Green Bonds: Commitment to Sustainability under Asymmetric Information

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Abstract

This paper studies whether green bonds mitigate information asymmetries about issuers' exposure to climate risks through a signaling mechanism. Green bonds are debt instruments in which issuers commit to investing proceeds in sustainable projects. Using a novel identification strategy that controls for standard effects of debt announcements, this paper shows that green bond announcements result higher equity valuations and lower yields on extant bonds, particularly at longer maturities. Issuers also become less sensitive to climate change concerns. The results suggest that markets view green bonds as credible signals of commitment and reduced climate risk exposure.

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1 Introduction

Climate change is widely viewed as posing a growing threat to our planet, with extreme weather events and rising sea levels becoming more frequent and severe. Regulatory authorities are under increasing pressure to address climate change and implement necessary regulations to reduce emissions and foster sustainable practices. As a result, climate risks, which encompass potential costs associated with climate regulations as well as broader physical and transition risks, have gained significant importance in financial markets (Krueger et al., 2020; Giglio et al., 2021; Bolton and Kacperczyk, 2021, 2023b). However, markets suffer from information asymmetries regarding a firm's "greenness" and its exposure to climate risks (Ilhan et al., 2023). This paper investigates whether green bonds mitigate information asymmetries about the issuer's exposure to climate risks through a signaling mechanism.

Green bonds are debt instruments where the issuer commits to investing the proceeds in sustainable projects. Typically, these projects have to fulfill specific standards, and issuers are required to provide ongoing reporting on the allocation of the funds and third party verification.[1] Thereby, green bonds substantially limit the issuer's flexibility, as any deviation from green project implementation can result in the loss of the green label and reputational damage.[2] Prior research provides evidence for the effectiveness of commitments through green bonds, highlighting that issuers have been found to improve their environmental performance (Flammer, 2021; Fatica and Panzica, 2021; Lu, 2023; ElBannan and Löffler, 2024).[3] Survey evidence by Sangiorgi and Schopohl (2023) further suggests that signaling to

[1]For example, the framework by the Climate Bond Initiative (CBI, 2024) has been widely used in markets over the past decade. Their framework aligns "greenness" with projects that advance a net-zero emission economy and protect the environment.

[2]The Financial Times reported on a green bond issued by Repsol that failed to meet CBI requirements, resulting in exclusion from major green bond indices (Hale, 2018b), which can significantly affect investor demand for the bond and damage the issuer's reputation.

[3]This evidence is particularly significant among non-financial firms. In contrast, studies that include financial issuers, such as Aswani and Rajgopal (2024) and Bhagat and Yoon (2023), report nonsignificant effects. This highlights the importance of distinguishing between financial and non-financial green bond

the market is a leading motivation for issuing green bonds. Together, these findings point to green bonds as credible signals for the issuer's commitment, implying a reduced exposure to climate risks for the assets underlying the green bond.

While theory supports the idea that reducing information asymmetries through credible signals can be beneficial (Ross, 1977; Leland and Pyle, 1977; Myers and Majluf, 1984), empirical evidence on green bonds' valuation effects remain inconclusive. Evidence on stock market reactions is mixed (Flammer, 2021; Aswani and Rajgopal, 2024), as is the literature on the "green bond premium," which is the yield spread between green and conventional bonds (Zerbib, 2019; Larcker and Watts, 2020). This paper offers a novel empirical identification strategy to estimate the impact of green bonds and study whether they mitigate information asymmetries about issuers' exposure to climate risks.

The empirical analysis is structured in two steps. First, I examine how green bond announcements affect the issuer's existing bonds and equity, using a prior comparable conventional bond announcement by the same issuer as a benchmark. Essentially, the analysis employs a triple difference approach on extant bond yields and examines differences in cumulative abnormal stock returns around bond announcements, a novel approach in the green bond literature. By comparing green and conventional bond announcements by the same issuer, the methodology controls for the standard negative effects of debt announcements on both equity (Dann and Mikkelson, 1984; Eckbo et al., 2007; Howton et al., 1998) and bonds (Chen and Stock, 2018), which may vary across issuers (Bayless and Chaplinsky, 1991).

Second, I test the signaling mechanism directly by assessing whether the issuer's sensitivity to climate risks changes after the green bond announcement. I proxy sensitivity using the relationship between stock return volatility and climate concern shocks, estimated using the Media Climate Change Concern Index (MCCC) developed by Ardia et al. (2023). Volatility has been previously linked to information asymmetries (Kacperczyk and Pagnotta, 2019). The idea is that an increase in volatility in response to a climate concern shock indicates

issuers, which this paper will explore further.

investor uncertainty about the firm's climate risk exposure.

In the first step, empirical results show that green bond announcements are associated with lower yields on the issuer's extant bonds and positive stock market reactions, particularly for non-financial firms. For non-financial issuers, yields on extant bonds with maturities above 10 years decline by approximately 7 basis points (bps), and cumulative abnormal equity returns reach 1.5% over a five day event window. The effects on bond yields are concentrated at the longer end of the maturity spectrum, where climate risks are more likely to materialize (Painter, 2020), and among riskier firms, where information asymmetries are likely more pronounced and green bonds can therefore serve as a more informative signal. In contrast, financial issuers experience no significant valuation effects. A likely explanation are credibility concerns: while non-financial firms typically invest proceeds in physical assets that are difficult to reallocate, financial firms often fund green loans that can be more easily redirected after the bond's maturity.

In the second step, results show that climate risk sensitivity, proxied by the relationship of climate concern shocks and stock return volatility, declines following green bond announcements. In contrast, peer firms that did not issue green bonds exhibit no change in sensitivity over the same time periods. Taken together, the observed market reactions in the first step and the decline in climate risk sensitivity in the second step provide strong empirical support for the view that markets understand green bonds as a credible signal of reduced exposure to climate risks.

This paper contributes to the broad literature on information asymmetries in financial markets and the role of signaling to mitigate them. Seminal works, such as Leland and Pyle (1977) and Myers and Majluf (1984), show theoretically how different financing options are affected by adverse selection and point to the financing choice as a signal of managers' private information. In the context of climate finance, recent work has studied how the disclosure of environmental information, such as carbon emission data or firm commitments, can serve a similar signaling function (Clarkson et al., 2011; Christensen et al., 2021; Bolton and Kacperczyk, 2023a). Green bonds extend this by offering a distinct forward-looking disclosure tied to a specific amount of capital. The additional involvement of institutional oversight, including reporting and verification, enhance the credibility of commitments made via green bonds (Lu, 2023). This perspective aligns with Flammer (2021), who argues that green bonds reflect a firm's environmental commitment, while emphasizing that it is specifically the committed capital that reduces uncertainty.

This paper also contributes to the green bond literature by studying valuation effects on both extant debt and equity, using a novel identification strategy that controls for the standard effects of debt announcements. Most research on the impact on debt has focused on comparing yields of green and conventional bonds in primary and secondary markets (Baker et al., 2022; Zerbib, 2019; Larcker and Watts, 2020; Flammer, 2021; Kapraun et al., 2021; Pástor et al., 2022; D'Amico et al., 2024), finding mixed evidence of a "green bond premium." This paper, by contrast, adds to this discussion by studying how the announcement of a green bond can affect the valuation of extant conventional bonds of the same issuer.

The potential impact of green bond issuance on the yields of extant conventional bonds has been previously suggested. In the Financial Times, Hale (2018a) discusses potential "halo" effects of green bonds, proposing that issuing green bonds could benefit issuers' overall debt. However, empirical evidence supporting this remains limited. Feldhütter and Pedersen (2025) find no significant average changes in conventional bond yields around sovereign green bond issuances. However, for corporate issuers, they document positive abnormal bond returns when existing debt is relabeled as green. Pope et al. (2023) document that green bond issuance is associated with a decline in extant bond yield spreads over time, based on monthly panel regressions from 2013 to 2021.

The analysis on the impact on debt presented in this paper differs from that of Feldhütter and Pedersen (2025) and Pope et al. (2023) in three key aspects: First, it compares green bond announcements with matched conventional bond announcements by the same issuer, thereby controlling for standard effects of debt announcements. Second, it employs short event windows and benchmarks extant bonds using portfolios matched by sector, credit-rating, and maturity, thereby minimizing exposure to bias associated with term effects, which can arise from bond yields following their term structure, especially affecting long time-series regressions (Nyborg and Woschitz, 2025). And third, it examines effects across the maturity spectrum and shows that the treatment effect varies across maturity.

Regarding the impact on equity, the literature has been similarly inconclusive. Prior studies have emphasized the positive stock market reactions to green bond announcements (Flammer, 2021; Tang and Zhang, 2020; and others), typically focusing on cumulative abnormal returns over event windows of 16 days or more. However, recent work by Aswani and Rajgopal (2024), Bhagat and Yoon (2023), and Lam and Wurgler (2024) challenge this evidence, arguing that abnormal returns in shorter event windows are not significant. By controlling for standard effects of debt announcements, this paper provides new evidence of positive equity responses to green bond announcements.

Overall, this paper demonstrates that green bonds benefit both equity and bond valuations, suggesting a decrease in the issuer's cost of capital. Because green bond issuers in the sample mostly have investment-grade ratings, the decline in yields translates likely into a lower cost of debt, without significant bias from default risk. Moreover, since green bonds often refinance existing projects (Lam and Wurgler, 2024), their announcement is unlikely to reveal major operational news about the issuer. Rather, green bonds appear to reveal the issuer's commitment, thereby signaling a reduced exposure to climate risks. In line with Sharfman and Fernando (2008), El Ghoul et al. (2011), Chava (2014), and Bolton and Kacperczyk (2020, 2023b) the results suggest that sustainability, or "greenness," is rewarded with a lower cost of capital due to reduce exposure to risks. Importantly, the signaling effect identified here is independent of investor preferences for green securities.[4] Within the frame-

[4]Several factors support a risk-based interpretation of the results. First, the effects are identified on conventional bond yields, not green bonds themselves. Second, prior work finds that investor preferences are strongest for green bonds issued by highly rated financial firms (Caramichael and Rapp, 2024), yet the effects here are concentrated among non-financial and riskier firms. Third, the effects are strongest at longer

work of Starks (2023), green bonds can influence the issuer's overall cost of capital purely through "value" considerations, rather than through "values"-driven investor demand.

Finally, I present a theoretical signaling model, in which green bonds credibly reveal a firm's commitment to a green implementation of a project, thereby mitigating information asymmetries about its exposure to climate risk. In the model, a firm finances a project by issuing either a green or conventional bond. Green bonds require a commitment to green implementation, limiting future flexibility but providing a credible signal to investors. The model features two project types, one of which ex ante favors green implementation. I show the existence of a separating equilibrium where the firm that intends to implement their project green chooses a green bonds, while the other opt for a conventional bond to retain flexibility. This equilibrium results from a trade-off between the value of flexibility and the reduced climate risk exposure achieved through commitment. Importantly, green bonds reveal not only project type but also the firm's commitment, highlighting the forward-looking nature of the signal.

Related theoretical models include Daubanes et al. (2024) and Gao and Schmittmann (2022), who also study green bonds under asymmetric information. Daubanes et al. (2024) model green bond issuances linked to carbon policies, investor preferences, and managerial sensitivity to stock prices. Analyzing a continuum of firms with projects that vary in the green implementation profitability, they find that only the most profitable green projects are financed through green bonds because managers benefit from positive stock price reactions. Gao and Schmittmann (2022) link green bond premiums to firm emission types, future carbon taxes, and greenwashing costs. Green bonds signal low-emission types and thus lower exposure to future carbon taxes. While these models focus on the interaction between investor preferences, policy, and firm heterogeneity, the model in this paper abstracts from

maturities, consistent with the long-term nature of climate risks. Preference driven demand would likely affect shorter maturities as well. Finally, the second part of the empirical analysis highlights the decline in firms' sensitivity to climate concern shocks after green bond announcements, providing direct evidence that green bonds are associated with a reduced exposure to climate risks.

market-wide dynamics and investor preferences and focuses instead on a single firm's trade-off between commitment and flexibility.

The remainder of this paper is structured as follows. Section 2 presents the green bond signaling model, Section 3 discusses the data and methodology, Section 4 covers the empirical analysis of the impact of green bond announcements on debt and equity, and Section 5 studies how green bonds affect issuers' sensitivity to climate concerns. Finally, Section 6 concludes.

2 Green bond signaling model

In this section, I present a theoretical model of green bond signaling.

There are three dates, $t = 0, 1, 2$. At time 0, a firm receives a project that is either green- or brown-aligned. The project's alignment indicates whether the project is inherently more suited for a "green" or "brown" implementation. For example, a car manufacturer may be assigned a project to develop a vehicle, aligned either toward an electric vehicle (EV, green) or an internal combustion engine vehicle (ICE, brown). The alignment is assumed to be exogenously determined.[5] It is denoted by $j \in \{g, b\}$ and is private information to the firm, where $j = g$ represents a green-alignment and $j = b$ a brown-alignment.

Still in $t = 0$, the firm must decide on an implementation policy, $p \in \{c, f\}$, where $p = c$ represents a commitment to green implementation, and $p = f$ denotes flexibility, allowing the firm to postpone the implementation decision to a later stage. For example, the green commitment could involve the firm's board voting in favor of green implementation, making it institutionally difficult to reverse, or the firm making verbal agreements with long-standing business partners, creating relational pressure to follow through. Importantly, this decision is not observable to investors.

Both project types require the same amount of funding. However, the firm has no assets

[5] For instance, the alignment can depend on exogenous factors such as the costs and availability of resources, specific technological requirements (e.g., advanced battery technology favoring green), or location (e.g., access to renewable energy infrastructure).

in place and lacks internal funds. To finance the project, the firm issues a bond in $t = 0$. To keep the model simple, it abstracts from any other financing options and normalizes the interest rate to zero. It is further assumed that investors are always willing to provide funding, the firm will always implement the project, and all participants are risk neutral.

After financing, in $t = 1$, the firm learns the net returns of green and brown implementations. This can be seen as the firm observing market conditions or input prices that allow it to assess returns. If committed, the firm must follow through with the green implementation. If flexible, it selects the option with the higher net return. The implementation decision is denoted by $i \in \{g, b\}$, where $i = g$ indicates green and $i = b$ brown implementation.

2.1 Expected net returns and alignment benefits

In $t = 2$, the project generates a net return, R_i^j, which depends on the project's alignment, j, and its implementation, i. The firm can implement the project either consistently or inconsistently. For the car manufacturer, implementing the green-aligned project as EV (green) is consistent, while implementing it as ICE vehicle (brown) is inconsistent.

Assumption 1. *The firm benefits from a consistent implementation of the project. Specifically, a consistent implementation has a higher ex-ante expected net return.*

The net returns are modeled as independent normally distributed random variables:

$$R_i^j \sim \begin{cases} N(\mu + \gamma, \sigma^2), & \text{if } i = j. \\ N(\mu - \gamma, \sigma^2), & \text{if } i \neq j. \end{cases} \tag{1}$$

The parameter μ is the fundamental expected value of net returns, $\gamma > 0$ describes the "alignment benefit," and σ is the standard deviation. The difference in expected net returns between a consistent and inconsistent implementation is 2γ.[6]

[6] Although in this setup realized returns can potentially be negative, the model abstracts from issues

2.2 Green law and expected adjustment costs

Assumption 2. *At $t = 2$, a green regulation that is certain and commonly known takes effect, and the firm must comply. Brown implementation leaves assets that incur adjustment costs $\kappa > 0$, while green implementation avoids these costs.*

Let $K(i)$ denote the adjustment costs under implementation choice i:

$$K(i) = \begin{cases} 0, & \text{if } i = g. \\ \kappa > 0, & \text{if } i = b. \end{cases} \tag{2}$$

A brown implementation creates negative externalities, such as pollution. The green law can be viewed to serve to internalize these via an adjustment cost κ, which reduces the net return. Since the regulation is certain, the firm chooses brown only if $R_b^j - \kappa > R_g^j$.

2.3 The project's expected true value

The ex-ante expected true value of project type j following policy p can be expressed as:[7]

$$V(p|j) = \begin{cases} E[max(R_g^j, R_b^j - \kappa)], & \text{if } p = f. \\ E[R_g^j], & \text{if } p = c. \end{cases} \tag{3}$$

Lemma 1. *Flexibility has value. The expected true value under the flexible policy exceeds the committed policy for both project types: $V(p = f|j) > V(p = c|j)$, $j \in \{g, b\}$.*

The intuition behind Lemma 1 is simple: The ability to choose the maximum of the two random independent net returns adds value relative to committing to green. While adjust-

related to bankruptcy and limited liability. For simplicity, assume that investors receive some sort of guarantee. E.g., that the firm's owners are fully liable with their private wealth, ensuring that investors are always repaid.

[7] Appendix A.1.1 provides calculations and simulations of ex-ante true values across project types and implementation policies.

ment costs reduce this value, the option to implement brown when its return is sufficiently high still results a net benefit, for both project types.[8]

Lemma 2. *The cost of giving up flexibility is smaller for the firm with a green-aligned project than for one with a brown-aligned project:* $V(f|g) - V(c|g) < V(f|b) - V(c|b)$.

Lemma 2 results from the benefits of a consistent implementation of a project. First, the green-aligned project has a higher expected value under the committed policy. Second, under the flexible policy, the ex-ante true value are identical for both project types if $\kappa = 0$ (since the net returns are modeled symmetrical), and the ex-ante true value of the brown-aligned project decreases faster in κ than the green-aligned project. Therefore, the cost of giving up flexibility is strictly larger for the brown-aligned project.[9]

2.4 Information asymmetries and green bond signaling

The firm has private information about its project type $j \in \{g, b\}$. It selects the implementation policy, $p \in \{c, f\}$. In a standard signaling game the firm could use this action to signal its project type. Here, however, the selected implementation policy is not observable to investors. In this model, the firm can use the bond issuance as a secondary layer of signaling by choosing the appropriate bond type, which is then observable to investors.

The firm has two options: it can issue a green bond, $\mathcal{GB}$, which requires external certification of the firm's green commitment, or a conventional bond, $\mathcal{CB}$, which imposes no restrictions on implementation. The idea is that there is an exogenous certification process involved with the green bond that verifies and certifies the green commitment of the firm. For simplicity, this certification process is assumed to be perfect, and thereby, the model abstracts from issues such as greenwashing.[10] Additionally, it is assumed that there are no

[8] Appendix A.1.2 provides calculations.

[9] Appendix A.1.3 provides calculations and simulations.

[10] This assumption is supported by empirical evidence on the effectiveness of issuers' commitments through green bonds. Studies by Flammer (2021), Fatica and Panzica (2021), Lu (2023), or ElBannan and Löffler

costs associated with issuing either bond type. The bond type, $\tau \in \{\mathcal{GB}, \mathcal{CB}\}$, is observable to investors.

2.5 The firm's strategies and investors' beliefs

The firm maximizes a weighted combination of its market and true value, following the standard approach in signaling models (Ross, 1977; Miller and Rock, 1985).[11] Let $\alpha \in [0, 1]$ denote the weight on the market value. The firm's objective function is:

$$u(p, \tau|j) = \alpha\hat{V}(\tau) + (1 - \alpha)V(p|j) \ , \tag{4}$$

where $\hat{V}(\tau)$ is the market valuation on the bond type, $\tau \in \{\mathcal{GB}, \mathcal{CB}\}$, and $V(p|j)$ is the expected true value given implementation policy p and project type j. For simplicity, the subsequent analysis sets $\alpha = 0.5$.

The firm's optimal strategy depends on its market valuation, which in turn depends on the strategy investors believe the firm is following. To characterize equilibrium behavior, the model specifies how investors form and update these beliefs.

First, investors have prior beliefs $P(j)$ over project types j, reflecting initial expectations about whether the project is green- or brown-aligned. The firm then publicly issues either a green bond ($\mathcal{GB}$) or a conventional bond ($\mathcal{CB}$. Upon observing bond type, investors update their prior beliefs to form posterior beliefs using Bayes' Rule.

Because the implementation policy p is not observable, investors form joint posterior beliefs over project type and policy: $P(j, p|\mathcal{GB})$ and $P(j, p|\mathcal{CB})$. These beliefs determine how investors price the project, and therefore influence the firm's choice of bond type and implementation policy.

(2024), show that issuers that adhere to green bond frameworks that cover standards, reporting, and verification improve their environmental performance.

[11] This can be seen as the market value representing a short-term utility derived from the market price, and the true value capturing the long-term value of the project.

Given these updated beliefs, the market value of the project under bond type τ is the probability weighted average of the project's true values across all possible types and policies:

$$\hat{V}(\tau) = \sum_{j,p} P(j, p|\tau)V(p|j) \tag{5}$$

2.6 Separating equilibrium

This section shows that, for suitable values of exogenous parameters, a separating equilibrium exists in which the firm with the green-aligned project commits to green implementation and issues a green bond, while the firm with the brown-aligned project chooses flexibility and issues a conventional bond. In this equilibrium, the project type, implementation policy, and bond type are perfectly aligned, allowing investors to infer both type and policy from the observed bond.

The separating equilibrium is driven by the alignment benefit γ (Assumption 1), and follows through the trade off between the value of flexibility (Lemma 1), and the avoidance of adjustment costs through commitment (Assumption 2).

In this equilibrium, the investors' beliefs are clear: $\mathcal{P}(j = g, p = c|\mathcal{GB}) = 1$ and $\mathcal{P}(j = b, p = f|\mathcal{CB}) = 1$. Upon observing a green bond, investors are certain the project is green-aligned and committed. Upon observing a conventional bond, they are certain the project is brown-aligned and follows a flexible policy. All other combinations are assigned a posterior probability of zero.

2.6.1 Incentive compatibility conditions

The separating equilibrium requires incentive compatibility (IC) conditions, ensuring that each project type chooses its utility-maximizing strategy, given investors equilibrium beliefs $\mathcal{P}$. The given setup rules out some actions, reducing the number of necessary IC conditions.

First, given the exogenous certification process and the absence of greenwashing, any firm issuing a green bond must commit to green implementation. As a result, issuing a green bond while following a flexible policy is not possible: $P(p = f|\mathcal{GB}) = 0$.

Second, a firm issuing a conventional bond always follows a flexible policy, so $P(p = c|\mathcal{CB}) = 0$. This is because flexibility results a higher expected true value than commitment ($V(f|j) > V(c|j)$, see Lemma 1). As a result, in the separating equilibrium, the firm strictly prefers flexibility with a conventional bond: $u(f, \mathcal{CB}|j) > u(c, \mathcal{CB}|j)$.

Therefore, the following two IC conditions need to be considered:

$$u(c, \mathcal{GB}|g) = V(c|g) > u(f, \mathcal{CB}|g) = 0.5[V(f|b) + V(f|g)] \qquad \text{(IC1)} \qquad (6)$$

$$u(f, \mathcal{CB}|b) = V(f|b) > u(c, \mathcal{GB}|b) = 0.5[V(c|g) + V(c|b)] \qquad \text{(IC2)} \qquad (7)$$

For the firm with the green-aligned project, the green commitment with a green bond has to dominate flexibility with a conventional bond (IC1). And for the firm with the brown-aligned project, the flexible implementation policy with a conventional bond has to dominate the green commitment with a green bond (IC2).

Theorem 1. *There are values for the exogenous parameters γ, κ, α and σ such that there exists a separating equilibrium in which the firm with the green-aligned project, $j = g$, commits green, $p = c$, with a green bond, $\mathcal{GB}$, and the firm with the brown-aligned project, $j = b$, remains flexible, $p = f$, with a conventional bond, $\mathcal{CB}$.*

Combining the two IC conditions imposes restrictions on the parameters γ, κ, α and σ. In Appendix A.1.4 and A.1.5 I numerically solve a simplified case with $\sigma = 1$ and $\alpha = 0.5$ to identify valid (γ, κ) combinations supporting the separating equilibrium (see Figure A.3). The solution reveal two key restrictions: First, γ must exceed a threshold to incentivize the firm with the green-aligned project to commit green. Second, for a given γ, κ must lie within a range. The lower bound ensures adjustment costs are high enough to discourage green-aligned projects from remaining flexible, while the upper bound ensures they do not reduce the value of flexibility for brown-aligned projects too much, which might otherwise prefer to commit.

2.7 Predictions of the separating equilibrium

This section discusses predictions for green bond announcements within the context of the separating equilibrium described in Theorem 1.

Proposition 1. *In the separating equilibrium, the market valuation of a project financed by a green bond exceeds that of a project financed by a conventional bond.*

This follows directly from IC1, which requires that the expected true value of a green-aligned project under commitment exceeds the average under flexibility: $V(c|g) > 0.5V(f|g) + 0.5V(f|b)$. Lemma 2 and Figure A.1 show that $V(f|g) > V(f|b)$, since the true value of brown-aligned projects decline faster in κ. It follows that, $V(c|g) > V(f|b)$.

Proposition 2. *In the separating equilibrium, the market valuation of a green-aligned project becomes insensitive to changes in the adjustment costs for brown assets, κ, following a green bond announcement:* $\frac{\delta V(c|g)}{\delta \kappa} = 0$.

This result holds because the green bond credibly signals the firm's commitment to green implementation, avoiding exposure to adjustment costs. As a result, within the separating equilibrium, changes in the expected severity of future climate regulation no longer affect the valuation of the underlying assets.

In summary, the separating equilibrium implies that bond type signals the firm's implementation policy and project type. Green bonds are associated with higher market valuations and reduced sensitivity to costs linked to future climate policy.

3 Data and methodology

This section describes the construction of the green bond dataset and their matched conventional bonds. It also outlines the dataset of extant debt and equity securities used in the event studies around the bond announcements.

3.1 Green bond sample construction

The starting point is the green bond list from Refinitiv Eikon.[12] It contains 11,798 green bonds from 2,958 issuers. This study focuses on bonds certified or aligned with the Climate Bond Initiative (CBI), issued by EU or US issuers between January 1, 2016 and June 22, 2024. This restriction ensures a well established green bond market.[13] This results a list of 4,834 green bonds from 924 issuers.

Three additional filters are applied: First, 1,365 green bonds are dropped due to missing issuer's credit ratings (either from Moody's or Fitch), sourced via Eikon.[14] Second, 539 instruments are excluded that do not qualify as traditional bonds, such as certificates and nontradable registered notes. To ensure a coherent bond sample, securities with maturities at issuance of less than one year (e.g., commercial papers, discount notes, and certificates) and nontradable registered securities are dropped. Third, to ensure clean announcements, the sample is restricted to dates where (i) only green bonds are announced, (ii) all issued bonds share the same seniority,[15] and (iii) the issuer has no other bond announcement within

[12]The list was downloaded on June 22, 2024.

[13]The CBI requires that bonds meet specific industry-level standards and issuers provide ongoing reporting with third-party verification (for further details, see CBI (2024)). The CBI dataset covers a broad spectrum of the green bond market, representing up to $4 trillion USD in cumulative issuance as of 2024.

[14]The following ratings are considered: "Fitch Long-term Issuer Default Rating," "Fitch Long-term Issuer Rating," "Fitch Senior Unsecured," "Moody's Long-term Issuer Rating," and "Moody's Senior Unsecured." If unavailable for the issuer, the parent organization's rating is used.

[15]With the field "Seniority Type Description" provided by Eikon, all bonds are grouped into three seniority classes: (1) "Secured" bonds, (2) "Senior Unsecured" bonds, and (3) "Junior" or "Subordinated" bonds. Bonds within the same seniority class are treated as having the same seniority.

a twenty day window $[-10, 9]$. For each announcement date, the total issued face value (in USD) and size-weighted residual maturity are calculated. and third, the issuer has no other close bond announcement within a twenty-day window $[-10, 9]$. For each announcement date, I calculate the total issued face value in US Dollars and a size weighted average residual maturity. The remaining dataset covers 1,102 announcement dates from 460 issuers.

3.2 Comparable conventional bond announcements

To control for the standard effects of debt announcements, each green bond is matched with a comparable conventional bond from the same issuer. The process is outlined below.

In a first step, I collect all conventional bond announcements by the same issuer from 1 month to 5 years before the green bond announcement. As with green bonds, I drop short-term securities (residual maturity < 1 year) and nontradable registered notes to ensure a consistent sample. I keep only announcement dates where (i) only conventional bonds are announced, (ii) all issued bonds share the same seniority, and (iii) no other bond is announced by the issuer within a twenty day window $[-10, 9]$. For each announcement, I calculate the total issued face value and size weighted residual maturity.

Then, each green bond is matched to a conventional bond based on the following criteria: (i) same issuer; (ii) announced between 1 month and 5 years prior the green bond; (iii) same seniority; (iv) residual maturity at issuance between 0.5x and 1.5x that of the green bond; and (v) total issued face value between 0.25x and 4x that of the green bond. This results 449 green bond announcements from 227 issuers with at least one matched comparable conventional bond announcement.

To ensure that matched pairs fall within similar market conditions, the sample is restricted to three time periods defined by two major events: the Covid-19 crisis and the recent surge in inflation rates. First, 163 pairs are dropped because either the green or conventional bond was announced between February 20 and April 7, 2020, a period of heightened market volatility during the Covid crisis. Both bonds in a pair must be announced either before or after this window. Second, announcements between March 1 and November 1, 2022, are excluded due to significant changes in interest rates driven by inflation. Again, both bonds in a pair must be announced either before or after this window. Finally, conventional bonds are only considered if announced after January 1, 2014. If multiple conventional bonds match the same green bond, only the one closest in announcement date is kept. The final sample consists of 194 matched bond pairs from 130 issuers.

This results in three time periods during which matched bond pairs occur: (i) January 1, 2014, to February 20, 2020; (ii) April 7, 2020, to March 1, 2022; and (iii) November 1, 2022, to June 22, 2024. These are shown in Figure 1, which plots EU corporate bond yields by risk class (5-7 year maturities).

Insert Figure 1 here.

3.3 Underlying assumptions for identification

The identification strategy relies on the premise that, ceteris paribus, market reactions to matched bond announcements should be similar.

One potential concern is that changing market conditions may influence results.[16] To address this, the final sample includes only matched pairs announced during periods with comparable market conditions, excluding windows of heightened volatility during the Covid crisis and the recent surge in inflation rates (see Figure 1). Additionally, Table A.2 in the Appendix confirms that there is no structural relationship between the main results and the length of the time interval between announcements and to changes in macroeconomic variables such as inflation, consumer confidence, investor sentiment, and commodity prices.

A second concern is that investor perceptions of the issuers may change between an-

[16] For example, Barry et al. (2008) documents that firms adjust their debt issuance behavior in response to changes in the interest rate levels.

nouncement dates. While the matching procedure requires the issuer to have the same credit rating for both bonds, ratings can be sticky and may not fully capture changes in investor perception. To assess this, i compare th issuer's capital structure at both announcement dates, using the total face value of outstanding bonds as a proxy. Since green bonds are issued later by design, issuers typically have more debt outstanding at the time of the green bond announcement. This pattern is confirmed in the data. If higher outstanding debt means increased risk, this should bias the results against finding more favorable market reactions to green bonds. However, Table A.2 in the Appendix shows no systematic relationship between changes in outstanding bonds and the observed effects, supporting the identification strategy.

3.4 Data - bond event study

The bond event study uses data on all conventional bonds outstanding at the time of each green and matched conventional bond announcement. Bond-level data are obtained from Refinitiv Eikon. To ensure comparability and avoid financial side effects, the sample is restricted to unsecured straight bonds with residual maturities between 1 and 30 years. This maturity range aligns with the benchmark bond indices used in the analysis. The US and EU datasets are separately pruned for weekends and holidays, ensuring that event studies are conducted on business days. Bond pricing data are sourced from Refinitiv Datastream. Observations missing bid or ask prices, or stale quotes (no change in ask- and bid-price from the previous day), are excluded. For each bond, I keep a ten day event window $[-5, 4]$ around the announcement.

To benchmark extant conventional bonds I follow the matched portfolio approach suggested by Bessembinder et al. (2009) applied to bond yields. Each bond is matched to a benchmark index based on region (EU or US), sector (sovereign or corporate), currency, credit rating, and maturity. For EU bonds, I use the iBoxx bond index family from the

International Index Company, while for US bonds, I use the ICE Bank of America bond index family. Data is obtained from Refinitiv Datastream. Maturity buckets include $1-3$, $3-5$, $5-7$, $7-10$, and >10 years. Bonds are excluded if the yield to maturity differs from the matched index by more than 3 percentage points or if fewer than ten observations are available within the event window.[17]

The final dataset includes pricing data for 1,620 bonds across 108 green bond announcements from 75 issuers, covering 19,980 bond-day observations. For the matched conventional bond announcements, 1,594 bonds across 91 announcements are included, resulting 17,820 bond-day observations. Some bonds appear in multiple announcement windows, and some conventional bond announcements are matched to more than one green bond.

3.5 Data - stock event study

For the stock event study, I collect stock prices from Refinitiv Datastream. The sample is limited to publicly listed firms.[18] As done with the bond data, the US and EU samples are adjusted to exclude weekends and holidays to conduct the analysis on business days. Stock price data is pruned for missing or stale prices, using the same criteria applied to bond prices. The analysis uses total returns, and any observations with missing total returns are excluded. To be included in the sample, an issuer must have complete return data for each day within a twenty day event window $[-10, 9]$ around announcements. For the estimation of market betas, at least 75% of daily returns the estimation window $[-250, -21]$. These criteria results 74 green bond announcements and 52 matched conventional bond announcements from 61 issuers. As benchmark, I use the primary country-level total return index corresponding to

[17]To address potential concerns about price accuracy in Refinitiv Datastream (whether they reflect actual market prices or theoretical estimates), I replicate the analysis using Bloomberg's BGN prices, which reflect market-based quotes. Appendix Table A.1 confirm that the main findings are robust.

[18]If a green bond is issued by a non-listed subsidiary, stock price data from the parent firm are used when available. This applies to 33 announcement pairs.

the issuer's headquarters.[19]

3.6 Descriptive statistics on the final dataset

Table 1 summarizes the final sample used in the bond and stock event studies. Panel A presents the number of matched green and conventional bond announcement pairs. The bond event study includes 108 matched pairs from 75 issuers, while the stock event study covers 74 pairs from 52 issuers. Panel B presents the distribution of bond pairs and issuers across countries and sectors. Panel C displays the distribution across six harmonized credit rating classes. Ratings from Moody's and Fitch are mapped to a harmonized scale, with class 1 indicating the highest credit quality.

Insert Table 1 here.

Table 2 provides descriptive statistics on the matched bond announcement pairs and compares key characteristics of green and conventional bonds. Panel A covers the sample used in the bond event study, and Panel B presents the sample used in the stock event study.

Insert Table 2 here.

Both panels begin by describing the distribution of announcement across issuers, showing that most issuers have one or two announcements within the dataset. They also report how green bond announcement are matched to conventional bonds, noting that a small number of conventional announcements serve as control events for more than one green bond. In most cases, matched bond announcements are close in time, typically occurring within one year. The panels also compare key bond characteristics, including residual maturity and issue size. Maturities are broadly similar, though green bonds tend to have slightly longer residual maturities at issuance. Issue sizes are comparable overall, but green bonds are, on

[19]Examples include the CAC40 for France, DAX30 for Germany, IBEX35 for Spain. If country-specific data are unavailable, I use the STOXX Europe 600 index.

average, somewhat smaller than their matched conventional counterparts. [20]

Table 3 presents statistics on the issuer's extant conventional bonds around announcement dates, which form the basis for the bond event studies. Panel A shows the distribution of the number of extant bonds per announcement, with an average of around 19 bonds outstanding. Panel B presents the distribution of announcement pairs with extant bonds across residual maturity buckets. The sample spans across the maturity spectrum, allowing for analysis of heterogeneous effects across short-, medium-, and long-term bonds.

Insert Table 3 here.

Table 4 presents the distribution of green bond sizes by issuer sector for the bond (Panel A) and stock (Panel B) event study samples. Issuers are grouped into three broad sectors: (1) *non-financial*, (2) *financial*, and (3) *public sector*.[21] Each panel contains three parts: (i) green bond issue sizes (in million USD), (ii) the issuer's total extant bond size at the announcement date, and (iii) the green bond's size relative to the issuer's extant bonds.

Insert Table 4 here.

In the bond event study sample, non-financial issuers account for 33 announcements with an average green bond size of 975 million USD; financial issuers account for 42 announcement, averaging 859 million USD; and public sector issuers contribute 33 announcements averaging 2,919 million USD. In the stock event study, the sample includes non-financial announcements averaging 793 million USD and 24 financial announcements averaging 919 million USD. Green bonds issue by non-financial issuers represent approximately 12.1% of their total extant bonds in the bond event study, and 17.6% in the stock event study. For financial and public sector issuers, around 7.5% in the bond market sample, and 3.7% for

[20]Appendix Table A.2 confirms that differences in residual maturity and size are not structurally related with the empirical results.

[21]The *public sector* includes issuers classified as *Agency*, *Sovereign*, *Supranational*, and *Municipal*. The *financial* sector covers *Banks* and *Other-Financials*. And the *non-financial* sector covers all remaining corporate categories.

financials in the stock event study.

4 Valuation impact of green bond announcements

4.1 Impact on debt

To study the impact of green bond announcements on the valuation of issuers' extant bonds across the maturity spectrum, I conduct a triple difference analysis on bond yields.

In a first step, I calculate yield spreads between extant conventional bonds, j, and its matched bond index, p, over a ten day event window around announcements, $t \in [-5, 4]$:

$$\Delta y_{j,t} = y_t^j - y_t^p \tag{8}$$

where y_t^j is the yield to maturity of extant bond j and y_t^p of the matched bond index.

Because issuers typically have multiple bonds outstanding at a given time, I aggregate yield spreads at the issuer-day level using a size-weighted average:

$$\Delta \bar{y}_{n,t} = \sum_{j=1}^{J} \Delta y_{j,t} \times w_j \ , \tag{9}$$

where J denotes the number of extant bonds around announcement n, and w_j is the bond's weight based on its total issued face value.

To analyze effects across maturity, bonds are grouped into three buckets: short-term (maturity < 5 years), medium-term (≥ 5 and < 10 years) and long-term (≥ 10 years).

The triple-difference regression model is:

$$\Delta \bar{y}_{n,t} = \beta_1 \mathbb{1}_{Post,t} + \beta_2 \mathbb{1}_{Post,t} \times \mathbb{1}_{Green,n} + \gamma_n + \epsilon_{n,t} \ , \tag{10}$$

where $\mathbb{1}_{Post,t}$ indicates post-announcement days, $\mathbb{1}_{Green,n}$ indicates observations around green bond announcements, and γ_n are announcement fixed effects. The coefficient β_2 captures the differential impact of green versus conventional bond announcements on yield spreads.

Insert Figure 2 here.

Figure 2 plots trends in aggregated yield spreads, $\Delta\bar{y}_{n,t}$, over the ten-day event window $[-5, 4]$ around green (green squares) and conventional bond (brown circles) announcements, separately by maturity: (a) short-term ($1 - 5$ years), (b) medium-term ($5 - 10$ years), and (c) long-term (> 10 years). The black triangles represent the differences in spreads between green and conventional announcements, which forms the basis of the triple difference analysis.

The displayed patterns preview the main result: for the medium and long-term bonds, yields increase following conventional bond announcements, while they remain stable or slightly decline after green bond announcements, indicating a negative impact of green bonds on bond yields after controlling for standard effects of debt announcements (black triangles). This pattern does not appear for short-term bonds.

Insert Table 5 here.

Table 5 reports the estimated coefficients from running Equation (10) with ordinary least squares (OLS) and standard errors clustered at the bond announcement level. The positive and significant coefficients on $\mathbb{1}_{Post,t}$ for medium and long-term bonds confirm that conventional bond announcements lead to higher yields on extant bonds relative to benchmark indices, consistent with prior evidence that debt issuance is often perceived negatively by existing bondholders (Chen and Stock, 2018).

The interaction term $\mathbb{1}_{Green,n} \times \mathbb{1}_{Post,t}$ is negative and significant for medium- and long-term bonds. After a green bond announcement, yield spreads decreases by approximately 1.33 bps for medium-term bonds and 2.96 bps for long-term bonds relative to conventional bond announcements. No significant effects are observed in the short-term maturity bucket.

The decline in yield spreads for medium- and long-term bonds is consistent with a green bond signaling mechanism. Green bonds may reduce investor uncertainty about the issuer's climate risk exposure, which is more relevant for longer-dated debt (Painter, 2020). The absence of yield effects for short-term bonds supports this explanation.

4.2 Impact on equity

To study the impact of green bonds announcements on the issuer's equity, I apply the classical event study methodology following Fama et al. (1969) and Brown and Warner (1985). The market model is estimated separately for each issuer using OLS over a one-year period $[-250, -21]$ prior to the announcement:

$$R_{n,t} = \alpha_n + \beta_n \times R_{m,t} + \epsilon_{n,t} \, , \tag{11}$$

where $R_{n,t}$ is the daily return of issuer n, and $R_{m,t}$ is the return on the country-level stock index. The estimated $\hat{\alpha}_n$ and $\hat{\beta}_n$ are used to compute expected returns:

$$\hat{R}_{n,t} = \hat{\alpha}_n + \hat{\beta}_n \times R_{m,t} \, . \tag{12}$$

The abnormal return, $AR_{n,t}$, is the difference between the actual and expected return.

$$AR_{n,t} = R_{n,t} - \hat{R}_{n,t} \tag{13}$$

Cumulative abnormal returns, CAR, are calculated by summing abnormal returns over different event windows:

$$CAR_{n,t_0,t_1} = \sum_{t_0}^{t_1} AR_{n,t} \, . \tag{14}$$

To control for standard effects of debt announcements, I compare CARs across matched green and conventional bond announcement pairs. The difference in cumulative abnormal returns (DAR) is defined for each pair m as:

$$DAR_{m,t_0,t_1} = CAR^{GB}_{m,t_0,t_1} - CAR^{CB}_{m,t_0,t_1} \, , \tag{15}$$

where CAR^{GB} and CAR^{CB} denote the cumulative abnormal returns around green and conventional bond announcements, respectively.

Table 6 presents average CARs around green (left) and conventional bond announcements (right), as first step of the analysis. Green bond announcements are associated with small, statistically insignificant positive abnormal returns. Over the five day event window $[-2, 2]$, the average CAR^{GB} is 0.35% with t-statistics below conventional thresholds. This result aligns with recent contributions in the green bond literature that challenge earlier findings of significant positive equity market responses to green bonds. For example, Aswani and Rajgopal (2024), Lam and Wurgler (2024), and Bhagat and Yoon (2023) find no significant abnormal returns around green bond announcements using short event windows.

Conventional bond announcements, by contrast, are associated with negative stock price reactions. Over the same $[-2, 2]$ window, the average CAR^{CB} is -0.70%, statistically significant at the 10% level. This aligns with the existing view that straight debt announcements tend to have negative effects on the issuer's stock price (Dann and Mikkelson, 1984; Eckbo, 1986; Howton et al., 1998).

Table 7 reports the average difference in cumulative abnormal returns (DAR) between matched green and conventional bond announcements, controlling for the standard effects of debt announcements. Over the $[-2, 2]$ window, green bond are associated with significantly more favorable stock market reactions, with a DAR of 1.08%, significant at the 5% level.

This result is consistent with a green bond signaling mechanism, where green bond announcements reveal reduced climate risk exposure, interpreted as good news by equity investors.

Insert Table 7 here.

4.3 Financial and non-financial issuers

The average effects on debt and equity may conceal heterogeneity across issuer types. The corporate finance literature often distinguishes financial and non-financial firms due to differences in asset structure and financing practices.

Insert Table 8 here.

Table 8 presents the triple difference results from Specification (10) for debt and (15) for equity, split by sector. Panel A (left) shows the impact on bond yields, and Panel B (right) reports results for equity. Subpanels A1 and B1 cover non-financial issuers, A2 and B2 cover financials, A3 covers public sector issuers (debt only).

Results indicate that the effects are concentrated among non-financial issuers. Green bond announcements lower long-term (> 10 years) bond yields by approximately 7.1 bps and medium-term ($5 - 10$ years) yields by a smaller, yet significant, amount. Equity also responds positively, with and average DAR of 1.48% over the $[-2, 2]$ window (significant at the 5% level).

By contrast, financial issuers show no significant changes in yields or equity returns. For these firms, market reactions to green bonds are similar to conventional bonds.

These patterns suggest that markets view green bond announcements from non-financial firms as more credible commitments. Non-financials typically allocate proceeds to physical investments (e.g., infrastructure) that are costly to reverse, enhancing the credibility of their green commitment. In contrast, financial firms often channel proceeds into green loans, which can be more easily reallocated after the green bond's maturity. This flexibility may reduce perceived credibility, limiting the announcement's information value.

Finally, Panel A3 shows that public sector issuers experience a smaller but significant a yield reduction of about 1.4 bps at the long end of the maturity spectrum.

4.4 Issuer riskiness

To further explore heterogeneity in the impact of green bonds, I examine whether the effects vary across credit risk. The idea is that investor uncertainty is typically more severe for lower-rated firms, making green bonds more effective at mitigating information asymmetries.

This analysis excludes financial issuers, because their green bonds are found to induce no significant market reaction. For each remaining announcement pair n, I keep the estimated treatment effects: $\hat{\beta}_{2,n}$ for bond yields and DAR_n for equity.

Issuer risk is captured using a dummy variable, $\mathbb{1}_{HighRisk,n}$, equal to 1 if the issuer's credit rating is at or above the sample median (i.e., lower credit quality). Ratings are harmonized across agencies as described in Panel C of Table 1). The following regression is estimated:

$$z_n = \alpha + \beta \mathbb{1}_{HighRisk,n} + \epsilon_n \ , \tag{16}$$

where $z_n \in \{\hat{\beta}_{2,n}, DAR_n\}$. Equation (16) is estimated using OLS with standard errors Huber-White corrected for heteroscedasticity.

Table 9 presents the results (debt on the left, equity on the right). Green bond announcements have stronger effects for riskier firms. Long-term bond yields decline by 4.7 bps more for risky firms (significant at the 5% level), and abnormal equity return are over 3 percentage points higher. In contrast, estimates for safer firms are insignificant in both markets.

The pattern supports the green bond signaling mechanism: for riskier issuers, where investor uncertainty is greater, green bonds serve as a more informative signal. For safer firms, where uncertainty is likely lower, such signal adds less information.

Insert Table 9 here.

5 Mitigation of climate risk information asymmetries

This section directly tests whether green bonds mitigate climate risk information asymmetries, as predicted by Proposition 2. Specifically, I assess whether issuing a green bond reduces a firm's sensitivity to climate concern shocks, which serves as proxy for investor uncertainty about climate risk exposure.

To measure climate change concerns, I use the Media Climate Change Concerns index (MCCC) developed by Ardia et al. (2023).[22] The MCCC tracks climate change coverage from major US newspapers from January 2003 to August 2022.[23] I use the monthly version of the index to smooth short-term fluctuations and account for potential publication lags. Following Ardia et al. (2023) and Pástor et al. (2022), I estimate climate concern shocks as the prediction errors from a rolling autoregressive AR(1) model: each month's MCCC value is predicted using the preceding 36 months, and the shock is the deviation from the forecast. Figure 3 displays the time series of the index, monthly changes, and shocks.

Insert Figure 3 here.

To proxy for investor uncertainty about climate risk exposure, I study how firm-level stock return volatility responds to climate concern shocks. The underlying idea is as follows: if climate concern shocks significantly increase firm's stock return volatility, this suggests investor uncertainty about the firm's exposure to these shocks (information asymmetry). If green bonds credibly reduce that uncertainty, the firm's sensitivity to climate concern shocks should decline following issuance. I test this by comparing changes in the firm's sensitivity before and after green bond announcements, and compare it with peer firms over the same

[22]The authors provide the data for the MCCC index here: `https://sentometrics-research.com/`.

[23]The index measures concern by analyzing the frequency of climate-related articles, focusing on risk emphasis and the balance of negative versus positive language. It is calculated by interacting the fraction of total risk-related words with the scaled difference between negative and positive words in each article. Daily values are summed for each newspaper, averaged across papers to adjust for reporting style differences, and a square root transformation is applied to account for non-linear increases in concerns.

time periods that did not issue green bonds.

The initial sample includes 1,107 green bond announcements from 461 issuers (see Section 3.1). Among these, 235 announcements have available stock price data between January 2016 and August 2022. I calculate monthly stock return volatilities over a 24 month event window $(-12, 11)$ around each announcement. Data from February to April 2020 is excluded due to the Covid crisis. Events must have data for at least 12 months within the window. In cases of overlapping windows for the same issuer, only the first announcement is kept. This results a sample of 113 green bond announcements from 97 issuers.

To construct a control group, I use the issuer's peer list provided by Refinitiv, which is based on a proprietary peer selection algorithm that "combines competitor lists from filings, analyst cross coverage, business classification, and revenue proximity." Peers that have issued a green bond or are based outside the EU or US are excluded. Peer firms must have complete data for the full event window to maintain balanced panels. This results in data for 1,014 peer firms across 75 green bond announcements, averaging around 15 peers per issuer.

To estimate firm's sensitivity to climate concern shocks, I run the following panel regression:

$$\Delta\sigma^i_{n,t} = \beta_0 + \beta_1 \mathbb{1}_{Post,n,t} + \beta_2 \Delta\sigma^m_{n,t} + \beta_3 \mathbb{1}_{Post,n,t} \times \Delta\sigma^m_{n,t} + \beta_4 \Delta C_t + \beta_5 \mathbb{1}_{Post,n,t} \times \Delta C_t + \gamma_n + \theta_t + \epsilon_{n,t} \,, \quad (17)$$

where $\Delta\sigma^i_{n,t}$ is the monthly change in stock return volatility for issuer n, and $\Delta\sigma^m_{n,t}$ is the corresponding change for the issuer's country-level stock index. ΔC_t denotes monthly climate concern shocks. $\mathbb{1}_{Post,n,t}$ indicates the post green bond announcement periods. Fixed effects γ_n and θ_t control for announcement level and calendar year heterogeneity. The specification is estimated using OLS with standard errors clustered at the bond announcement level. The same specification is applied to the peer firm sample, where each observation represents the average volatility change across all peers for a given bond announcement and moth.

Table 10 presents the results. Panel A (left) reports estimates for green bond issuers, and Panel B (right) for peer firms. Each panel shows results over the full event window and separately for the pre- and post-announcement subperiods.

Insert Table 10 here.

For green bond issuers, climate concern shocks (ΔC_t) are positively and significantly associated with changes in stock return volatility prior to the announcement, indicating that investor perceived uncertainty about these firms' climate risks exposure. Following the green bond announcement, this sensitivity declines: the coefficient on ΔC_t falls and loses statistical significance. Over the full window, the interaction term $\mathbb{1}_{Post,n,t} \times \Delta C_t$ is negative, although not significant. This pattern suggests that green bonds are associated with a modest reduction in the volatility response to climate concern shocks.

In contrast, peer firms that did not issue green bonds show no such reduction. Their volatility remains significantly sensitive to ΔC_t both before and after the corresponding event dates, and the interaction term is close to zero. This contrast supports the interpretation that the reduced sensitivity among issuers is attributable to the green bond announcement.

Taken together, these results support the view that markets understand green bonds as a credible signal of reduced climate risk exposure. The observed decline in sensitivity is consistent with the green bond signaling mechanism described in Proposition 2.

6 Conclusion

This paper provides new evidence that markets understand green bonds as a credible signal of firms' commitment to sustainability and reduced exposure to climate risks. Using a novel identification strategy, I document that green bond announcements are associated with positive valuation effects in both extant debt and equity: stock prices rise, and yields on extant bonds decline, particularly at the long end of the maturity spectrum, overall suggesting a reduction in the firm's cost of capital.

The effects are concentrated among non-financial firms and issuers with lower credit ratings, consistent with green bonds being more informative when commitment credibility through physical investments of proceeds is higher and investor uncertainty is greater. Financial firms, by contrast, show no significant response, likely due to concerns over the credibility of their commitment by allocating proceeds in green loans.

The second part of the analysis tests the green bond signaling mechanism directly by showing that firms' sensitivity to climate concern shocks declines after green bond announcements. This decline in sensitivity is consistent with investors updating their beliefs about the firm's climate risk exposure in response to the commitment revealed by the green bond.

Together, the findings contribute to the literature on sustainable finance by demonstrating that green bonds can mitigate climate-related information asymmetries. For issuers, green bonds offer a potential channel to reduce financing costs. For policymakers, the results highlight the importance of well-designed standards and market infrastructure to facilitate green bond issuance and thereby incentivize credible commitments to sustainability.

Overall, this paper advances our understanding of how financial instruments can shape the pricing of climate risks, alleviate adverse selection related to them, and support the transition to a more sustainable economy by incentivizing credible commitments.

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Table 1: Bond pair sample for event studies.

This table summarizes the final sample of matched green and conventional bond announcements used in the bond and stock event studies. The sample includes green bond announcements from January 1, 2016, to June 22, 2024, drawn from Refinitiv Eikon. Matched pairs are identified and pruned according to the procedures described in Section 3. Panel A presents the number of matched announcements and issuers, Panel B shows the distribution across countries and sectors, and Panel C reports the distribution across harmonized credit rating classes.

Panel A: Bond announcement pairs and issuers

	Total number of	
event study	bond pairs	issuers
Bond	108	75
Stock	74	52

Panel B: Issuer country and sectors

Country of issuer	Bond event study		Stock event study	
	Number of		Number of	
Country	bond pairs	issuers	bond pairs	issuers
France	21	16	8	7
Italy	18	9	15	10
Netherlands	15	11	3	2
Germany	14	8	5	3
Spain	13	10	11	8
Belgium	7	5	3	2
Sweden	5	3	4	4
Austria	3	2	2	1
Finland	2	2	.	.
Ireland	2	2	1	1
Luxembourg	2	1	.	.
United States	2	2	22	14
Czech Republic	1	1	.	.
Island	1	1	.	.
Lithuania	1	1	.	.
Poland	1	1	.	.

Sector of issuer	Bond event study		Stock event study	
	Number of		Number of	
Sector	bond pairs	issuers	bond pairs	issuers
Banks	39	29	19	15
Agency	23	13	.	.
Electric Power	19	12	28	16
Sovereign	7	6	.	.
Energy	4	3	4	3
Gas Distribution	4	2	4	2
Manufacturing	3	2	9	8
Other Financials	3	2	5	4
Supranational	2	2	.	.
Telephone	2	2	3	2
Municipal	1	1	.	.
Transportation	1	1	.	.
Service Company	.	.	2	2

Panel C: Issuer credit ratings

	Bond event study		Stock event study		Rating origin	
Harmonized	Number of		Number of			
rating class	bond pairs	issuers	bond pairs	issuers	Moody's	Fitch
1	6	3	0	0	Aaa	AAA
2	23	18	3	3	Aa1 to Aa3	AA+ to AA-
3	33	23	32	20	A1 to A3	A+ to A-
4	44	30	35	26	Baa1 to Baa3	BBB+ to BBB-
5	2	1	4	3	Ba1 to Ba2	BB+ to BB-
6	0	0	0	0	Ba3 and lower	B+ and lower

Table 2: Descriptive statistics on matched bond pairs.
This table presents summary statistics for the final sample of matched green and conventional bonds introduced in Table 1. Panels A reports statistics for the bond event study sample, Panel B for the stock event study. The table presents statistics on the announcement pairs per issuer, the distribution of the number of matched green bond announcements per conventional bond announcement, and key bond characteristics of the green bonds and their comparable conventional bonds.

Panel A: Bond event study sample	N	mean	std. dev.	std. error	median	min	max
Issuer statistics							
Bond pairs per issuer	75	1.44	0.68	0.08	1	1	4
Bond pair statistics							
Green bonds per conv. bond	91	1.19	0.42	0.04	1	1	3
Announcement date diff. (yrs)	108	1.01	0.89	0.09	0.72	0.09	4.22
Bond characteristics statistics							
Residual maturity							
green bond (years)	108	8.66	4.31	0.41	8.00	2.00	25.06
conv. bond (years)	91	7.95	4.61	0.48	7.00	1.17	30.05
difference (years)	108	0.86	2.56	0.25	1.00	-5.72	10.23
rel. diff. (× green bond)	108	0.09	0.25	0.02	0.14	-0.42	0.50
Size							
green bond (mn USD)	108	1,523.80	3,182.05	306.19	751.24	21.40	23,943.16
conv. bond (mn USD)	91	2,328.38	4,173.44	437.50	1,082.90	5.58	26,219.61
difference (mn USD)	108	-641.70	2,210.04	212.66	-505.10	-11,932.88	13,038.04
rel. diff. (× green bond)	108	-0.69	1.07	0.10	-0.52	-2.96	0.74

Panel B: Stock event study sample	N	mean	std. dev.	std. error	median	min	max
Issuer statistics							
Bond pairs per issuer	52	1.42	0.70	0.10	1	1	4
Bond pair statistics							
Green bonds per conv. bond	61	1.21	0.52	0.07	1	1	4
Announcement date diff. (yrs)	74	1.22	1.07	0.12	0.76	0.09	3.99
Bond characteristics statistics							
Residual maturity							
green bond (years)	74	11.29	8.34	0.97	8.00	3.00	30.66
conv. bond (years)	61	10.09	8.56	1.10	7.00	2.00	33.00
difference (years)	74	0.50	2.73	0.32	0.56	-9.87	8.82
rel. diff. (× green bond)	74	0.07	0.26	0.03	0.09	-0.48	0.50
Size							
green bond (mn USD)	74	833.81	603.96	70.21	698.79	10.74	4109.81
conv. bond (mn USD)	61	1180.65	934.41	119.64	1000.00	42.93	5366.02
difference (mn USD)	74	-334.81	709.24	82.45	-333.50	-2111.45	1047.08
rel. diff. (× green bond)	74	-0.70	1.10	0.13	-0.51	-3.00	0.73

Table 3: Extant conventional bonds across bond announcements.
This table presents descriptive statistics for the issuer's extant conventional bonds with pricing data around bond announcements. Panel A shows the number of extant bonds across bond announcements. Panel B presents the distribution of announcement pairs with extant bonds across residual maturity buckets. These bonds form the basis for the bonds event study.

Panel A: Distribution of extant bonds							
		Number of extant bonds per announcement					
Announcement	N	mean	std. dev.	std. error	median	min	max
green bond	108	18.50	35.91	3.46	7	1	209
conv. bond	91	19.58	34.00	3.56	7	1	181
Panel B: Extant bonds across maturity buckets							
		Residual maturity of extant bonds					
	N	1 to 5y	5 to 10y	$\geq$ 10y			
Bond pairs	108	97	77	45			

Table 4: Bond sizes across sectors.
This table shows the size of the announced green bonds and all extant bonds of the same issuer at the announcement date, and the relative size of the green bond compared to all extant bonds across three sectors. Green bond issuers are grouped into three sectors: non-financials, financials and public sector. Panel A (B) reports the statistics for the bond (stock) market event studies.

Panel A: Bond market							
Sector	N	mean	std. dev.	std. error	median	min	max
Non-financials							
Size green bond (mn USD)	33	974.9	593.9	103.4	751.2	322.0	3,219.6
Size extant bonds (mn USD)	33	13,355.7	14,382.2	2,503.6	9,000.8	1,100.2	79,094.9
Rel. size green bond (%)	33	12.1	9.7	1.7	9.0	2.8	48.8
Financials							
Size green bond (mn USD)	42	858.7	721.4	111.3	689.0	21.4	4,109.8
Size extant bonds (mn USD)	42	34,841.9	37,660.0	5,811.1	19,570.9	860.3	130,624.2
Rel. size green bond (%)	42	7.6	13.7	2.1	3.9	0.2	74.8
Public sector							
Size green bond (mn USD)	33	2,919.2	5,471.6	952.5	751.2	73.0	23,943.2
Size extant bonds (mn USD)	33	210,399.7	566,217.1	98,565.8	21,617.4	1,460.2	2,843,297.0
Rel. size green bond (%)	33	7.5	10.9	1.9	2.7	0.2	45.1
Panel B: Stock market							
Sector							
Non-financials							
Size green bond (mn USD)	50	793.1	445.3	63.0	698.8	119.4	2,146.4
Size extant bonds (mn USD)	50	19,508.9	25,830.1	3,652.9	11,187.5	112.2	154,728.2
Rel. size green bond (%)	50	17.6	66.9	9.5	6.3	0.7	478.2
Financials							
Size green bond (mn USD)	24	918.7	850.9	173.7	751.2	10.7	4,109.8
Size extant bonds (mn USD)	24	81,205.6	108,369.2	22,120.8	25,251.3	2,961.3	318,578.1
Rel. size green bond (%)	24	3.7	4.1	0.8	2.3	0.1	18.1

Table 5: The impact of green bonds on the issuer's debt.
This table reports results from the triple difference regression specified in Equation (10): $\Delta\bar{y}_{n,t} = \beta_1 \mathbb{1}_{Post,t} + \beta_2 \mathbb{1}_{Post,t} \times \mathbb{1}_{Green,n} + \gamma_n + \epsilon_{n,t}$. The dependent variable, $\Delta\bar{y}_{n,t}$, is the size-weighted average daily yield spread between the issuer's extant bonds and their matched bond indices over a ten day event window $[-5, 4]$ surrounding each bond announcement. $\mathbb{1}_{Post,t}$ indicates post bond announcement observations, $\mathbb{1}_{Green,n}$ equals one for observations around green bond announcements. The interaction term captures the differential response to green versus conventional bond announcements. Results are shown for all bonds and separately by maturity: short- ($1-5$ years), medium- ($5-10$ y.), and long-term (> 10 y.) bonds. Standard errors are clustered at the bond announcement level. The green bond announcement dummy is absorbed by bond announcement (event) fixed effects. T-statistics are reported in brackets. Significance at the 1%, 5%, and 10% levels is denoted by a, b, and c. Bold coefficients are significant at the 10% level or better.

	$\Delta\bar{y}_{n,t}$			
	all	$1-5$y	$5-10$y	>10y
$\mathbb{1}_{Post,t}$	0.0121	0.0084	**0.0132^{b}**	**0.0147^{c}**
	(1.509)	(0.970)	(2.053)	(1.821)
$\mathbb{1}_{Post,t} \times \mathbb{1}_{Green,n}$	-0.0094	-0.0032	**-0.0133^{c}**	**-0.0296^{a}**
	(-0.943)	(-0.294)	(-1.708)	(-2.796)
N	2160	1940	1540	900
R^2_{adj}	0.988	0.988	0.992	0.994
Event FE	Yes	Yes	Yes	Yes
Number of bond announcement pairs	108	97	77	45

c: p< 0.1, b: p< 0.05, a: p< 0.01

Table 6: The impact of bond announcements on equity.
This table reports cumulative abnormal returns (CAR) from the stock event study around green bond announcements (left) and their matched conventional bond announcements (right). Results are based on t-tests of the estimated CAR over three windows: one pre-announcements window $[-10,-6]$ and two windows during the announcement $[-2,2]$ and $[-5,4]$. T-statistics are shown in parenthesis below the estimates. The symbols a, b, and c indicate significance at the 1%, 5%, and 10% levels (two-sided), respectively. Coefficients significant at the at 10%-level or better are displayed in bold.

	Green bond			Conventional bond		
	pre-event	event windows		pre-event	event windows	
	[-10,-6]	[-2,2]	[-5,4]	[-10,-6]	[-2,2]	[-5,4]
CAR	0.285	0.350	0.156	0.453	**-0.704**^{c}	-0.516
	(0.841)	(1.038)	(0.350)	(1.130)	(-1.795)	(-0.956)
N	74	74	74	61	61	61

c: p< 0.1, b: p< 0.05, a: p< 0.01

Table 7: The impact of green bonds on equity.
This table presents results from the stock event study comparing the cumulative abnormal returns around green and matched conventional bond announcements. The difference in cumulative abnormal returns (DAR) captures the equity market response to green bond announcements, controlling for the standard impact of a bond announcement. The table shows t-tests on average DARs over one pre-announcement window $[-10,-6]$ and two windows during the announcement $[-2,2]$ and $[-5,4]$. T-statistics are reported in parenthesis below the coefficients. The symbols a, b, and c indicate significance at the 1%, 5%, and 10% levels, respectively. Coefficients significant at the at 10%-level or better are highlighted in bold.

	pre-event	event windows	
	[-10,-6]	[-2,2]	[-5,4]
DAR	-0.374	**1.078**^{b}	0.815
	(-0.870)	(2.183)	(1.178)
N	74	74	74

c: p< 0.1, b: p< 0.05, a: p< 0.01

Table 8: The impact of green bonds across sectors.
This table presents results from the triple difference regression of green bond announcements, estimated separately by sector. Panel A (left) shows the impact on bond yield spreads between an issuer's outstanding bonds and matched bond indices over a ten-day window $[-5, 4]$, as denoted by Specification (10). The dependent variable $\Delta\bar{y}_{n,t}$ is the size-weighted yield spread. $\mathbb{1}_{Post,t}$ indicates post-announcement days; $\mathbb{1}_{Post,t} \times \mathbb{1}_{Green,n}$ captures the differential impact of green versus conventional bond announcements. Event fixed effects absorb the green bond indicator. Results are reported for all maturities and by buckets: short- $(1-5$ years), medium- $(5-10$ years), and long $(> 10$ years). Standard errors are clustered at the bond announcement level. Panel B shows the equity market response, defined as the difference in cumulative abnormal returns (DAR) between matched green and conventional bond announcements, based on Equation (15). Results are reported across three event windows: $[-10, 6]$, $[-2, 2]$, and $[-5, 4]$. Each DAR estimate is based on matched bond announcement pairs. Results in both panels are split by sectors: Panel A1 and B1 for non-financial issuers, Panel A2 and B2 for financial issuers, and Panel A3 for public sector issuers. T-statistics are reported in brackets. Significance at the 1%, 5%, and 10% levels is denoted by a, b, and c. Bold coefficients are significant at the 10% level or better.

Panel A: Bond Event Study ($\Delta\bar{y}_{n,t}$)

	all	$1-5$y	$5-10$y	> 10y
Panel A1: Non-Financial issuers				
$\mathbb{1}_{Post,t}$	**0.0324^b**	**0.0264^c**	**0.0353^b**	**0.0551^b**
	(2.255)	(1.957)	(2.405)	(2.154)
$\mathbb{1}_{Post,t} \times \mathbb{1}_{Green,n}$	**-0.0262^c**	-0.0144	**-0.0306^c**	**-0.0710^b**
	(-1.701)	(-0.996)	(-1.736)	(-2.323)
N	660	600	480	220
R^2_{adj}	0.987	0.991	0.989	0.983
No. of bond pairs	33	30	24	11
Panel A2: Financial issuers				
$\mathbb{1}_{Post,t}$	0.0059	0.0012	0.0120	-0.0050
	(0.350)	(0.069)	(0.925)	(-0.303)
$\mathbb{1}_{Post,t} \times \mathbb{1}_{Green,n}$	0.0011	0.0058	-0.0072	-0.0218
	(0.048)	(0.249)	(-0.481)	(-0.771)
N	840	820	460	180
R^2_{adj}	0.984	0.984	0.987	0.994
No. of bond pairs	42	41	23	9
Panel A3: Public sector issuers				
$\mathbb{1}_{Post,t}$	-0.0003	-0.0009	-0.0035	0.0041
	(-0.083)	(-0.241)	(-0.794)	(0.961)
$\mathbb{1}_{Post,t} \times \mathbb{1}_{Green,n}$	-0.0060	-0.0045	-0.0042	**-0.0141^b**
	(-1.081)	(-0.929)	(-0.584)	(-2.019)
N	660	520	600	500
R^2_{adj}	0.997	0.997	0.997	0.995
No. of bond pairs	33	26	30	25

Panel B: Stock event study (DAR)

	pre-event	event windows	
	[-10,-6]	[-2,2]	[-5,4]
Panel B1: Non-Financial issuers			
DAR	-0.185	**1.478^b**	1.275
	(-0.415)	(2.343)	(1.547)
No. of bond pairs	50	50	50
Panel B2: Financial issuers			
DAR	-0.767	0.246	-0.144
	(-0.803)	(0.324)	(-0.114)
No. of bond pairs	24	24	24

c: p< 0.1, b: p< 0.05, a: p< 0.01

Table 9: Issuer riskiness and the impact of green bonds.
This table presents regression results examining whether the impact of green bond announcements varies with issuer credit risk, as denoted by Equation (16). The analysis combines evidence from both bond and equity markets. On the left, the dependent variable is the estimate triple-difference coefficient, $\beta_{2,n}$ from Specification (10), which captures the differential impact of green versus conventional bond announcements on bond yields. Regressions are shown for all maturities and separately for short ($1-5$ years), medium ($5-10$ years), and long-term (>10 years) bonds. On the right, the dependent variable is the difference in cumulative abnormal stock returns, $DAR_{-2,2}$, over a five day event window $[-2,2]$, comparing green and matched conventional bond announcements, as denoted by Specification (15). In both specifications, the key explanatory variable is a high-risk indicator, $\mathbb{1}_{HighRisk,n}$, which equals 1 if the issuer's credit rating is at or above the sample median credit rating class (i.e., higher credit risk). The regression tests whether valuation effects are stronger for riskier firms. All regressions are estimated using OLS with standard errors Huber-White corrected for heteroscedasticity. T-statistics are reported in parenthesis below the coefficients. The symbols a, b, and c indicate significance at the 1%, 5%, and 10% levels, respectively. Coefficients that are statistically significant at the at 10%-level or better are highlighted in bold.

	Bond event study $Green_k \times Post_t$				Stock event study $DAR_{-2,2}$
		Maturity bucket			
	all	1-5y	5-10y	> 10y	
$\mathbb{1}_{HighRisk,n}$	-0.01780	-0.01354	-0.01871	**-0.04683**^{b}	**3.269**^{a}
	(-1.273)	(-0.929)	(-0.998)	(-2.305)	(2.944)
Constant	-0.00508	-0.00229	-0.00658	-0.00680	-0.549
	(-1.171)	(-0.503)	(-1.492)	(-1.476)	(-0.775)
N	66	56	54	36	50
R^2	0.016	0.013	0.019	0.124	0.129

c: p< 0.1, b: p< 0.05, a: p< 0.01

Table 10: Sensitivity to climate concerns.
This table reports results from Specification (17), testing whether firms' stock return volatility responds to shocks in climate concerns. Panel A focuses on green bond issuers, with the dependent variable $\Delta\sigma^i_{n,t}$ denoting monthly changes in stock return volatility. The regressors include: $\mathbb{1}_{Post}$ (post-announcement indicator), $\Delta\sigma^m$ (change in monthly market index return volatility), ΔC (climate concern shock from AR(1) residuals of the MCCC index, and interaction terms. Estimation covers the full 24-month window $[-12, 11]$, and pre-/post-periods separately. Fixed effects at the bond announcement level (γ_n) and calendar year level (θ_t) control for firm and time heterogeneity. Standard errors are clustered at the announcement level. Panel B repeats the analysis for peer firms that did not issue green bonds, using Refinitiv's pee classification. For each green bond announcement, peer-firm values reflect averages across all matched peers. Significance at the 1%, 5%, and 10% levels is indicated by a, b, and c, respectively, with bold marking coefficients significant at the 10% level or better.

Dependent variable:	$\Delta\sigma^i_{n,t}$					
	Panel A: Green bond issuer			*Panel B: Peer firms*		
Variables	Full	Pre	Post	Full	Pre	Post
$\mathbb{1}_{Post,n,t}$	-0.0002			-0.0000		
	(-0.598)			(-0.101)		
$\Delta\sigma^m_{n,t}$	**0.8844^a**	**0.8821^a**	**0.9346^a**	**0.9326^a**	**0.9265^a**	**0.8591^a**
	(11.824)	(11.750)	(8.507)	(16.605)	(16.211)	(15.729)
$\mathbb{1}_{Post,n,t} \times \Delta\sigma^m_{n,t}$	0.0505			-0.0714		
	(0.405)			(-1.073)		
$\Delta C_{n,t}$	**0.0015^a**	**0.0016^b**	0.0012	**0.0014^a**	**0.0015^a**	**0.0016^a**
	(2.674)	(2.639)	(1.540)	(3.304)	(3.319)	(3.719)
$\mathbb{1}_{Post,n,t} \times \Delta C_{n,t}$	-0.0004			0.0001		
	(-0.463)			(0.186)		
N	1610	855	754	1610	855	754
R^2_{adj}	0.275	0.229	0.253	0.400	0.363	0.391
No. of announcements	75	75	75	75	75	75
No. of firms	65	65	65	1014	1014	1014
Event FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Clustered Std. Err.	Event	Event	Event	Event	Event	Event

c: p< 0.1, b: p< 0.05, a: p< 0.01

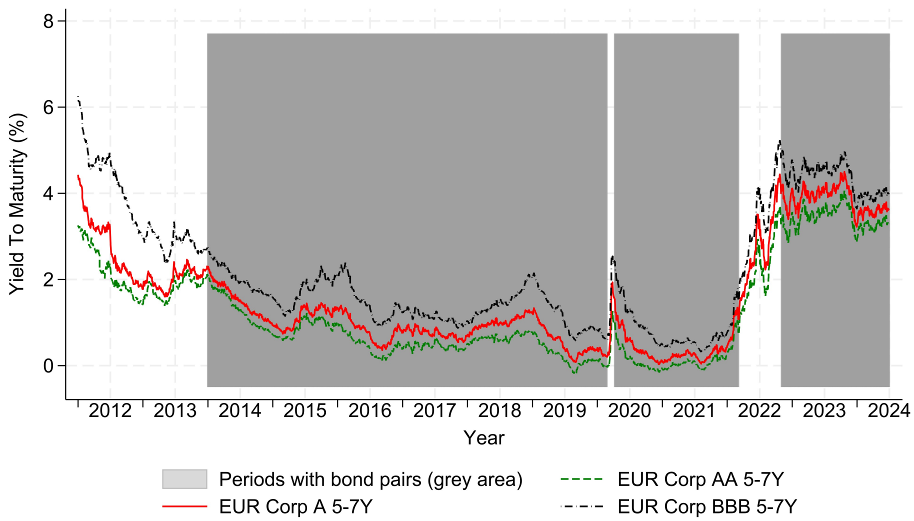
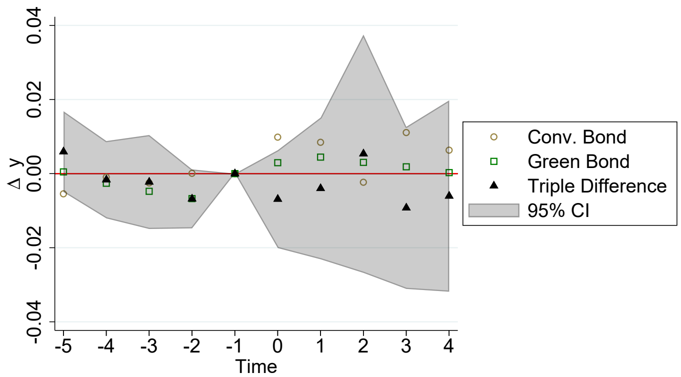
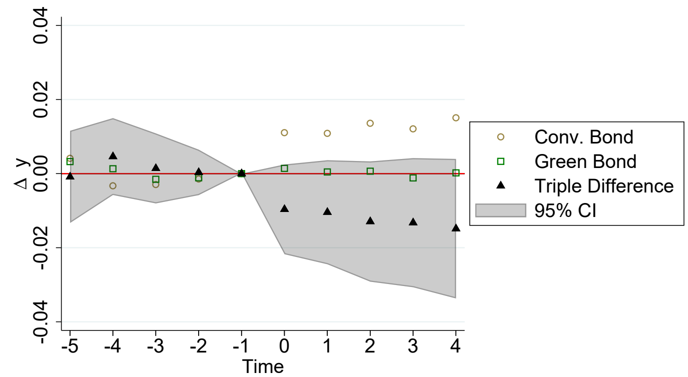


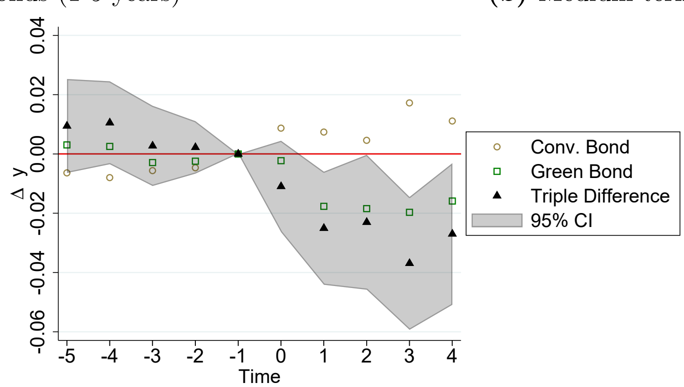
Figure 1: Economic conditions and bond pairs.
This figure highlights the three distinct periods, shaded in gray, within which matched bond pairs occur. The periods are separated by the Covid crisis (February 20 to April 7, 2020) and the recent surge in inflation rates (March 1 to November 1, 2022). It also displays the yield to maturity for three different bond indices, covering EU corporate bonds with residual maturities between 5 and 7 years and credit ratings BBB, A, and AA.



(a) Short-term bonds (1-5 years)



(b) Medium-term bonds (5-10 years)



(c) Long-term bonds ($>$ 10 years)

Figure 2: Trends in yield spreads around bond announcements.
This figure shows trends in $\Delta\bar{y}$, the mean yield spread of the issuer's extant bonds and their matched index, around bond announcements ($t = 0$). Green squares indicate green bond announcements, brown circles represent matched conventional bonds, and black triangles show their difference, which forms the basis of the triple difference analysis. The event window spans ten days $[-5, 4]$, with $t = -1$ as the baseline. Subfigures (a) to (c) present results by bond maturity: (a) short-term (1–5 years), (b) medium-term (5–10 years), and (c) long-term ($>$ 10 years). The model includes fixed effects and clustering at the announcement level, consistent with Specification (10). Shaded areas indicate 95% confidence intervals for the triple difference estimates, reflecting whether coefficients differ from the baseline.

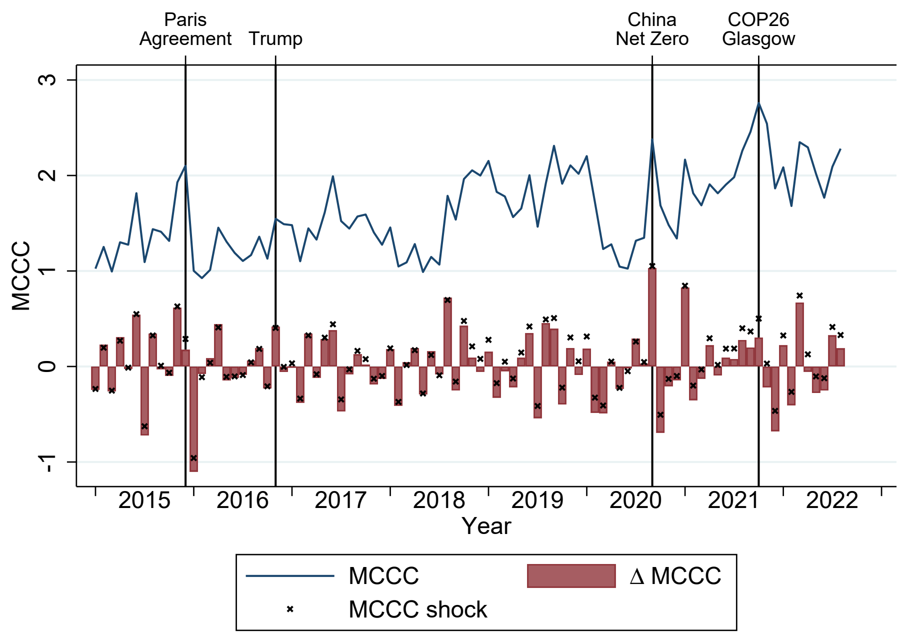


Figure 3: Media climate change concern index and identified climate concern shocks.
This figure presents the MCCC index (blue line) developed by Ardia et al. (2023), monthly changes (red bars), and AR(1) shocks (black crosses) as done by Ardia et al. (2023) and Pástor et al. (2022). Key climate-related events are marked for reference.

A Appendix

A.1 Appendix for model

A.1.1 Proofs - expected true values

This section derives the expected true values of the project for all types and implementation policies. Returns are random variables drawn from a normal distribution and firms benefit from a consistent implementation of a project:

$$R_i^j \sim \begin{cases} N(\mu+\gamma, \sigma^2), & \text{if } i = j. \\ N(\mu-\gamma, \sigma^2), & \text{if } i \neq j. \end{cases} \tag{A1}$$

where $j \in \{g, b\}$ denotes if the project is green- or brown-aligned, and $i\{g, b\}$ defines if the project is implemented in a green or brown way.

Committed policy Under the committed policy the firm implements the project in a green way. The expected true value, denoted by $V(p|j)$ are as follows:

$$V(c|b) = \mathbb{E}[R_g^b] = \mu - \gamma\ , \tag{A2}$$

$$V(c|g) = \mathbb{E}[R_g^g] = \mu + \gamma\ . \tag{A3}$$

Flexible policy Under the flexible policy, the firm selects the better implementation after learning the realizations of the net returns in $t = 1$. Let X_1 and X_2 represent two random variables and $X = \max(X_1, X_2)$. The expected maximum of two independent normally distributed variables with the same variance σ but different means, μ_1 and μ_2, is given by (Nadarajah and Kotz, 2008):

$$E(X) = \mu_1 \Phi\left(\frac{\mu_1 - \mu_2}{\sqrt{2\sigma^2}}\right) + \mu_2 \Phi\left(\frac{\mu_2 - \mu_1}{\sqrt{2\sigma^2}}\right) + \sqrt{2\sigma^2}\phi\left(\frac{\mu_1 - \mu_2}{\sqrt{2\sigma^2}}\right) \tag{A4}$$

Next, I use this result and define the expected values for the parameters given by the

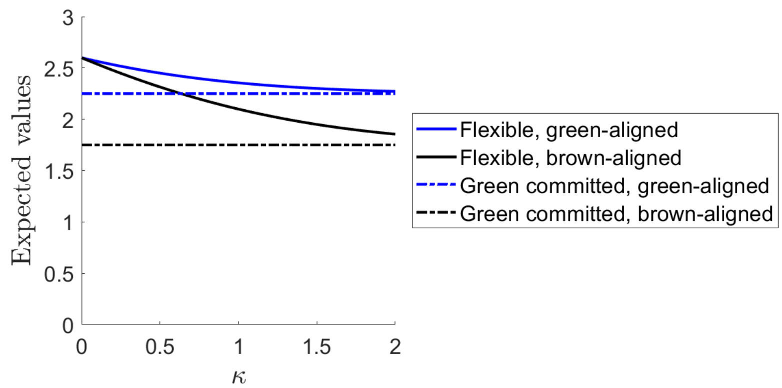


Figure A.1: The figure illustrates the expected true values $V(p|j)$ for the two projects types (brown- and green-aligned) under and two implementation policies (commitment and flexibility) across the adjustment cost κ. The values are simulated for the following parameter values: $\mu = 2$, $\gamma = 2$, $\sigma^2 = 1$.

model. First, for the green-aligned project, $j = g$, the expected true value under the flexible policy can be denoted by $V(f|g) = E[max(R^g_g, R^g_b - \kappa)]$ and equals:

$$E[max(R^g_g, R^g_b - \kappa)] = \mu - \gamma - \kappa + (2\gamma + \kappa)\Phi(\frac{2\gamma + \kappa}{\sqrt{2\sigma^2}}) + \sqrt{2\sigma^2}\phi(\frac{2\gamma + \kappa}{\sqrt{2\sigma^2}}) \quad \text{(A5)}$$

And for $j = b$ it follows that $V(f|b)$ equals:

$$E[max(R^b_g, R^b_b - \kappa)] = \mu + \gamma - \kappa + (-2\gamma + \kappa)\Phi(\frac{-2\gamma + \kappa}{\sqrt{2\sigma^2}}) + \sqrt{2\sigma^2}\phi(\frac{-2\gamma + \kappa}{\sqrt{2\sigma^2}}) \quad \text{(A6)}$$

Figure A.1 plots the expected true values across values of the adjustment cost κ. Two results are discussed subsequently: First, flexibility has value. And second, the cost of giving up flexibility is smaller for the green-aligned project compared to the brown-aligned project.

A.1.2 Value of flexibility - Lemma 1

Lemma 1 states that for both project types $j \in \{g, b\}$, the true value under the flexible policy $V(f|j)$ is greater than under the committed policy $V(c|j)$. The intuition is simple: under the flexible policy, the firm has the additional optionality to observe the realization of returns before deciding between the green and brown implementation, rather than committing to the green implementation at $t = 0$. This result is visible in the simulation in Figure A.1. For the mathematical intuition, consider that $\gamma > 0$, and $\sigma^2 > 0$.

First, for the green-aligned project, the difference in the true values is denoted by $\Delta V(g)$:

$$\Delta V(g) = V(f|g) - V(c|g) \tag{A7}$$

$$= -2\gamma - \kappa + (2\gamma + \kappa)\Phi\left(\frac{2\gamma + \kappa}{\sqrt{2\sigma^2}}\right) + \sqrt{2\sigma^2}\phi\left(\frac{2\gamma + \kappa}{\sqrt{2\sigma^2}}\right) \tag{A8}$$

Because $\frac{2\gamma+\kappa}{\sqrt{2\sigma^2}} > 0$, it follows that $\Phi\left(\frac{2\gamma+\kappa}{\sqrt{2\sigma^2}}\right) > 0.5$, and $\phi\left(\frac{2\gamma+\kappa}{\sqrt{2\sigma^2}}\right) > 0$. As γ and κ grow towards ∞ it follows that $\Phi(..) \to 1$ and $\phi(..) \to 0$, such that $\Delta V(g) \to 0$. However, for relatively small positive values of the parameters it holds that $\Delta V(g) > 0$.

Second, for the brown-aligned project, $\Delta V(b)$ is defined by:

$$\Delta V(b) = V(f|b) - V(c|b) \tag{A9}$$

$$= (2\gamma - \kappa)\left(1 - \Phi\left(\frac{-2\gamma + \kappa}{\sqrt{2\sigma^2}}\right)\right) + \sqrt{2\sigma^2}\phi\left(\frac{-2\gamma + \kappa}{\sqrt{2\sigma^2}}\right) \tag{A10}$$

Similarly, if $\mu \to \infty$ it follows that $\Phi(..) \to 0$ and $\phi(..) \to 0$, and if $\kappa \to \infty$ it follows that $\Phi(..) \to 1$ and $\phi(..) \to 0$. Consequently, if $\gamma \to \infty$ it follows that $\Delta V(b) \to \infty$, and if $\kappa \to \infty$ that $\Delta V(b) \to 0$. For relatively small positive values of the parameters $\Delta V(b) > 0$ holds, as displayed in Figure A.1.

A.1.3 Cost of giving up flexibility - Lemma 2

A firm that commits green has to give up flexibility. Lemma 2 states that the cost of giving up flexibility is smaller for the firm with the green-aligned project compared to the firm with the brown-aligned project. This result is visible in the simulation in Figure A.1: the distance between the solid and dotted line is smaller for the green-aligned project (blue) versus the brown-aligned project (black), especially for relatively small values of κ. An

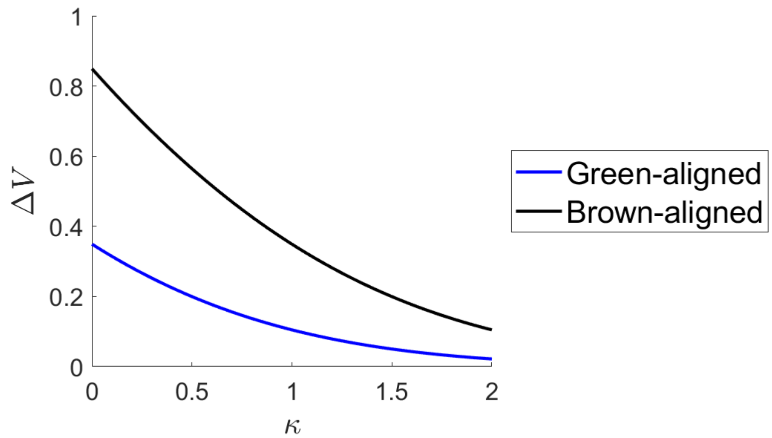


Figure A.2: The figure displays a simulation of the cost of giving up flexibility $\Delta V(j) = V(f|j) - V(c|j)$ for the two project types (brown- and green-aligned) across the adjustment cost κ. The values are simulated for the following parameter values: $\mu = 2$, $\gamma = 2$, $\sigma^2 = 1$.

individual simulation of the cost of giving up flexibility for the two project types is displayed in Figure A.2. Clearly, this Lemma holds only for values of $\kappa < \infty$ because else, the value of flexibility is converging to zero anyways, as discussed above. For values of $\kappa < \infty$ it holds that $\Delta V(g) < \Delta V(b)$:

$$\left((2\gamma+\kappa)(\Phi\left(\frac{2\gamma+\kappa}{\sqrt{2\sigma^2}}\right)-1)\right)+\sqrt{2\sigma^2}\phi\left(\frac{2\gamma+\kappa}{\sqrt{2\sigma^2}}\right)<\left((2\gamma-\kappa)\Phi\left(\frac{2\gamma-\kappa}{\sqrt{2\sigma^2}}\right)\right)+\sqrt{2\sigma^2}\phi\left(\frac{-2\gamma+\kappa}{\sqrt{2\sigma^2}}\right) \tag{A11}$$

A.1.4 Proof - ICs for separating equilibrium

Overview of ICs For simplicity, let $\sigma = 1$ and $\alpha = 0.5$. Using the previously defined expected true values and the market values on the investor's conditional prior belief $\mathcal{P}$, the ICs in the separating equilibrium can be written as follows:

$$V(c|g) > 0.5\,[V(f|b)]] + 0.5\,[V(f|g)]] \tag{IC1}$$

$$V(f|b) > 0.5\,[S(c|g)] + 0.5\,[S(c|b)] \tag{IC2}$$

IC1 denotes the condition for the firm with the green-aligned project, and IC2 for the firm with the brown-aligned project. Using the earlier defined true values, the ICs become:

$$\mu + \gamma > 0.5\left[\mu - \gamma - \kappa + (2\gamma + \kappa)\Phi(\frac{2\gamma + \kappa}{\sqrt{2\sigma^2}}) + \sqrt{2\sigma^2}\phi(\frac{2\gamma + \kappa}{\sqrt{2\sigma^2}})\right]\ldots$$

$$+ 0.5\left[\mu + \gamma - \kappa + (-2\gamma + \kappa)\Phi(\frac{-2\gamma + \kappa}{\sqrt{2\sigma^2}}) + \sqrt{2\sigma^2}\phi(\frac{-2\gamma + \kappa}{\sqrt{2\sigma^2}})\right] \tag{IC1}$$

$$\left[\mu + \gamma - \kappa + (-2\gamma + \kappa)\Phi(\frac{-2\gamma + \kappa}{\sqrt{2\sigma^2}}) + \sqrt{2\sigma^2}\phi(\frac{-2\gamma + \kappa}{\sqrt{2\sigma^2}})\right] > \frac{\mu + \gamma + \mu - \gamma}{2} \tag{IC2}$$

The intuition for IC1 is that the advantage of a consistent implementation for a green-aligned project, γ, must exceed the average value of flexibility while accounting for adjustment costs of both project types. IC2 indicates that the value of the flexible brown-aligned project must be greater than the average values of the green committed projects.

Next, I numerically solve for valid parameter values that satisfy the two ICs in the separating equilibrium.

A.1.5 Simulation of valid parameter values in the separating equilibrium

Figure A.3 simulates valid combinations of γ and κ within the separating equilibrium.

The blue line in the figure plots IC1 for the firm with the green-aligned project. The area above the blue line are valid combination of γ and κ where it is favorable to commit for the firm with the green-aligned project. First, IC1 defines a minimum value for the alignment benefit γ. In order to incentivize the firm with the green-aligned firm to give up flexibility, the green-aligned project has to benefit from implementing the project in a green way. Second, IC1 describes also a minimum κ. A minimum κ is required to ensure positive adjustment costs exist under the flexible policy, making flexibility less valuable. However, as γ increases, the value of flexibility decreases anyways (because a green implementation is favored more and more likely) and the minimum required κ approaches zero.

The black line describes IC2 for the firm with the brown-aligned project. The area left of the black line represents valid parameter combinations where the brown-aligned project prefers flexibility over the green commitment. Given some value of γ, IC2 puts a maximum on the adjustment cost κ. Intuitively, if the adjustment cost κ become large relative to a certain value of γ, flexibility loses more and more value (because the brown implementation will less likely be implemented due to the large adjustment costs). Therefore, committing to a green implementation becomes more attractive for the firm with the brown-aligned project and the separating equilibrium eventually breaks down.

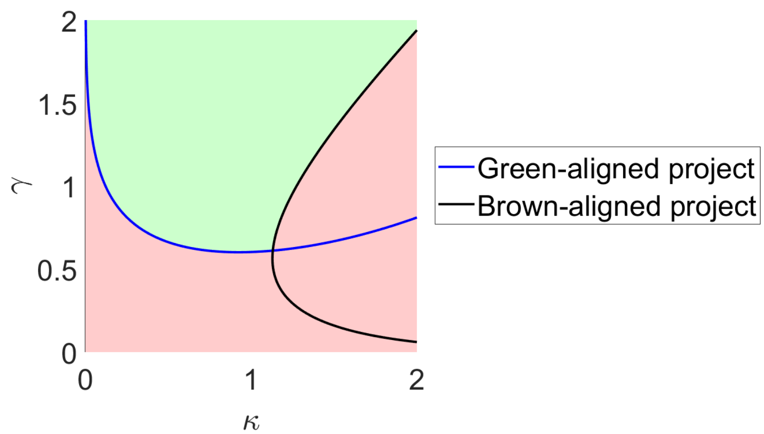


Figure A.3: Validity across values of γ and κ
This figure displays combinations of γ and κ that satisfy the two ICs required for the separating equilibrium lined out by Theorem 1 for parameter values: $\mu = 2$, $sigma = 1$, and $\alpha = 0.5$. The blue line represents IC1, ensuring the firm with the green-aligned project commits to a green implementation and issues a green bond, and the black line represents IC2, ensuring the firm with the brown-aligned project remains flexible and issues a conventional bond. The green area between the two lines covers valid combinations of exogenous parameters that satisfy the ICs for the separating equilibrium.

A.1.6 Prediction of separating equilibrium

In the separating equilibrium green bonds have a beneficial impact on the issuing firm when the true value of the firm with the green-aligned project under the committed policy exceeds the true value of the firm with the brown-aligned project under the flexible policy: $V(c|j = g) > V(f|j = b)$. This condition can be expressed as:

$$V(c|g) > V(f|b)\,,$$
$$0 > -\kappa + (-2\gamma + \kappa)\Phi(\frac{-2\gamma + \kappa}{\sqrt{2\sigma^2}}) + \sqrt{2\sigma^2}\phi(\frac{-2\gamma + \kappa}{\sqrt{2\sigma^2}})$$

This condition holds in the separating equilibrium through IC1. This condition requires that the green-aligned project prefers the commitment over the average of the flexible values of the project types. Since the flexible value of the green-aligned project exceeds the flexible value of the brown-aligned project (as displayed in Figure A.1) it follows that $V(c|g) > V(f|b)$ has to hold in the separating equilibrium. If not, the green-aligned project would not be willing to commit.

A.1 Appendix for empirical analysis

Table A.1: Robustness: Impact of green bond on extant bond yields with BGN quotes. This table shows results of running the identical triple difference regression as given in Specification 10, using market prices retrieved as Bloomberg's "BGN" quotes, as a robustness check for the results documented in Table 5, which are based on Refinitiv Datastream quotes. The dependent variable $\Delta\bar{y}_{n,t}$ is the size-weighted average daily difference in yields between the issuer's extant bonds and their matched bond indices over a ten day event window $[-5, 4]$ surrounding each bond announcement. $\mathbb{1}_{Post,t}$ indicates post bond announcement date observations. $\mathbb{1}_{Green,n}$ indicates if the observation is from a green bond announcement. The coefficient on $\mathbb{1}_{Post,t} \times \mathbb{1}_{Green,n}$ measures the effect of green bond announcement on the yield differentials compared to conventional bond announcements. The results are displayed as average across all, short- ($1-5$ y. residual maturity), medium- ($5-10$ y.), and long-term (>10 y.) bonds. Standard errors are clustered at the bond announcement level. The $\mathbb{1}_{Green,n}$ dummy is not estimated individually, because it is absorbed by bond announcement (event) fixed effects. T-stats are reported in brackets below the coefficients. The symbols a, b, and c indicate significance at the 1%, 5%, and 10% levels (two-sided), respectively. Coefficients that are statistically significant at the at 10%-level or better are highlighted in bold.

	$\Delta\bar{y}_{n,t}$			
	all	$1-5$y	$5-10$y	>10y
$\mathbb{1}_{Post,t}$	**0.0150**^{b}	0.0107	**0.0164**^{b}	**0.0233**^{b}
	(2.383)	(1.588)	(2.198)	(2.216)
$\mathbb{1}_{Post,t} \times \mathbb{1}_{Green,n}$	0.0000	-0.0014	-0.0141	**-0.0272**^{b}
	(-0.799)	(-0.131)	(-1.525)	(-2.345)
N	1880	1700	1320	600
R^2_{adj}	0.985	0.985	0.998	0.992
Event FE	Yes	Yes	Yes	Yes
No. of bond ann. pairs	94	85	66	30

c: p< 0.1, b: p< 0.05, a: p< 0.01

Table A.2: Robustness: issuer characteristics and market conditions.
This table tests whether changes in bond and issuer characteristics (Panel A) or market conditions (Panel B) between announcement dates drive the bond and stock market event study results. Each variable is regressed on the triple-difference coefficient on bond yields, $\beta_{2,n}$, (left) and the difference in abnormal stock returns, DAR, (right). T-statistics are reported in brackets. Explanatory variables include: (i) $\Delta Bonds$, the change in total face value of extant bonds, which represents the difference in total face value of extant bonds of the issuer at the green vs. conventional bond announcement; (ii) $\Delta AnnDates$, the difference in days between announcement dates; (iii) $\Delta Size$, the difference in face value of the announced green and conventional bonds; (iv) $\Delta ResMat$, the difference in residual maturity at issuance. Macroeconomic controls include changes in: (v) *Inflation*, inflation (CPI for US or EU); (vi) *ConsConf*, consumer confidence (conference board survey US; director general for economic and financial affairs survey for EU); (vii) *InvestSent*, investor sentiment (Sentix Index for EU); and (viii) *Commodities*), commodity prices (Bloomberg Commodity Index). The consumer and investor indices, as well as CPI data, are from Refinitiv. The symbols a, b, and c indicate significance at the 1%, 5%, and 10% levels (two-sided), respectively.

Panel A: Issuer and bond characteristics					
	Bond event study $\beta_{2,n}$				Stock event study $DAR_{-2,2}$
		Maturity bucket			
	all	1-5y	5-10y	> 10y	
Panel A1: Difference in extant bonds at announcements and triple difference estimates					
$\Delta Bonds$	0.00001	0.00001	0.00001	0.00002	-0.00000
	(0.93)	(0.589)	(1.089)	(1.168)	(-0.15)
Constant	-0.03155^c	-0.01684	-0.03595^c	-0.08758^b	1.52807^b
	(-1.87)	(-1.138)	(-1.843)	(-2.650)	(2.13)
N	33	30	24	11	50
R^2	0.027	0.012	0.051	0.132	0.000
Panel A2: Time interval between announcements and triple difference estimates					
$\Delta Ann\ Dates$	0.00004	0.00003	0.00007	-0.00006	-0.00199
	(0.874)	(0.737)	(1.373)	(-0.457)	(-1.297)
Constant	-0.04301^c	-0.02645	-0.05973^b	-0.05456	2.52493^b
	(-1.725)	(-1.223)	(-2.116)	(-1.137)	(2.471)
N	33	30	24	11	50
R^2	0.024	0.019	0.079	0.023	0.014
Panel A3: Difference in sizes of announced bonds and triple difference estimates					
$\Delta Size$	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000
	(-0.975)	(-0.745)	(-1.198)	(-0.034)	(-0.658)
Constant	-0.03262^c	-0.02038	-0.04648^c	-0.07112^c	1.29962^c
	(-1.902)	(-1.252)	(-2.022)	(-2.213)	(1.884)
N	33	30	24	11	50
R^2	0.030	0.019	0.061	0.000	-0.012
Panel A4: Difference in residual maturities of announced bonds and triple difference estimates					
$\Delta Resmat$	-0.00004	0.00243	-0.00394	-0.00609	0.16187
	(-0.007)	(0.426)	(-0.483)	(-0.590)	(0.768)
Constant	-0.02620	-0.01581	-0.02858	-0.06737^c	1.44331^b
	(-1.546)	(-1.081)	(-1.449)	(-2.102)	(2.273)
N	33	30	24	11	50
R^2	0.000	0.006	0.011	0.037	-0.008

Panel B: Market characteristics					
	Bond event study $\beta_{2,n}$				Stock event study $DAR_{-2,2}$
		Maturity bucket			
	all	1-5y	5-10y	> 10y	
Panel B1: Difference in inflation rates and triple difference estimates					
$\Delta Inflation$	0.00159	-0.00377	0.01629	-0.00424	0.01123
	(0.212)	(-0.428)	(1.000)	(-0.360)	(0.038)
Constant	-0.02592	-0.01381	-0.03527^c	-0.07605^c	1.35258^b
	(-1.605)	(-0.966)	(-1.806)	(-2.189)	(2.371)
N	33	30	24	11	50
R^2	0.001	0.006	0.043	0.014	0.000
Panel B2: Difference in consumer sentiment and triple difference estimates					
$\Delta ConsConf$	-0.00152	-0.00070	0.00044	-0.00393	0.00108
	(-0.428)	(-0.222)	(0.104)	(-0.543)	(0.022)
Constant	-0.02269	-0.01296	-0.03141	-0.05638	1.34577^b
	(-1.256)	(-0.828)	(-1.500)	(-1.359)	(2.038)
N	33	30	24	11	50
R^2	0.006	0.002	0.000	0.032	0.000
Panel B3: Difference in investor sentiment and triple difference estimates					
$\Delta InvestSent$	-0.00113	-0.00082	-0.00121	-0.00228	0.01595
	(-1.512)	(-1.262)	(-1.257)	(-1.493)	(0.588)
Constant	-0.02080	-0.01035	-0.02524	-0.04244	1.36430^b
	(-1.305)	(-0.726)	(-1.314)	(-1.230)	(2.400)
N	33	30	24	11	50
R^2	0.069	0.054	0.067	0.199	0.007
Panel B4: Difference in commodity prices and triple difference estimates					
$\Delta Commodities$	-0.00164	-0.00150	-0.00312	-0.00173	0.07834
	(-1.095)	(-1.115)	(-1.558)	(-0.633)	(1.411)
Constant	-0.02652	-0.01332	-0.02999	-0.06807^c	1.48752^b
	(-1.680)	(-0.951)	(-1.630)	(-2.147)	(2.624)
N	33	30	24	11	50
R^2	0.037	0.042	0.099	0.043	0.040

c: p< 0.1, b: p< 0.05, a: p< 0.01