com

§John Molson School of Business, Concordia University, 1455 de Maisonneuve West, Montréal, Québec H3G 1M8, Canada. erkan.yonder@concordia.ca

1 Introduction

Green bonds are a recent and innovative financial instrument. Compared to conventional corporate bonds, the proceeds from green bonds are exclusively committed to environmentally friendly projects such as energy efficiency, water conservation, and renewable energy. The first corporate green bond was issued in 2013, and its popularity has increased significantly thereafter. More than USD2.8 trillion in green bonds have been issued to-date, with 15% of that total issued in 2023.[1] In Europe, the portion of the total bond market made up by green bonds has doubled from 2020 through 2022, to approximately 9%, and S&P Global projects that by year-end 2023, sustainable and sustainably-linked bonds will make up approximately 15% of all bond issuance.[2] Green bonds are growing in size and uptake, and with is grows the need for clarity on the impact of dedicated capital.

The literature on green bonds has grown with the financial tool's popularity (seeBhutta et al. (2022) for a recent summary of the literature). Most studies have focused on the impacts for and by investors in green bonds and green bond-issuing firms. The findings in literature have been mixed in the market for municipal (and sovereign) bonds. Baker et al. (2018) and Zerbib (2019) find a green bond premium, i.e., a negative yield differential for green bonds, of about six and two basis points, respectively. find a green bond discount of about eight basis points. In a critical study, Larcker and Watts (2020) argue that the matching methodology of these papers has been insufficient to control for the differences between green and non-green (i.e. conventional) bonds, resulting in mixed evidence from these studies. Following a tight matching method, they find that the green bond premium is essentially zero, and investors would not invest in green bonds if the returns were not competitive.

In two recent corporate green bond studies, authors find that stock prices respond positively to green bond issuance. Tang and Zhang (2020) show that institutional ownership

[1]For details, see: https://www.climatebonds.net/.

[2]For details, see: https://www.eea.europa.eu/data-and-maps/daviz/percentage-of-green-bond-issuances-1 and https://www.spglobal.com/_assets/documents/ratings/research/101585823.pdf.

increases after the firm issues green bonds. Moreover, stock liquidity improves significantly following the issuance of green bonds. Flammer (2021) shows that the response is stronger for first-time issuers and for green bonds certified by third parties. In line with the signaling argument, firms improve their environmental performance after the green bond offering i.e., obtaining higher environmental ratings and lower carbon emissions. Both studies do not find a consistently significant premium for the green bonds.

Yet while green bonds, by definition, carry both economic and environmental impacts, only financial outcomes are being studied; there is little evidence on if organizations keep their promises regarding the use of green bond proceeds. Without ex post analysis of the impact of green bond funds, we are missing the core sustainability materiality risk measurement tool for green bonds. This measurement is of particular importance when organizations are considering subsequent green bond issuances. That is, when evaluating whether or not to provide a loan to an organization, we look to their loan repayment history to inform our risk analysis. In the same vein, we should be looking to how well firms kept their use of proceeds commitments on prior green bonds when considering the funding of future green bonds. Yet despite a growing industry focus and concern regarding the misrepresentation of commitments to environmental endeavors, or "greenwashing," there is little evidence or tracking of how well firms met their green bond environmental commitments.

The lack of insight is largely due to difficulty in teasing apart details on the green bond-funded projects, and these issues fall into two categories. First, green bonds are issued across numerous industries, and much of the analysis to-date has attempted to evaluate those green bonds collectively. This was a reasonable approach for early work in the field, as data limitations meant more could be learned by pooling industries than separating them. As can be seen from Figure 1, the primary industry for green bond issuing organizations spans from finance to food, and the organization types span from governments to corporations. With such breadth in studied fields and organizational format, results are noisy (a hypothesis found true through the work of Larcker and Watts (2020)), and difficult to interpret. Second,

many green bonds fund projects with a stated goal of decreased estimated emissions. This obfuscates the measurability of green bond outcomes, as the stated impact is both an estimate, and that estimate may be measured differently by each firm, both in terms of which scope of activities they capture in their measurement, and how they define their emission scopes (1, 2, and 3). Without measurable, environmental outcomes, it is difficult for investors to differentiate effective from ineffective GB issuers.

(Insert Figure 1 about here)

U.S. real estate firms offer an important and useful laboratory to study green bonds, both in terms of impact and analytical clarity. Almost 80% of all green bond use of proceeds are associated with real asset investment, with 1 of every 3 green bond dollars financing green buildings directly. Nearly 40% of green bond use of proceeds for buildings occur through financial corporate green bonds, such as those issued by real estate investment trusts (REITs). Further, the U.S. green bond real estate footprint outsizes the global average, with U.S. organizations issuing 12% of global green bonds, but 20% of global real estate green bonds (see Figure 2).

(Insert Figure 2 about here)

In addition to the magnitude of the real estate green bonds, the industry also carries the benefit of consistent environmental outcome measurement. REIT green bond use of proceeds is linked almost exclusively to the (re)development of green buildings. This measurement brings clarity through third-party, arm's length green building certification, and accuracy through highly transparent and up-to-date asset valuation. Further, U.S. tax law restrictions mean that REITs are singular in their business activities, removing the possibility of other noisy or offsetting corporate initiatives (tangibility ratio of 98% (Demirci et al., 2023)). Therefore, U.S. REIT green bonds offer the opportunity to measure the impact in a single industry which has a highly restricted range of business activities, by observing a quantifiable metric of both environmental commitment and financial impact.

We aim to address the dearth of this important topic by exploring three questions. First, what is the environmental performance of green bonds (complementing the well-studied financial performance)? Second, does the market price capital differently for firms that promise (or exhibit) environmental commitment through green bond? And third, in what way is the capital structure of a firm altered following a green bond issuance?

1.1 Green Bond Use of Proceeds Performance

Despite the importance of understanding the efficacy of green bond use of proceeds, the depth of related studies is quite thin. This is largely due to the aforementioned difficulties in measuring environmental sustainability outcomes. These few studies only focus on the carbon emission estimates (Kim and Pouget, 2023; Seltzer et al., 2022).

Interestingly, most of the research that does successfully tease out the question of green bond use of funds focuses on real estate green bonds, specifically those issued with the concurrent goal of affordable housing (Heffernan et al., 2021; MacAskill et al., 2021). Affordable housing is another important sustainability goal, through a social (rather than environmental) lens. For example, Devine and McCollum (2022) examines features of the Fannie Mae green bond program at issuance and find those borrowers receive lower interest rates, debt service coverage ratios, and higher leverage ratios, with some of those features being stated program benefits and some not. A subsequent study by the authors explores the changes in energy efficiency for multifamily affordable housing properties which received green bond funds issued to improve energy efficiency (Devine and McCollum, 2024). Interestingly, despite funds issued specifically for energy efficiency improvements, energy efficiency did not always improve following the investments. Such studies offer insight the "greenwashing" concerns observed in the industry, highlighting the importance to better measure efficacy of green bond fund use.

Compared to general corporations, REITs provide a unique laboratory to study green bonds. By regulation, REITs are required to receive at least 75% of their gross income from

real estate assets. Based on our calculations, 98% of REIT assets are tangible. REITs mainly operate in real estate and their green bond proceeds will be essentially invested in energy efficient and sustainable, green buildings. Hence, unlike regular corporations, we can observe and track REIT investments one by one and evaluate their performance in terms of greenness at the asset level. We track the commitment of REITs to invest in energy efficiency and green building improvements after the issuance of green bonds, measured through achievement under green building certification schemes such as LEED and Energy Star. Our project will make an important contribution to the literature by investigating corporate green bonds used to finance green property investments.

H1: REIT green bond issuance leads to increased environmentally-focused investment

1.2 Capital Marking Pricing Response

The benefits of (sustainable) product differentiation come through two major channels: operational improvements; and, corporate image benefits (McWilliams and Siegel, 2001). The operational benefits of green building investment through green bond use of proceeds for REITs agglomerate through the operations of the green buildings. This field is well research in the academic literature, including evidence that rental and occupancy rate premiums (Devine and Kok, 2015; Eichholtz et al., 2010, 2013), as well as energy efficiency (Clayton et al., 2021; Kats, 2010; Newsham et al., 2009; Scofield, 2013), being capitalized into asset values (Fuerst and McAllister, 2011; Holtermans and Kok, 2019). Corporate image benefits extend to firm-level operations and include the cost of capital as well as the availability of capital; put a different way, this captures how risky a firm is determined to be by the market. This is substantial evidence of firm level benefits for green building investment by REITs, including evidence of lower cost of capital for mortgage debt (Devine and Yönder, 2023; Eichholtz et al., 2019) and equity (Eichholtz et al., 2018), and lower probability of default (An and Pivo, 2018).

This raises questions regarding how capital markets respond when a firm can evidence a commitment to environmental sensitivity (and, further, performance on that commitment). If capital markets treat as-agreed-upon performance as evidence of a lower risk firm, it is expected that such firms receive yield premiums or be offered higher risk capital, such as equity or unsecured debt. This result may be common and clear when the use of proceeds is transparent and measurable, such as in the case of REIT green bonds. Therefore, we examine the impact of green bonds issuance on REIT cost of capital, focusing on analysis of the green bond premium and the market reaction to the issuance of green bonds, and third-party measurement of environmental performance of bond issuers.

H2: Green bond issuing firms experience a lower cost of capital.

In addition to experiencing lower costs of capital, if investors interpret green bond issuing firms as being lower risk, they may also obtain access to a broader pool of liquidity based on corp image benefits. Existing literature on the response of equity markets to green bond issuance indicates that stock prices response positively, there is an increase in institutional ownership, and the firms experience improved liquidity, particularly following an initial green bond issuance. While these studies find no evidence of a yield premium, such findings do support the theory of access to additional and lower risk capital (Flammer, 2021; Tang and Zhang, 2020). In addition, Giambona et al. (2018) show that better quality firms separate themselves by issuing unsecured debt (Giambona et al., 2018) as it adds financial flexibility to firms (Demirci et al., 2023; Riddiough and Steiner, 2020). However, we can find no evidence of analysis regarding the impact of sustainable corporate image on firm access to capital. Given this, we look for evidence that green bond issuing REITs have access to a broader and lower risk capital pool.

H3: Green bond issuing firms gain access to a broader and lower risk capital pool, including more equity and unsecured debt.

2 Data and Methodology

We use S&P Global Market Intelligence database (a/k/a the SNL Real Estate Property dataset) for REIT characteristics and property portfolios. We obtain bond data from both S&P Global Market Intelligence and the Trade Reporting and Compliance Engine (TRACE) database. While S&P Global Market Intelligence provides us with the information about all bonds issued by U.S. REITs, Trace tracks daily trading of these bonds in the secondary markets. We merge TRACE with Market Intelligence to limit the sample to REIT bond issuance. We collect information on REIT green bond issuance from the Environmental Finance Bond Database. In the end, we merge all three databases to create a sample of all REIT bonds, including their green bonds, in both the primary and secondary bond markets.

For the 2013-2022 period, we identify LEED and Energy Star labeled buildings in the portfolios of REITs by matching the addresses of REIT-owned assets provided by SNL Real Estate with LEED and Energy Star data provided by the U.S. Green Building Council (USGBC) and the Environmental Protection Agency (EPA).[3] Using GIS techniques, we transform all addresses into longitudes and latitudes, which enables us to geographically map the different datasets, identifying matching assets.

Following Eichholtz et al. (2012), we construct a dynamic measure of portfolio greenness at the REIT level (Green Cert Share). For each REIT, we sum the square feet of all properties certified as green by either LEED or Energy Star for each year and divide the sum by the total square feet of all properties in the REIT portfolio in the same year.

To measure firm greenness and the use of green bonds, we divide REITs into four categories: 1) REITs that are not green (i.e., have a below-median share of green building certified properties in their portfolio, and do not issue green bonds in the timeline of our study); 2) REITs that are not green but start to issue green bonds; 3) REITs that are already green (i.e., have an above-median share of green building certified properties in their portfolio, but do not

[3]For details, please visit: www.usgbc.org/leed and www.energystar.gov

issue green bonds); and, 4) REITs that are green and start to issue green bonds, as well. For each of these categories we study the persistence of REIT environmental commitment after the issuance, the green bond premium, the equity market reaction to green bond issuance, and the possible changes in capital structure.

(Insert Table 1 about here)

Table 1 provides summary descriptive statistics for the firm-quarter observations in the sample. Panel A highlights that green bonds exists for 2% of firm-quarters, and the average portfolio portion that is green building certified is 14%, yet scales from 0% to 84%. Panel B indicates that the subsamples of REIT-quarters that have experienced a green bond issuance only differ statistically, in simple non-parametric analysis, on the aspects of bond spread, debt-to-asset ratio, and size. These findings foreshadow some of our later parametric analyses.

2.1 Empirical Methods

A major debate in the literature is whether the green commitments associated with a green bond stated use of proceeds are credibly implemented following the issuance of the green bond, or whether such green financing is rather greenwashing. REITs offer a excellent venue for such analysis, as the green bond commitments are overwhelmingly related to LEED and Energy Star certification of buildings.

To test this, we develop a difference-difference (DiD) style model around the issuance of bonds by REITs, either labeled as green or conventional. We track 8 quarters before any bond issuance and 12 quarters following bond issuance. We estimate the following equation:

$$GreenCertShare = f(GreenBond, GreenBond \times PostDummy, FirmCharacteristics, BondFixedEffects, TimeFixedEffects) \quad (1)$$

We use two-way fixed effects in our specification to isolate the impact of green bond issuance on green property ownership controlling for both bond and year-quarter fixed effects. Our variable of interest is $GreenBond \times PostDummy$. We expect the coefficient of this interaction term to be positive if firms keep their promises following a green bond issue.

This type of model can help us to investigate the possibility of greenwashing by REITs, by tracking the green property investment activity of the REIT following bond issuances up to three years. If a REIT acquires a green property or portfolio of properties or certifies a property with an environmental certification following its green bond issuance, this activity may add to the credibility of its commitment signal to environmental sustainability.

In addition to the two-way fixed effects DiD, we also examine a Callaway and Sant'Anna (2021) DiD model. The benefit of this methodology is that it captures the impact of micro shocks, such as when similar shocks have previously occurred in parallel markets, rendering the studied shock not completely exogenous. For example, if a new policy is introduced in California, and then a similar policy is introduced in New York two years later, the New York policy isn't a true exogenous shock. This is because those impacted by the New York policy may have expected the new policy, given it's prior introduction in California, and would be able to observe response efficacy to the California policy and incorporate that information into their own decisions. We follow the econometric procedure proposed by Callaway and Sant'Anna (2021). Our green bond data has a staggered shock structure following the first issuance of green bonds in the REIT market and the Callaway-Sant'Anna model allows us to control for these staggered shocks.

We also focus on the bond spread in the secondary markets. Our sample contains firms with no green bonds and green bonds or no green bonds at all. This allows us to control for firm fixed effects to isolate the impact of green bond issuance from time-variant unobservable firm characteristics since we evaluate bond spread in the secondary markets. We basically estimate the following equation:

$$BondSpread = f(GreenBondDummy, GreenCertShare, Bond\&FirmCharacteristics, FixedEffects) \quad (2)$$

Our variable of interest in Equation (2) is the coefficient of the *GreenBond* dummy. We expect a lower bond spread for green bonds. In some specifications, we also control for *GreenShare* to differentiate the impact of green property ownership from the green bond issuance.

We then evaluate the capital structure of REITs following the issuance of green bonds and track the possibility of a significant change in the debt-to-equity ratio (D/E Ratio) and access to the unsecured debt, measured as a proportion of total debt (Unsecured Debt Ratio).

$$D/ERatio = f(GreenBond, GreenBond \times PostDummy, FirmCharacteristics, BondFixedEffects, TimeFixedEffects) \quad (3)$$

$$UnsecuredDebtRatio = f(GreenBond, GreenBond \times PostDummy, FirmCharacteristics, BondFixedEffects, TimeFixedEffects) \quad (4)$$

3 Results

We begin by testing *H1*, exploring the relationship between green bond proceeds and environmentally-sensitive investment. Using Equation (1), we constructed a set of DiD tests estimating the relationship between REIT green bond issuance (*GB Issuance*) and investment into green building certified assets (*Green Share*). The full results tables is included in Appendix Table A1, with results summarized in Figure 3.

(Insert Figure 3 about here)

Panel A presents the traditional two-way fixed effects DiD model presented in Table A1, Column 3, and Panel B presents the Callaway-Sant'Anna DiD model. Both models cover a time horizon from two years prior until three years following the initial green bond issuance, presented quarterly, and results include 90% confidence interval markers. Both panels present models which include year (or quarter)-borrower fixed effects, thereby capturing unobservable time-varying borrower characteristics; importantly, such characteristics include the REIT's green corporate image.

For Panel A, the Y-axis presents *Green Share*, indicating that within two years of green bond issuance, there is a substantial and statistically significant increase in green building certified properties held by a REIT. This lag in the impact on *Green Share* is expected, as the three methods of increasing *Green Share* (investing in green capital improvements and subsequently earning green building certification; purchasing a green building-certified asset; or, purchasing an asset and then seeking green building certification) all require a substantial time commitment. Panel B presents the Callaway-Sant'Anna DiD results, which largely mirror those of Panel A. The notable difference here is the increase in confidence intervals, which is expected given the increased stringency of this model technique, causing both larger standard errors and the loss of some observations in the sample. Importantly, in neither model is there evidence of a pre-trend, further supporting the observed outcome that REITs issuing green bonds are subsequently investing funds into green building certification-related activities. Together, this is the first measured proof that green bonds funds are translating to environmental impact.

Turning to capital market impacts, we first examine our dataset for evidence of a green bond premium, testing *H2*. Table 2 presents results from Equation (2), for models of increasing stringency measuring the impact of green bond issuance and Green Share on the bond spread. Results indicate that issuance of a green bond is economically and statistically related to a decrease in the bond spread. This spread decreases as the model stringency increases, yet

the significance remains, which is a compelling result considering Columns (3) - (5) include time varying borrower fixed effects and all models control for trading volume. Notably, the debt-to-equity ratio decreases with the inclusion of the fixed effects, indicating a stronger reliance on equity and foreshadowing upcoming results regarding access to capital.

(Insert Table 2 about here)

The above findings are consistent with the literature on green bond spreads, evidencing that the capital markets are pricing green bonds as a signal of (financially) lower risk firms. Yet we again aim to extend past the market's measure of a firm's financial performance, looking at how capital markets measure a firm's environmental performance as well. Here the literature is also quite thin. Most notably, Kim and Pouget (2023) investigates the relationship between environmental performance and capital pricing, finding evidence of emissions penalties in capital pricing. Our study benefits from a cleaner dataset and measured outcomes rather than estimated ones. We turn to GRESB participation to add comparative environmental performance to our bond yield analysis.

Within the real estate industry, GRESB (formerly the Global Real Estate Sustainability Benchmark) serves as the preeminent sustainability reporting and benchmarking scheme.[4] The primary goal of GRESB is the provision of sustainability performance metrics for real estate firms to investors. The scheme measures real estate firm in three categories: performance; management; and, (where applicable) development. Given the dominance of green building activity in real estate firm sustainability efforts, green building certification is the single largest component of the GRESB score, comprising approximately 10% of the total score.

(Insert Table 3 about here)

In Table 3, we re-estimate the analysis completed in Table 2, with propensity score weights matching GRESB participating firms with non-GRESB participating firms; as with the prior

[4]For details, see: www.gresb.com

analysis, models include bond-clustered robust standard errors. Through this, we quantify the impact of GRESB reporting, which allows investors to tease out sustainably-committed REITs from their similar, yet less sustainably focused, counterparts. While the magnitude of the results weakens slightly, particularly in the most stringent models, the decrease in bond spread remains. This indicates that investors may not only be interpreting the commitment to sustainability as a signal of lower risk, but also the performance of sustainability as well.

With evidence of a lower bond spread confirmed, including early signs of a move toward greater proportions of equity funding associated with green bond issuance, we turn to analysis of the types of capital utilized by REITs subsequent to green bond issuance, testing *H3*. We first examine the impact of green bond issuance on REIT debt-to-equity ratio, following Equation (3). Full results tables is included in Appendix Table A2, with results summarized in Figure 4.

(Insert Figure 4 about here)

Panel A highlights an adjustment in capital sourcing in the two-way fixed effects DiD model, with a move toward more equity in the years following a green bond issuance. As with the environmental investment analysis, the trend toward a change in capital stack begins after issuance, with no evidence of pretrend, but is not statistically significant until almost two years after the green bond issuance. The reasoning for this could be similar to that regarding observed changes in environmental performance: changes in the the capital sourcing for a REIT take time to institute. Notably, in the Panel B Callaway Sant'Anna DiD analysis, the results are much noisier, yet statistical significance is also observed as of quarter 8.

(Insert Figure 5 about here)

A similar analysis is completed, following Equation (4) and changing out the debt-to-equity ratio for the unsecured debt-to-total debt ratio; full results tables is included in Appendix Table A3, with results summarized in Figure 5. Unlike the debt-to-equity analysis, both

DiD analyses provide little evidence indicating a move toward more unsecured debt. Taking Figures 4 and 5 together, along with the supporting evidence from Table 2, results indicate that capital markets are offering green bond issuers greater access to equity, aligning with the literature Flammer (2021); Tang and Zhang (2020).

4 Conclusion

The core difference between a green bond and a conventional bond is how the funds raised from a bond sale (a/k/a the use of proceeds) are utilized: in a green bond, those funds are earmarked for climate related or environmentally beneficial projects. There have been many studies on green bond yield premiums (Baker et al., 2018; Zerbib, 2019) and discounts (Karpf and Mandel, 2017), and the response of the equity markets to green bond issuance (Flammer, 2021; Tang and Zhang, 2020). Yet while there is a growing literature investigating the financial performance of green bonds, both academia and the industry are largely silent on the measurement of environmental performance. Amidst an increased focus on greenwashing activities - the practice of conveying misleading information about a company's commitment to environment - the need to understand both the financial and environmental performance of green bonds is evident.

We leverage the REIT market as a laboratory to measure environmental investment activity following green bond issuance, providing some of the first insights into this space. We then look to capital market response to green bond issuance, measuring both the impact to bond spread and the change in REIT capital structure following green bond issuance. While the literature has largely shied away from this topic, likely due to the difficulty in measuring environmental performance, our analysis benefits from the clean measurement of green investment by REITs predominantly into green building certification-related activities, and from stringent models which include time varying borrower effects.

Our results indicate that REITs which issue a green bond do show an economically and statistically significant increase in the environmental performance of their assets within two years following green bond issuance. Additionally, there is persistent evidence of a decreased bond spread for REITs that issue green bonds, as well as evidence that such REITs re-balance their capital toward heavier equity components also within the two years following green bond issuance.

References

An, Xudong, and Gary Pivo, 2018, Green buildings in commercial mortgage-backed securities: The effects of leed and energy star certification on default risk and loan terms, *Real Estate Economics* 48, 7–42.

Baker, Malcolm P., Daniel B. Bergstresser, George Serafeim, and Jeffrey A. Wurgler, 2018, Financing the response to climate change: The pricing and ownership of u.s. green bonds, *SSRN Electronic Journal* .

Bhutta, Umair Saeed, Adeel Tariq, Muhammad Farrukh, Ali Raza, and Muhammad Khalid Iqbal, 2022, Green bonds for sustainable development: Review of literature on development and impact of green bonds, *Technological Forecasting and Social Change* 175, 121378.

Callaway, Brantly, and Pedro H.C. Sant'Anna, 2021, Difference-in-differences with multiple time periods, *Journal of Econometrics* 225, 200–230.

Clayton, Jim, Avis Devine, and Rogier Holtermans, 2021, Beyond building certification: The impact of environmental interventions on commercial real estate operations, *Energy Economics* 93, 105039.

Demirci, Irem, Mehdi Rasteh, and Erkan Yönder, 2023, Unpledged collateral, reit liquidity constraints, and asset sales, *Journal of Real Estate Finance and Economics* 39–60, Forthcoming.

Devine, Avis, and Nils Kok, 2015, Green certification and building performance: Implications for tangibles and intangibles, *Journal of Portfolio Management* 41, 151–163.

Devine, Avis, and Meagan McCollum, 2022, Advancing energy efficiency through green bond policy: Multifamily green mortgage backed securities issuance, *Journal of Cleaner Production* 345, 131019.

Devine, Avis, and Meagan McCollum, 2024, Assessing the environmental performance of green MBS Working Paper.

Devine, Avis, and Erkan Yönder, 2023, Impact of environmental investments on corporate financial performance: Decomposing valuation and cash flow effects, *Journal of Real Estate Finance and Economics* 66, 778–805.

Eichholtz, Piet, Peter Barron, and Erkan Yönder, 2018, Sustainable reits : Reit environmental performance and the cost of equity, *The Routledge REITs Research Handbook* 77–94.

Eichholtz, Piet, Rogier Holtermans, Nils Kok, and Erkan Yönder, 2019, Environmental performance and the cost of debt: Evidence from commercial mortgages and reit bonds, *Journal of Banking and Finance* 102, 19–32.

Eichholtz, Piet, N Kok, and J M Quigley, 2010, Doing well by doing good? green office buildings, *The American Economic Review* 100, 2494–2511.

Eichholtz, Piet, Nils Kok, and John M Quigley, 2013, The economics of green building, *Review of Economics and Statistics* 95, 50–63.

Eichholtz, Piet, Nils Kok, and Erkan Yönder, 2012, Portfolio greenness and the financial performance of reits, *Journal of International Money and Finance* 31, 1911–1929.

Flammer, Caroline, 2021, Corporate green bonds, *Journal of Financial Economics* 142, 499–516.

Fuerst, Franz, and Patrick McAllister, 2011, Green noise or green value? measuring the effects of environmental certification on office values, *Real Estate Economics* 39, 45–69.

Giambona, Erasmo, Antonio S. Mello, and Timothy J. Riddiough, 2018, Real assets, collateral and the limits of debt capacity, *Real Estate Economics* 46, 836–886.

Heffernan, Troy W., Emma E. Heffernan, Nina Reynolds, Wai Jin Lee, and Paul Cooper, 2021, Towards an environmentally sustainable rental housing sector, *Housing Studies* 36, 397–420.

Holtermans, Rogier, and Nils Kok, 2019, On the value of environmental certification in the commercial real estate market, *Real Estate Economics* 47, 637–642.

Karpf, Andreas, and Antoine Mandel, 2017, Does it pay to be green?

Kats, Greg, 2010, *Greening Our Built World: Costs, Benefits, and Strategies* (Island Press).

Kim, Daniel, and Sebastien Pouget, 2023, Do carbon emissions affect the cost of capital? primary versus secondary corporate bond markets, *SSRN Electronic Journal* .

Larcker, David F., and Edward M. Watts, 2020, Where's the greenium?, *Journal of Accounting and Economics* 69, 101312.

MacAskill, Stefen, Rodney A. Stewart, Eduardo Roca, Benjamin Liu, and Oz Sahin, 2021, Green building, split-incentives and affordable rental housing policy, *Housing Studies* 36, 23–45.

McWilliams, A, and D Siegel, 2001, Corporate social responsibility: A theory of the firm perspective, *Academy of management Review* 26, 117–127.

Newsham, Guy R, Sandra Mancini, and Benjamin J Birt, 2009, Do leed-certified buildings save energy? yes, but. . . , *Energy and Buildings* 41, 897–905.

Riddiough, Timothy J., and Eva Steiner, 2020, Financial Flexibility and Manager–Shareholder Conflict: Evidence from REITs, *Real Estate Economics* 48, 200–239.

Scofield, John H, 2013, Efficacy of leed-certification in reducing energy consumption and greenhouse gas emission for large new york city office buildings, *Energy and Buildings* 67, 517–524.

Seltzer, Lee H., Laura Starks, and Qifei Zhu, 2022, Climate regulatory risk and corporate bonds NBER Working Paper.

Tang, Dragon Yongjun, and Yupu Zhang, 2020, Do shareholders benefit from green bonds?, *Journal of Corporate Finance* 61, 101427.

Zerbib, Olivier David, 2019, The effect of pro-environmental preferences on bond prices: Evidence from green bonds, *Journal of Banking and Finance* 98, 39–60.

5 Tables and Figures

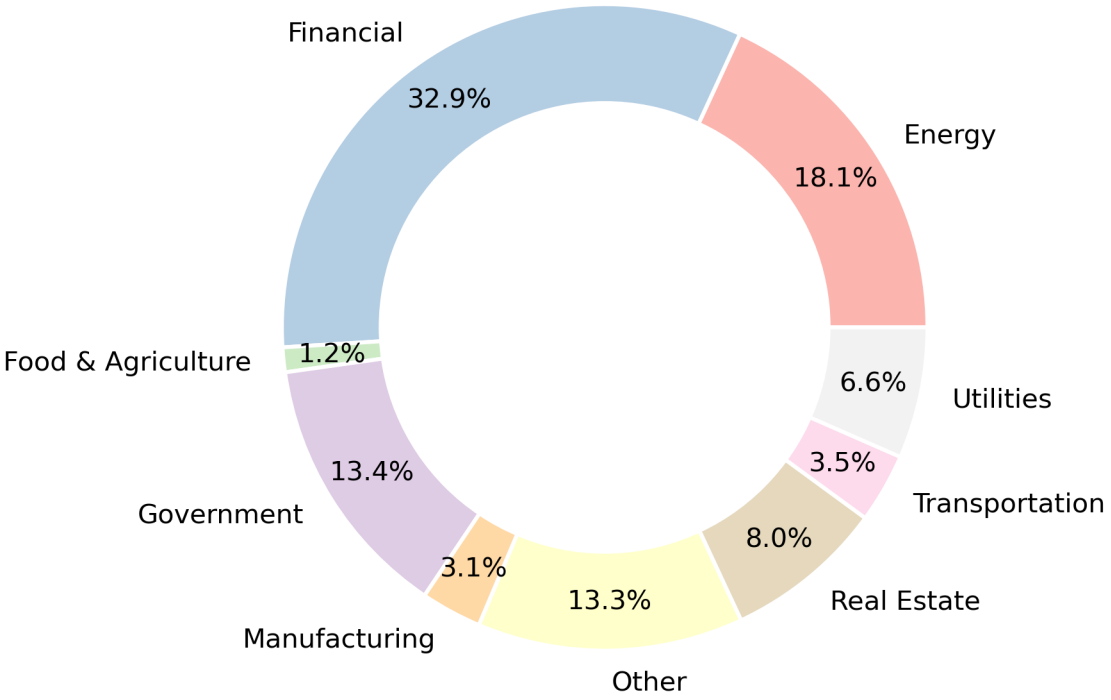


Figure 1. Global Green Bonds Outstanding 2022, by Issuer Industry

This figure presents the proportion of global green bond value in existence in 2022 across the industries of the issuing firm. Data is collected from the Environmental Finance Data bond data.

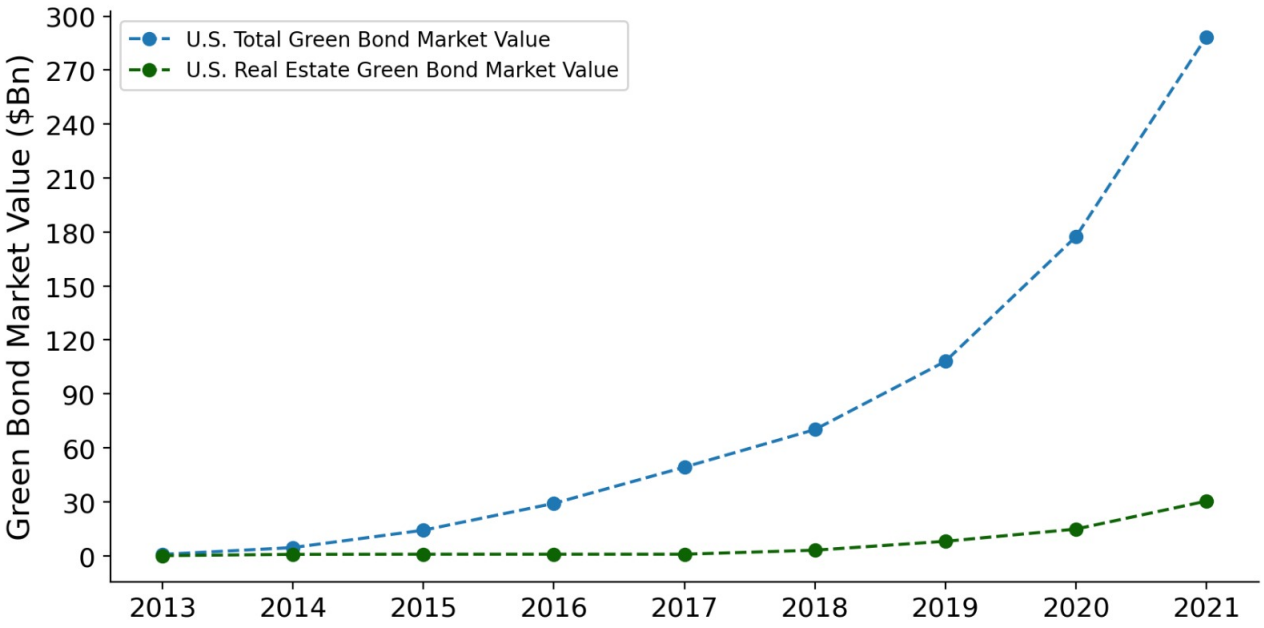
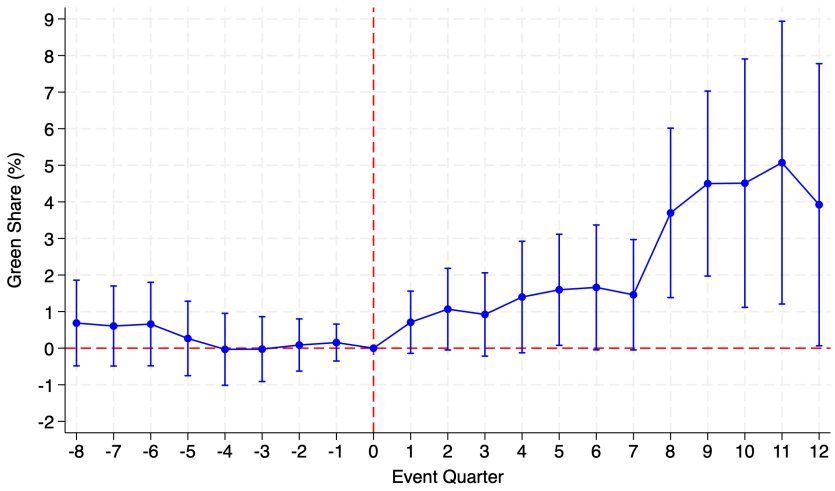
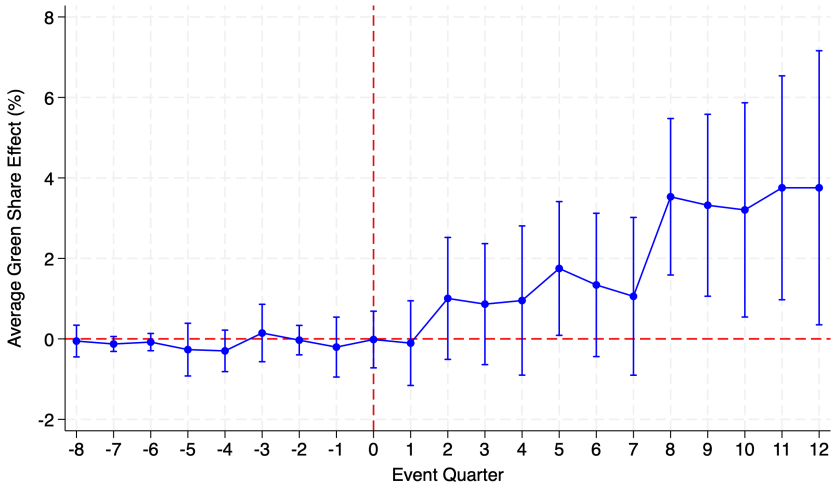


Figure 2. U.S. Green Bond Issuance Over Time

This figure presents the total annual issuance of green bonds, in billions of USD, in the U.S. from 2013 through 2021. The blue line presents total green bond issuance, and the green line presents total real estate estate green bond issuance.



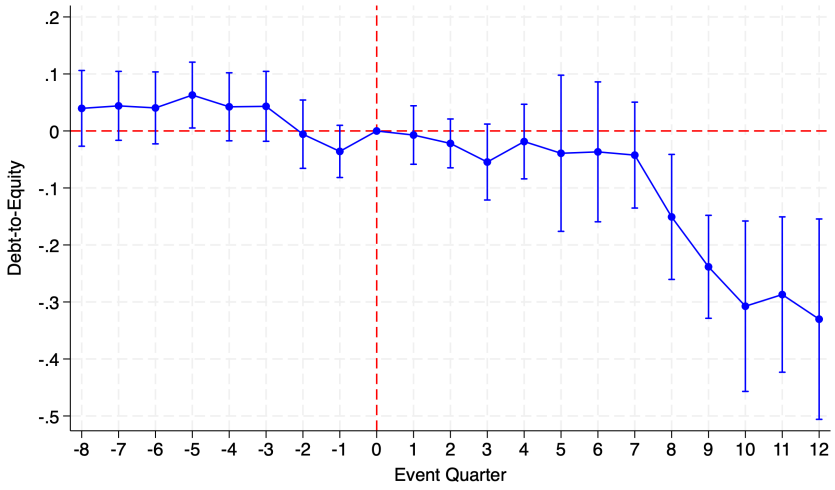
(a) Two-Way Fixed Effects Difference in Difference



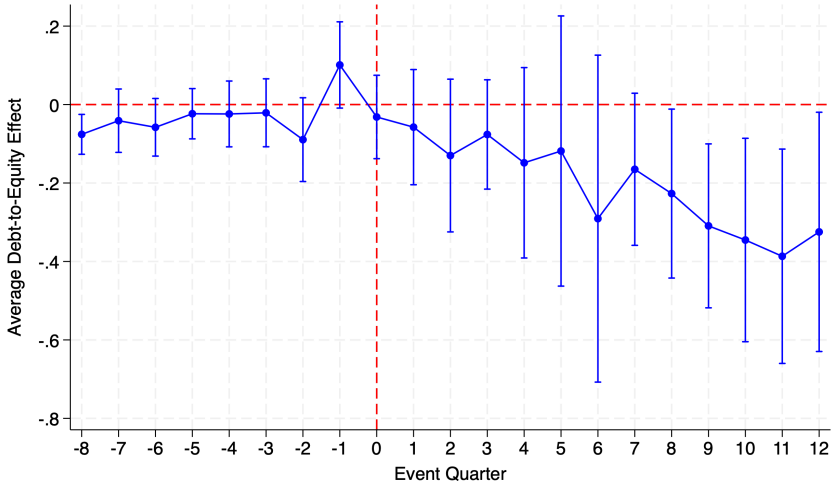
(b) Callaway Sant'Anna Difference in Difference

Figure 3. Differential Impact of Green Bond Issuance on Green Share

The figure shows the change in the differential impact of green bond issuance on Green Share. The 90% confidence intervals are shown in the figure.



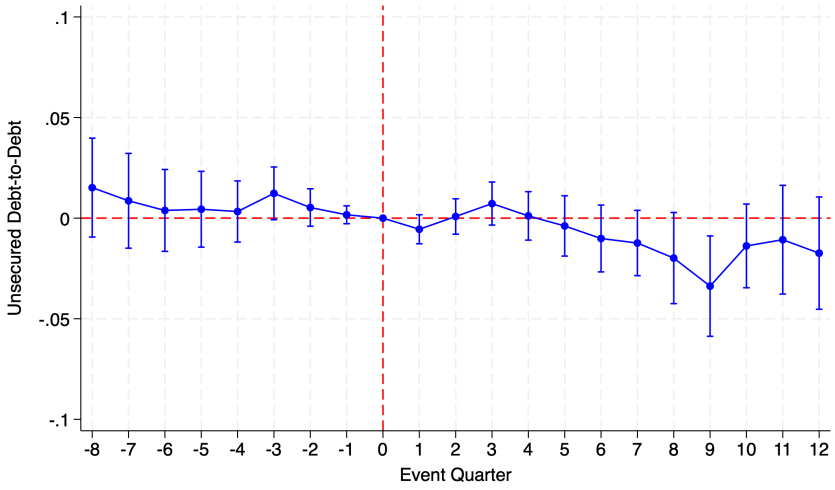
(a) Two-Way Fixed Effects Difference in Difference



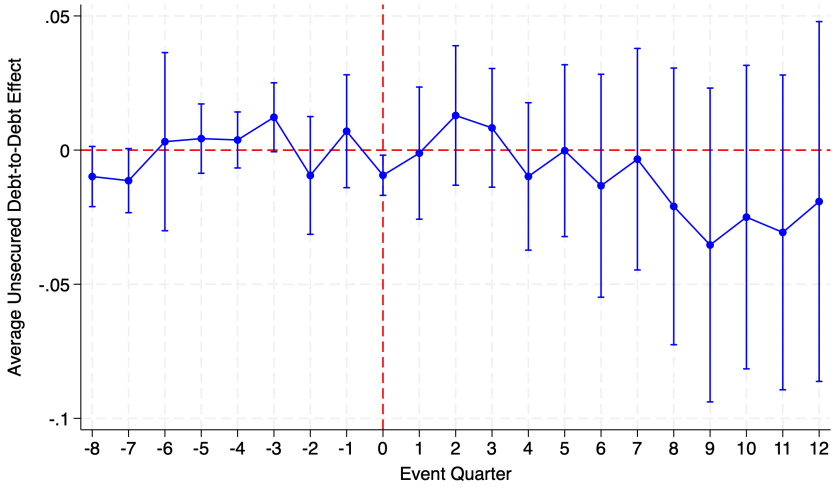
(b) Callaway Sant'Anna Difference in Difference

Figure 4. Differential Impact of Green Bond Issuance on Debt-to-Equity Ratio

The figure shows the change in the differential impact of green bond issuance on debt-to-equity ratio. The 90% confidence intervals are shown in the figure.



(a) Two-Way Fixed Effects Difference in Difference



(b) Callaway Sant'Anna Difference in Difference

Figure 5. Differential Impact of Green Bond Issuance on Unsecured Debt-to-Debt Ratio

The figure shows the change in the differential impact of green bond issuance on unsecured debt-to-debt ratio. The 90% confidence intervals are shown in the figure.

Table 1. Descriptive Statistics

Panel A - Summary Statistics

Variables	N	Mean	SD	Min	Max
Green Bond (1=yes)	11,144	0.02	0.14	0.00	1.00
Green Share (%)	11,144	0.14	0.18	0.00	0.84
Bond Spread (%)	11,144	1.73	1.74	-2.26	50.25
Ln(Bond Origination Amount)	11,144	12.80	0.52	10.71	14.15
Quarters since Bond Origination	11,144	14.14	9.71	1.00	48.00
Ln(Bond Trading Volume)	11,144	8.85	1.15	1.76	12.93
Debt-to-Assets (%)	11,144	50.40	11.27	7.34	84.74
Unsecured Debt-to-Total Debt (%)	11,031	78.63	15.89	0.00	100.37
Ln(Assets)	11,144	23.03	0.76	20.75	24.49
Market-to-Book (%)	11,144	1.58	0.47	0.71	4.47
Return-on-Assets (%)	11,140	0.78	1.06	-8.57	17.52

Panel B - Comparison of Green Bond Issuers vs. Non-Green Bond Issuers

	Green Bond		Equality of Means
Variables	Yes	No	t-Statistics
Green Bond (1=yes)	0.05	0.00	-4.25***
	[0.01]	[0.01]	
Green Share (%)	0.13	0.14	0.13
	[0.05]	[0.04]	
Bond Spread (%)	1.29	2.07	2.17**
	[0.28]	[0.22]	
Ln(Bond Origination Amount)	12.88	12.74	-1.07
	[0.10]	[0.08]	
Quarters since Bond Origination	14.27	14.04	-0.19
	[0.93]	[0.73]	
Ln(Bond Trading Volume)	8.86	8.83	-0.20
	[0.13]	[0.10]	
Debt-to-Assets (%)	45.83	54.02	2.49**
	[2.60]	[2.02]	
Unsecured Debt-to-Total Debt (%)	77.84	79.27	0.31
	[3.61]	[2.83]	
Ln(Assets)	23.36	22.76	-2.62**
	[0.18]	[0.14]	
Market-to-Book (%)	1.64	1.53	-0.78
	[0.11]	[0.09]	
Return-on-Assets (%)	0.84	0.73	-0.64
	[0.12]	[0.10]	

This table provides descriptive statistics for the full sample of REIT-quarter observations. Panel A presents summary statistics on the main variables. Panel B presents the average value of each variable for the green bond issuing and non-green bond issuing subsamples, followed by a t-statistic test capturing if these values are statistically differentiated. Significance is indicated as follows: * p<0.1; ** p<0.05; *** p<0.01.

Table 2. Bond Spread of Green Bonds

VARIABLES	Bond Spread				
	(1)	(2)	(3)	(4)	(5)
Green Bond (1=yes)	-0.164***	-0.163***	-0.188***	-0.185***	-0.143***
	(0.045)	(0.045)	(0.036)	(0.036)	(0.036)
ln(Bond Origination Amount)	0.134**	0.134**	0.079	0.081	0.001
	(0.055)	(0.055)	(0.053)	(0.053)	(0.039)
Quarters since Bond Origination	-0.010***	-0.010***	-0.016***	-0.016***	-0.015***
	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)
ln(Assets)	0.012	0.013	-0.208	-0.174	
	(0.164)	(0.171)	(0.397)	(0.381)	
Debt-to-Assets	0.038***	0.038***	-0.060*	-0.060*	
	(0.007)	(0.007)	(0.032)	(0.032)	
Market-to-Book	-0.347***	-0.347***	1.154***	1.178***	
	(0.108)	(0.108)	(0.259)	(0.256)	
Green Share		0.070		-2.849***	
		(0.561)		(0.937)	
ln(Bond Trading Volume)	-0.023	-0.023	-0.019	-0.020	-0.047***
	(0.019)	(0.019)	(0.028)	(0.028)	(0.014)
Constant	Yes	Yes	Yes	Yes	Yes
Borrower Asset Type FE	Yes	Yes	Yes	Yes	Yes
Borrower FE	Yes	Yes	–	–	–
Year-Quarter FE	Yes	Yes	–	–	–
Year×Borrower FE	–	–	Yes	Yes	–
Year-Quarter×Borrower FE	–	–	–	–	Yes
Observations	11,144	11,144	11,126	11,126	10,756
Adj. R-squared	0.615	0.615	0.809	0.810	0.912

Propensity-score-weighted and bond-clustered robust standard errors are reported in parentheses. Significance is indicated as follows: * p<0.1; ** p<0.05; *** p<0.01.

Table 3. Robustness: Bond Spread of Green Bonds
Propensity-Score Matching on GRESB Participation

VARIABLES	Bond Spread		
	(1)	(2)	(3)
Green Bond (1=yes)	-0.151***	-0.156***	-0.089**
	(0.045)	(0.047)	(0.043)
ln(Bond Origination Amount)	0.019	0.020	-0.096***
	(0.047)	(0.047)	(0.034)
Quarters since Bond Origination	-0.008*	-0.007*	-0.013***
	(0.004)	(0.004)	(0.003)
ln(Assets)	-0.455*	-0.449*	
	(0.252)	(0.251)	
Debt-to-Assets	0.023*	0.023*	
	(0.013)	(0.013)	
Market-to-Book	-0.552***	-0.557***	
	(0.135)	(0.139)	
Green Share		-1.069	
		(0.961)	
ln(Bond Trading Volume)	-0.004	-0.003	-0.035**
	(0.026)	(0.026)	(0.017)
Constant	Yes	Yes	Yes
Borrower Asset Type FE	Yes	Yes	Yes
Borrower FE	Yes	Yes	–
Year FE	Yes	Yes	–
Year×Borrower FE	–	–	Yes
Observations	2,006	2,006	1,950
Adj. R-squared	0.579	0.579	0.911

Propensity-score-weighted and bond-clustered robust standard errors are reported in parentheses. Significance is indicated as follows: * p<0.1; ** p<0.05; *** p<0.01.

Appendix

Table A1. Impact of Green Bond Issuance on Green Share

VARIABLES	Green Share					
	(1)	(2)	(3)	(4)	(5)	(6)
Green Bond (1=yes)						
× *Post*	1.615*	1.505*				
	(0.836)	(0.837)				
× *Quarter t+1*			0.520	0.492	0.732	0.717
			(0.759)	(0.785)	(0.488)	(0.522)
× *Quarter t+2*			0.870	0.881	1.080*	1.100
			(0.904)	(0.941)	(0.628)	(0.685)
× *Quarter t+3*			0.775	0.729	0.978	0.942
			(0.899)	(0.942)	(0.642)	(0.696)
× *Quarter t+4*			1.215	1.246	1.414*	1.457
			(1.088)	(1.160)	(0.858)	(0.941)
× *Quarter t+5*			1.386	1.441	1.586*	1.648*
			(1.116)	(1.135)	(0.880)	(0.899)
× *Quarter t+6*			1.591	1.522	1.789*	1.727*
			(1.210)	(1.229)	(0.997)	(1.013)
× *Quarter t+7*			1.453	1.317	1.643*	1.512*
			(1.095)	(1.093)	(0.898)	(0.896)
× *Quarter t+8*			3.680***	3.544**	3.870***	3.741***
			(1.404)	(1.374)	(1.423)	(1.404)
× *Quarter t+9*			4.577***	4.199***	4.766***	4.393***
			(1.543)	(1.470)	(1.587)	(1.548)
× *Quarter t+10*			4.655**	4.133**	4.850**	4.337**
			(2.067)	(1.991)	(2.115)	(2.075)
× *Quarter t+11*			5.336**	4.669**	5.528**	4.870**
			(2.234)	(2.269)	(2.307)	(2.376)
× *Quarter t+12*			4.395*	3.337	4.617**	3.563
			(2.490)	(2.454)	(2.318)	(2.335)

Table continued on next page.

Table A1. Impact of Green Bond Issuance on Green Share (Continued)

VARIABLES	Green Share					
	(1)	(2)	(3)	(4)	(5)	(6)
Green Bond (1=yes)						
× *Quarter t-1*					0.126	0.123
					(0.288)	(0.306)
× *Quarter t-2*					0.123	0.101
					(0.404)	(0.430)
× *Quarter t-3*					0.001	-0.035
					(0.513)	(0.537)
× *Quarter t-4*					-0.016	-0.003
					(0.573)	(0.585)
× *Quarter t-5*					0.247	0.253
					(0.609)	(0.621)
× *Quarter t-6*					0.629	0.636
					(0.681)	(0.707)
× *Quarter t-7*					0.528	0.589
					(0.664)	(0.671)
× *Quarter t-8*					0.567	0.708
					(0.699)	(0.707)
ln(Assets)		0.930		0.471		0.513
		(1.202)		(1.090)		(1.087)
Market-to-Book		-0.827		-0.624		-0.573
		(0.925)		(0.856)		(0.858)
Debt-to-Assets		-0.073		-0.054		-0.054
		(0.052)		(0.053)		(0.053)
Constant	Yes	Yes	Yes	Yes	Yes	Yes
Bond FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Event-Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	10,419	9,442	10,419	9,442	10,419	9,442
Adj. R-squared	0.987	0.987	0.987	0.987	0.987	0.988

Propensity-score-weighted and bond-clustered robust standard errors are reported in parentheses. Significance is indicated as follows: * p<0.1; ** p<0.05; *** p<0.01.

Table A2. Impact of Green Bond Issuance on Borrower Debt-to-Equity

VARIABLES	Debt-to-Equity					
	(1)	(2)	(3)	(4)	(5)	(6)
Green Bond (1=yes)						
× *Post*	-0.829	-0.086**				
	(0.649)	(0.043)				
× *Quarter t+1*			-1.611**	-0.029	-1.440	-0.007
			(0.725)	(0.047)	(1.037)	(0.031)
× *Quarter t+2*			-1.745**	-0.043	-1.582	-0.022
			(0.743)	(0.041)	(1.337)	(0.026)
× *Quarter t+3*			0.736	-0.075	0.881	-0.055
			(1.643)	(0.049)	(1.981)	(0.040)
× *Quarter t+4*			2.684	-0.039	2.837	-0.019
			(2.125)	(0.043)	(2.432)	(0.040)
× *Quarter t+5*			-0.863	-0.060	-0.689	-0.039
			(0.770)	(0.082)	(1.339)	(0.083)
× *Quarter t+6*			-0.612	-0.057	-0.457	-0.037
			(1.348)	(0.074)	(1.738)	(0.075)
× *Quarter t+7*			-1.787**	-0.061	-1.633	-0.042
			(0.704)	(0.055)	(1.293)	(0.056)
× *Quarter t+8*			-2.607***	-0.170**	-2.451*	-0.151**
			(0.732)	(0.068)	(1.297)	(0.067)
× *Quarter t+9*			-2.277***	-0.258***	-2.109*	-0.238***
			(0.651)	(0.059)	(1.266)	(0.055)
× *Quarter t+10*			-2.217***	-0.326***	-2.070	-0.307***
			(0.611)	(0.095)	(1.283)	(0.091)
× *Quarter t+11*			-2.203***	-0.306***	-2.045	-0.287***
			(0.630)	(0.087)	(1.315)	(0.083)
× *Quarter t+12*			-2.031***	-0.349***	-1.882	-0.330***
			(0.582)	(0.111)	(1.230)	(0.107)

Table continued on next page.

Table A2. Impact of Green Bond Issuance on Borrower Debt-to-Equity (Continued)

VARIABLES	Debt-to-Equity					
	(1)	(2)	(3)	(4)	(5)	(6)
Green Bond (1=yes)						
× *Quarter t-1*					-1.134	-0.036
					(1.342)	(0.028)
× *Quarter t-2*					1.108	-0.006
					(2.215)	(0.036)
× *Quarter t-3*					1.397	0.043
					(1.979)	(0.037)
× *Quarter t-4*					0.280	0.042
					(1.467)	(0.036)
× *Quarter t-5*					0.081	0.063*
					(1.847)	(0.035)
× *Quarter t-6*					-0.721	0.040
					(1.324)	(0.038)
× *Quarter t-7*					0.780	0.044
					(1.906)	(0.037)
× *Quarter t-8*					-0.380	0.040
					(1.287)	(0.040)
ln(Assets)		-0.474***		-0.431***		-0.428***
		(0.078)		(0.068)		(0.068)
Market-to-Book		-0.440***		-0.460***		-0.459***
		(0.084)		(0.085)		(0.086)
Green Share		0.254		0.508		0.497
		(0.447)		(0.476)		(0.474)
Constant	Yes	Yes	Yes	Yes	Yes	Yes
Bond FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Event-Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	12,871	9,612	12,871	9,612	12,871	9,612
Adj. R-squared	-0.002	0.898	-0.002	0.899	-0.002	0.899

Propensity-score-weighted and bond-clustered robust standard errors are reported in parentheses. Significance is indicated as follows: * p<0.1; ** p<0.05; *** p<0.01.

Table A3. Impact of Green Bond Issuance on Borrower Unsecured Debt-to-Debt

VARIABLES	Unsecured Debt-to-Debt					
	(1)	(2)	(3)	(4)	(5)	(6)
Green Bond (1=yes)						
× *Post*	-0.004	-0.011				
	(0.009)	(0.010)				
× *Quarter t+1*			-0.004	-0.011	-0.003	-0.006
			(0.006)	(0.007)	(0.002)	(0.004)
× *Quarter t+2*			-0.001	-0.005	-0.000	0.001
			(0.008)	(0.008)	(0.005)	(0.005)
× *Quarter t+3*			0.005	0.002	0.005	0.007
			(0.008)	(0.009)	(0.006)	(0.006)
× *Quarter t+4*			0.003	-0.004	0.004	0.001
			(0.009)	(0.010)	(0.007)	(0.007)
× *Quarter t+5*			-0.002	-0.009	-0.001	-0.004
			(0.010)	(0.012)	(0.008)	(0.009)
× *Quarter t+6*			-0.004	-0.016	-0.003	-0.010
			(0.012)	(0.013)	(0.009)	(0.010)
× *Quarter t+7*			-0.007	-0.018	-0.007	-0.012
			(0.011)	(0.013)	(0.009)	(0.010)
× *Quarter t+8*			-0.018	-0.025	-0.017	-0.020
			(0.014)	(0.017)	(0.012)	(0.014)
× *Quarter t+9*			-0.021	-0.039**	-0.020	-0.034**
			(0.017)	(0.018)	(0.014)	(0.015)
× *Quarter t+10*			-0.008	-0.019	-0.007	-0.014
			(0.017)	(0.015)	(0.014)	(0.013)
× *Quarter t+11*			-0.009	-0.016	-0.008	-0.011
			(0.017)	(0.018)	(0.015)	(0.016)
× *Quarter t+12*			-0.009	-0.023	-0.009	-0.017
			(0.019)	(0.018)	(0.016)	(0.017)

Table continued on next page.

Table A3. Impact of Green Bond Issuance on Borrower Unsecured Debt-to-Debt (Continued)

VARIABLES	Unsecured Debt-to-Debt					
	(1)	(2)	(3)	(4)	(5)	(6)
Green Bond (1=yes)						
× *Quarter t-1*					-0.002	0.002
					(0.003)	(0.003)
× *Quarter t-2*					0.000	0.005
					(0.006)	(0.006)
× *Quarter t-3*					0.004	0.012
					(0.007)	(0.008)
× *Quarter t-4*					0.002	0.003
					(0.010)	(0.009)
× *Quarter t-5*					-0.000	0.004
					(0.010)	(0.011)
× *Quarter t-6*					-0.003	0.004
					(0.011)	(0.012)
× *Quarter t-7*					-0.002	0.009
					(0.013)	(0.014)
× *Quarter t-8*					0.007	0.015
					(0.013)	(0.015)
ln(Assets)		-0.013		-0.011		-0.011
		(0.020)		(0.020)		(0.021)
Market-to-Book		0.002		0.001		0.002
		(0.014)		(0.014)		(0.014)
Green Share		0.089		0.105		0.104
		(0.095)		(0.092)		(0.092)
Constant	Yes	Yes	Yes	Yes	Yes	Yes
Bond FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Event-Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	12,815	9,556	12,815	9,556	12,815	9,556
Adj. R-squared	0.900	0.916	0.900	0.917	0.900	0.917

Propensity-score-weighted and bond-clustered robust standard errors are reported in parentheses. Significance is indicated as follows: * p<0.1; ** p<0.05; *** p<0.01.