Green Bonds: Commitment to Sustainability under Asymmetric Information

Benjamin Schneider*

University of Zurich

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*Department of Finance, University of Zurich, Plattenstrasse 14, CH-8032 Zurich, Switzerland, benjamin.schneider@df.uzh.ch.
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Abstract

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This paper studies the potential of green bonds in addressing information asymmetries related to firms' exposure to climate risks by signalling a commitment to sustainable investing. Using event study and triple-difference methodology on extant debt and equity securities around green bond and comparable conventional bond announcements, it introduces a new identification strategy to assess the impact of green bonds. The results show that green bonds are associated with higher equity valuations and lower bond yields, particularly for longer-maturity bonds, with the effects driven by non-financial issuers and those with lower credit ratings. Financial issuers show no significant impact, likely due to credibility concerns. Green bond issuers also become less sensitive to climate concerns post-announcement, supporting the signalling hypothesis. A green bond signalling model is introduced, illustrating how issuers give up their flexibility and signal a "green commitment," thereby indicating a reduced exposure to climate risks, which results in beneficial effects.
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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. Investors are recognizing climate risks as a significant investment risk (Krueger et al., 2020), and recent studies suggest that these risks are priced in financial markets (Giglio et al., 2021, Bolton and Kacperczyk, 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 the potential of green bonds as a means to support commitments to sustainable investments by benefiting issuers through the mitigation of climate risk related information asymmetries. Green bonds are debt instruments where the proceeds are used to finance sustainable projects. Typically, green bonds are verified by a third party and require issuers to meet specific criteria, including ongoing reporting on the allocation of funds.[1] As a result, green bonds significantly limit the issuers' flexibility in the implementation of the project. The risk of losing the green bond label, along with the associated reputational damage and loss of credibility, raises the cost of any future deviation from a "green" implementation. Empirical studies, such as those by Flammer (2021), Fatica and Panzica (2021), and ElBannan and Löffler (2024), find that green bond issuance is generally associated with improved environmental performance, especially for non-financial firms.[2] Survey evidence by Sangiorgi and Schopohl (2023) highlights a signal to the market as a primary motivation for green bond issuance, alongside reputational benefits and climate change mitigation. Similarly, Lu (2023) emphasizes that monitoring mechanisms, such as reporting and external reviews, bond issuers to institutional oversight and enhance the credibility of green bonds. Collectively, these findings suggest that green bonds act as a

[1] For example, the Green Bond Principles (ICMA, 2021) and the Standard of the Climate Bond Initiative (CBI, 2024) are widely used frameworks in markets over the past decade. Both align "greenness" with sustainable projects that foster a net-zero emission economy and protect the environment.

[2] In contrast, studies that include financial issuers, such as Aswani and Rajgopal (2024) and Bhagat and Yoon (2023), report nonsignificant effects. This underscores the importance of distinguishing between financial and non-financial green bond issuers, a distinction further explored in this paper.

credible signal of a "green" allocation of funds and the issuer's commitment to a consistent implementation, indicating a reduced exposure to climate risks. While theory supports the idea that reducing information asymmetries through credible signals can have beneficial effects (Ross, 1977, Leland and Pyle, 1977, Myers and Majluf, 1984), empirical evidence on the impact of green bonds on the issuer's equity and debt remains inconclusive. Studies examining stock market reactions to green bond announcements report mixed results (e.g., Flammer, 2021, and Aswani and Rajgopal, 2024), as do analyses of the "green bond premium," which compare yields between green and conventional bonds (e.g., Zerbib, 2019, and Larcker and Watts, 2020), as discussed later in more detail.

This paper implements a novel identification strategy, providing evidence that green bonds benefit the issuer by mitigating information asymmetries about its exposure to climate risks, primarily through a signalling mechanism. In a first step, to identify the impact of green bonds on the issuer's debt and equity, this study compares the effects of a green bond announcement on extant debt and equity securities with those of a comparable conventional bond previously announced by the same issuer. Essentially, the analysis employs a triple difference approach on extant bond yields and examines differences in cumulative abnormal stock returns around bond announcements. Controlling for the standard effects of debt announcements is essential for identifying the impact of green bonds, given that debt announcements are found to have negative effects on issuers' stock (Dann and Mikkelson, 1984, Eckbo et al., 2007, or Howton et al., 1998) and existing bonds (Chen and Stock, 2018).

The empirical results show that green bond announcements are associated with lower yields for the issuer's outstanding bonds as well as positive stock price reactions. Bond yields especially benefit in the medium- ($5 - 10$ years) to long-term (> 10 years) range of the maturity spectrum. These benefits are particularly strong for non-financial firms, where yields decline by 7 basis points (bps) at the longer end of the maturity spectrum (> 10 years) over a ten day event window, and the issuer's stock experiences a cumulative abnormal return of 1.5% over a five day window. In contrast, financial firms show no significant abnormal returns in either debt or equity valuation, likely due to credibility concerns. Non-financial firms typically invest in physical assets that are not easily repurposed into non-green assets after the bond's maturity. Conversely, financial firms might finance green loans that can be easily redirected to other purposes. This additional flexibility for financial firms due to the nature of their business may lead to scepticism about their green commitment and can explain the absence of significant market reactions. Additionally, green bond announcements for risky firms generate stronger market reactions, likely because these firms face greater investor uncertainty, making green bonds a more effective tool for reducing information asymmetry.

If green bonds effectively serve as a credible signal of a firm's green commitment and mitigate climate risk information asymmetries, a decline in the issuer's sensitivity to climate risks should be observed after the bond announcement. The idea is that information asymmetries about a firm's exposure to climate risks create investor uncertainty about how these risks impact firm valuation. If green bonds reduce these information asymmetries, a corresponding decline in this sensitivity is expected.

In the second step of the empirical analysis, to examine if green bonds mitigate climate risk information asymmetries, I study the effect of shocks in climate concerns on the stock volatility of green bond issuers as a proxy for the issuers' sensitivity to climate risks, utilising the Media Climate Change Concerns index (MCCC) developed by Ardia et al. (2023). Volatility has been previously linked to information asymmetries (e.g., Kacperczyk and Pagnotta, 2019). The results show that green bond issuers experience a decrease in sensitivity to climate concern shocks following the bond announcement. In contrast, peer firms that did not issue green bonds demonstrate no change in sensitivity during the same period. These findings support the signalling hypothesis, suggesting that green bonds effectively disclose a reduced exposure to climate risks.

The empirical study focuses on the Climate Bond Initiative (CBI) certified and aligned EU and US green bond market between January 2016 and June 2024, ensuring a well established green bond market.[3] Green bond issuers have announced multiple bonds, including both green and conventional, within a short time frame, sometimes even on the same day. To mitigate potential bias from overlapping or simultaneous bond announcements, this study focuses exclusively on events where green bonds were announced, with no other bond announcements occurring within a twenty-day window.

This paper contributes to the broad literature on information asymmetries in financial

[3]The CBI requires that bonds meet specific industry-level criteria and ask for ongoing reporting on fund allocation, verified by third parties (for further details, see CBI (2024)). The CBI dataset includes a broad spectrum of the green bond market, representing up to $4 trillion USD in cumulative issuance as of 2024. Widely used in previous studies, this dataset also serves as foundation for the EU green bond standard, which aims to harmonize the EU green bond market by incorporating current best practices.

markets and the role of signalling to mitigate the potential source of inefficiencies. 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-related risks, the literature has studied how firms disclose environmental information to signal their quality, such as carbon emissions or firm commitments (e.g., Clarkson et al., 2011 or Bolton and Kacperczyk, 2023a). Green bonds, however, offer a distinct form of forward-looking disclosure that is tied to a specific amount of capital. This clear financial commitment sets green bonds apart from other types of environmental disclosure. This perspective is similar but distinctive from Flammer (2021)'s argument that green bonds serve as signal of a firm's overall commitment towards the environment. Here, however, I argue that specifically the committed capital from the proceeds of the green bonds reduces uncertainty about the firm's climate risk exposure.

This paper also contributes to the literature on green bonds by estimating their impact on the valuation of issuer's equity and debt using a novel identification strategy. While a substantial body of research has explored the effects of green bonds, the findings remain mixed. Most research on debt has focused on comparing yields between green and conventional bonds in both primary and secondary markets, estimating a green bond premium that primarily reflects investor preferences for green securities (Baker et al., 2022, Zerbib, 2019, Larcker and Watts, 2020, Flammer, 2021, Kapraun et al., 2021, Pástor et al., 2022, Aswani and Rajgopal, 2024). While some studies have found evidence of a premium, others report no significant difference. Recent research also suggests that the investor preferences driving the green bond premium are time varying (D'Amico et al., 2023, Caramichael and Rapp, 2024). In this paper, I take a different approach by examining how green bond announcements affect the pricing of existing conventional bonds, thereby providing insights into the broader impact of green bonds on the issuers' debt.

The potential impact of green bond issuance on the yields of existing conventional bonds has been previously suggested. Hale (2018) discusses potential "halo" effects of green bonds in the Financial Times, proposing that issuing green bonds could benefit an issuer's overall debt. However, empirical evidence supporting this remains limited. Pope et al. (2023) document long-term downward pressure on conventional bond yield spreads for green bond issuers. Using time-series regression on monthly yield spreads from 2013 to

2021, they report an average decline of 8 bps in conventional bond yield spreads following the issuance of a green bond. The analysis on the issuer's debt presented here differs from that of Pope et al. (2023) in two key aspects: First, it examines the effects of green bonds across the issuer's maturity spectrum and shows that the treatment effect varies across maturity. Second, by employing short event windows and using bond portfolios matched by sector, credit-rating, and maturity, it minimizes the potential bias of curve roll effects, which especially affect long event window regressions (Nyborg and Woschitz, 2024).

The impact of green bonds on the issuer's equity has been similar inconclusive. Prior studies have emphasized the positive impact of green bond announcements on issuers' equity prices (Flammer, 2021, Tang and Zhang, 2020, and others), focusing on cumulative abnormal returns around green bond announcements. However, Aswani and Rajgopal (2024) and Bhagat and Yoon (2023) challenge this evidence, arguing that abnormal returns in short event windows are not statistically significant, and prior evidence is primarily driven by financial issuers. In this paper, the empirical analysis provides new insights by demonstrating that green bond announcements benefit issuers' equity when controlling for the standard effects associated with debt announcements.

Overall, this paper provides new evidence on the beneficial valuation effects of green bonds for both issuers' equity and bond securities, with broader implications for the cost of capital.[4] Given that the data sample primarily consists of issuers with investment-grade ratings, the reduction in bond yields can be linked to a lower cost of debt, without being significantly affected by default risk bias. Furthermore, since green bonds are frequently used to refinance existing projects (Lam and Wurgler, 2024), it is unlikely that their announcements reveal significant news about changes in the issuers' projects or future cash flows. Instead, these findings suggest that green bonds contribute to a lower ex-ante overall cost of capital, primarily by signalling a reduced exposure to climate risks. Unlike prior research, which largely attributes cost of capital effects to investor preferences for green securities (see above), this paper emphasizes the importance of the green bond signalling mechanism. Consistent with El Ghoul et al. (2011), Chava (2014), Pástor et al. (2021), and Eskildsen et al. (2024) the results suggest that sustainability, or "greenness," is rewarded

[4]According to the Merton (1974) model, equity and debt valuations typically move together when information asymmetries concern asset values. However, when these asymmetries relate to volatility, equity and debt may move in opposite directions. The empirical results suggest that green bonds primarily speak to asset values, as both debt and equity respond positively to their announcements.

with a lower ex-ante cost of capital.

Additionally, this paper introduces a theoretical signalling model for green bonds that demonstrates how green bonds signal a firm's green commitment and address information asymmetries related to climate risks. The model establishes a separating equilibrium where firms issue green bonds when they decide to sacrifice flexibility and commit to green project implementation, thereby credibly reducing their exposure to climate risks.

This model is similar but distinct from that of Daubanes et al. (2024). In their signalling model, green bond issuances are linked to carbon policies, investor preferences, and managerial sensitivity to stock prices. Analyzing a continuum of firms with projects that vary in the profitability of green implementation, they find that only the most profitable green projects are financed through green bonds because managers benefit from positive stock price reactions. Similarly, Gao and Schmittmann (2022) explain the existence of a green bond premium through asymmetric information about firm types, future carbon taxes, and the costs associated with greenwashing. In their model, green bonds serve as signals of low-emission firm types, which indicates lower default risk due to reduced exposure to carbon taxes. Analyzing firms with varying emission levels they link the size of the green bond premium and the amount of greenwashing to the level of carbon taxes.

In contrast, the model presented here focuses on a single firm's decision to finance a project with either a green or conventional bond, thereby abstracting from broader market dynamics. The emphasis is on the information asymmetries regarding the firm's exposure to climate risks. This model specifically explores the trade-off between the flexibility offered by conventional bonds and the value of the credible signal of a green commitment provided by green bonds, which indicates reduced climate risk exposure. Notably, green bonds not only reveal the project type but also certify a firm's commitment to a green implementation. This distinction is important because, while green bonds are often used to refinance existing projects in practice (Lam and Wurgler, 2024), the model demonstrates that they also signal the issuer's commitment, thereby revealing additional information.

The remainder of this paper is structured as follows. Section 2 presents the green bond signalling model, Section 3 discusses the data and methodology, Section 4 and 5 analyse the impact of green bonds on issuers' debt and equity, respectively, and Section 6 studies how green bonds affect issuers' sensitivity to climate concerns. Finally, Section 7 concludes.

2 Green bond signalling model

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

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 and is not explicitly modelled. 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). The alignment, denoted by $j \in \{g, b\}$, is private information to the firm, where $j = g$ represents a green-aligned project and $j = b$ a brown-aligned project.

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 $p = f$ represents flexibility that allows to decide about the implementation at a later stage. For example, the green commitment could involve the firm's board voting on the green implementation, making it institutionally difficult to reverse later, or the firm making verbal agreements with long-time business partners, creating relational pressure to adhere. Importantly, this decision is not observable to investors.

Both project types require the same amount of funding. But, the firm has no assets 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. Investors are assumed to always 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 both green and brown implementations. This can be seen as the firm observing market conditions or input prices that allow it to assess the returns from green or brown implementation. If committed to green, the firm must follow through with the green implementation. If flexible, it selects the implementation yielding the highest net return. The implementation decision is denoted by $i \in \{g, b\}$, where $i = g$ is the green implementation and $i = b$ is the 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 in a way that is either consistent or inconsistent with its alignment. For the example of 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 yields a higher expected net return than an inconsistent one.*

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" from implementing a project consistently, and σ is the standard deviation. The difference in expected net returns between consistent and inconsistent implementations is 2γ.[5]

The conditional expected net return in $t = 0$ is a function of the implementation policy p and project type j, and is denoted by $S(p, j)$. Under the committed policy ($p = c$), the firm is bound to implement the project as green ($i = g$). The conditional expected net returns before deciding about the implementation policy, denoted by $S(c|j)$, are as follows:[6]

$$\text{Brown-aligned project:} \quad S(c|j = b) = E[R_g^b] = \mu - \gamma\,, \tag{2}$$

$$\text{and green-aligned project:} \quad S(c|j = g) = E[R_g^g] = \mu + \gamma\,. \tag{3}$$

Under the flexible policy ($p = f$), the firm chooses the implementation that yields the higher realized net return. The expected net return before deciding the implementation

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

[6] For a detailed calculation of the expected returns calculated in this section see Appendix A.1.1.

policy is the expected maximum of two independent normally distributed variables with different means and same standard deviation (Nadarajah and Kotz, 2008). It has the same value for the two project types because the distributions of net returns are symmetric. Therefore the expected net return in $t = 0$ under the flexible policy is unconditional on the project type:

$$S(f) = E\left[\max(R_g^j, R_b^j)\right] = \mu + \frac{\sigma}{\sqrt{\pi}} + \gamma\left[2\Phi\left(\frac{2\gamma}{\sqrt{2\sigma^2}}\right) - 1\right], \tag{4}$$

where Φ is the standard normal cumulative distribution function. $S(f)$ consists of three parts: first, μ, the fundamental expected value; second, $\frac{\sigma}{\sqrt{\pi}}$, a fraction that describes the additional value from flexibility, which increases with the standard deviation of the underlying returns; and third, $\gamma\left[2\Phi\left(\frac{2\gamma}{\sqrt{2\sigma^2}}\right) - 1\right]$, an additional value from flexibility that increases with 2γ, the difference between the means of a consistent versus inconsistent implementation.[7]

2.2 Green law and expected adjustment costs

Assumption 2. *In $t = 2$ regulators will introduce a green law to tackle climate change, which is known with certainty. The firm is required to comply with the new regulation. A brown implementation accumulates brown assets on the firm's balance sheet that incur adjustment costs $\kappa > 0$, while a green implementation does not require any adjustments.*

Let the adjustment cost associated with the green law be denoted by $K(i)$, where i represents the implementation choice:

$$K(i) = \begin{cases} 0, & \text{if } i = g. \\ \kappa > 0, & \text{if } i = b. \end{cases} \tag{5}$$

A brown implementation has negative externalities, such as high carbon emissions or pollution. The green law can be viewed as a regulatory measure to force the firm to internalise these negative externalities, with the adjustment cost κ directly impacting the net return of the brown implementation. Given that the green law is certain, the firm will only choose

[7] See Appendix A.1.1 for detailed calculations of the expected values and the derivatives with respect to γ.

a brown implementation if its net return, after accounting for adjustment costs, exceed the net return from a green implementation; that is, if $R_b^j - \kappa > R_g^j$.

The expected adjustment costs are conditional on the project type, j, and the firm's implementation policy, p. These are positive under the flexible policy, $E[K|j, p = f] = P(R_b^j - \kappa > R_g^j|j) \times \kappa > 0$, and zero under the committed policy, $E[K|j, p = c] = 0$. Using the above distributions of the net returns, the conditional expected adjustment costs under the flexible policy are:[8]

$$\text{Brown-aligned project:} \quad E[K|j = b, p = f] = \left[\Phi\left(\frac{2\gamma - \kappa}{\sqrt{2\sigma^2}}\right)\right]\kappa\,, \tag{6}$$

$$\text{and green-aligned project:} \quad E[K|j = g, p = f] = \left[1 - \Phi\left(\frac{2\gamma + \kappa}{\sqrt{2\sigma^2}}\right)\right]\kappa\,, \tag{7}$$

where $\Phi\left(\frac{2\gamma-\kappa}{\sqrt{2\sigma^2}}\right)$ represents the probability that, for a brown-aligned project, the brown implementation with adjustment costs yields a higher return than the green implementation, and $1 - \Phi\left(\frac{2\gamma+\kappa}{\sqrt{2\sigma^2}}\right)$ represents the probability that, for a green-aligned project, the brown implementation with adjustment costs yields a higher return than the green implementation.

The conditional expected adjustment costs are lower for the green-aligned project than the brown-aligned project due to the alignment benefit. As described in Equation 1, it is less likely that for a green- (brown-) aligned project, the brown (green) implementation results a higher return than the green (brown) implementation. Moreover, the conditional expected adjustment costs are not linearly increasing in κ; as κ increases, the likelihood of choosing the brown implementation decreases, reducing the likelihood of incurring the adjustment cost.

2.3 The project's expected true value

The expected true value of project type j following policy p at $t = 0$ can be expressed as:

$$V(p|j) = S(p|j) - E[K|j, p]\,, \tag{8}$$

[8]Detailed calculations and simulations of conditional expected adjustment costs for different parameter values are provided in Appendix A.1.2, with two specific cases illustrated in Figure A.1.

which is the total of the expected net return minus the conditional expected adjustment costs. The true value is independent of the firm's bond type choice. In the Appendix A.1.3, I list all potential true values resulting for the different combinations of project types and implementation policies.

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

The intuition for Lemma 1 is simple: The ability to select the maximum of the two random independent net returns provides an extra value compared to committing to green. Even though the conditional expected adjustment costs reduce the value of flexibility, the additional optionality of implementing the project brown in case the realized return is large enough, still provides value. This holds for both project types.[9]

2.4 Information asymmetries and green bond signalling

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 signalling game the firm could use this action to signal its project type. However, in this model, the policy is not observable to investors.

In this model, the firm can use the bond issuance as a secondary layer of signalling. The firm can either 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. Additionally, there are no costs associated with either bond type issuance. The bond type, $\tau \in \{\mathcal{GB}, \mathcal{CB}\}$, is observable to investors.

[9] See Appendix A.1.4 for detailed calculations. Additionally, Figure A.2 simulates the true values of the two project types under different policies for different parameters (across κ on the left and across γ on the right). The figure provides the intuition that the true value of a committed firm never exceeds the true value of the flexible policy.

2.5 The firm's strategies and investors' beliefs

The firm maximizes a combination of its market value and true value (Ross, 1977; Miller and Rock, 1985). It assigns weight α to its market value and $(1-\alpha)$ to its true value. The objective function can be written as:

$$u(p, \tau | j) = \alpha \hat{V}(\tau) + (1-\alpha) V(p|j) \ , \tag{9}$$

where $\hat{V}(\tau)$ represents the market value of the project as a function of the bond type, τ, and $V(p|j)$ represents the expected true value of the project before learning the realization of returns. For simplicity, let the weight for the market valuation be $\alpha = 0.5$.

The firm's optimal strategy depends on the market valuation of the project. The market valuation depends, in turn, on the strategy that investors believe the firm is following. Therefore, to study any equilibrium, the model needs to describe how investors' beliefs are formed and updated.

First, investors have prior beliefs $P(j)$ over the firm's project types, $j \in \{g, b\}$. These prior beliefs reflect the initial assumptions investors make about whether the project is green- or brown-aligned, before any actions are observed. Next, the firm makes an observable decision by issuing either a green bond, $\mathcal{GB}$, or a conventional bond, $\mathcal{CB}$. When investors observe the bond type, they update their prior beliefs to form posterior beliefs about the firm's project type, using Bayes' Rule to do so in a rational way. However, because the firm's implementation policy, p, is not directly observable, investors must form joint beliefs about both the project type, j, and the policy, p. These joint posterior beliefs, $P(j, p|\mathcal{GB})$ and $P(j, p|\mathcal{CB})$, represent the updated probabilities investors assign to different combinations of project types and policies, based on the observed bond issuance.

Given these updated beliefs, the market value of the project, based on bond type τ, is the probability weighted average of the true values of the project:

$$\hat{V}(\tau) = \sum_{j,p} P(j, p|\tau) V(p|j) \tag{10}$$

2.6 Separating equilibrium

In this section, I show that there are values of exogenous parameters such that a separating equilibrium exists in which the firm with the green-aligned project commits to the 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 firm's project type, implementation policy, and bond issuance are perfectly aligned, allowing investors to fully infer the project type and implementation policy based solely on the type of bond issued.

This separating equilibrium is driven by the advantage of a consistent implementation of green-aligned projects, captured by the alignment benefit γ, as described in Assumption 1, and follows through the trade off between the value of flexibility, as described by Lemma 1, and the avoidance of adjustment costs to the green law through a green commitment, as noted in Assumption 2.

In this equilibrium, the investors' joint posterior beliefs are clear: $\mathcal{P}(j = g, p = c|\mathcal{GB}) = 1$ and $\mathcal{P}(j = b, p = f|\mathcal{CB}) = 1$. This means that if investors observe a green bond, they are certain that the project is green-aligned and the policy is committed. Conversely, if they observe a conventional bond, investors are certain that the project is brown-aligned and follows a flexible policy. Any other combination of project type and investment policy is assigned a posterior probability of zero.

2.6.1 Incentive compatibility conditions

The existence of the separating equilibrium requires that the firm's decisions satisfy certain incentive compatibility (IC) conditions, ensuring that for each project type the firm follows the strategy that maximizes its utility, given investors equilibrium beliefs $\mathcal{P}$. The model setup allows to rule out some actions, reducing the number of IC conditions that need to be examined.

First, due to the exogenous certification process for green bonds (see above), any firm issuing a green bond must commit to a green implementation. Therefore, it is impossible for a firm to issue a green bond while following a flexible policy: $P(p = f|\mathcal{GB}) = 0$.

Second, a firm issuing a conventional bond always follows a flexible policy, implying $P(p = c|\mathcal{CB}) = 0$. This is because the project's true value under the flexible policy exceeds that under the committed policy, $V(f|j) > V(c|j)$, as shown in Lemma 1. Therefore, in the separating equilibrium, flexibility with a conventional bond always dominates commitment with a conventional bond: $u(f, \mathcal{CB}|j) > u(c, \mathcal{CB}|j)$. The firm can increase its utility by switching to a flexible policy, because it increases the true value of the project without affecting its market value, which is based on the bond type and investors beliefs.

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

$$u(c, \mathcal{GB}|g) = V(c|g) > u(f, \mathcal{CB}|g) = 0.5[V(f|b) + V(f|g)] \qquad \text{(IC1)} \qquad (11)$$

$$u(f, \mathcal{CB}|b) = V(f|b) > u(c, \mathcal{GB}|b) = 0.5[V(c|g) + V(c|b)] \qquad \text{(IC2)} \qquad (12)$$

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 ICs imposes restrictions on the parameters γ, κ, α and σ. In the Appendix A.1.5 and A.1.6 I numerically solve a simplified case, where $\sigma = 1$ (the standard deviation of random returns) and $\alpha = 0.5$ (the weight firms assign to the market value in their utility function), to identify valid combinations of $\gamma > 0$ and $\kappa > 0$ that satisfy the conditions for the separating equilibrium (Figure A.3). The solution highlights two key restrictions: First, the alignment benefit γ must exceed a certain threshold to incentivise the firm with the green-aligned project to commit to a green implementation and forgo flexibility. Second, given a specific value of γ, the adjustment cost κ for a brown implementation must lie within a certain range. The lower bound ensures that conditional expected adjustment costs are sufficiently large to encourage the firm with the green-aligned project to commit green. The upper bound prevents conditional expected adjustment costs from becoming so high that flexibility becomes too expensive for the firm with the brown-aligned project.

2.7 Predictions of the separating equilibrium

In this section, I discuss the predictions for a green bond announcement 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.*

The proposition follows directly from IC1. Specifically, IC1 requires that the expected true value of a green-aligned project under the committed policy, $V(c|g)$, exceeds the weighted average of the flexible projects: $0.5V(f|g) + 0.5V(f|b)$. Since, under the flexible policy, expected adjustment costs for the green-aligned project are smaller than for the brown-aligned project (see Equation 6 and 7), we have: $V(f|g) > V(f|b)$. It follows that $V(c|g) > V(f|b)$.

Proposition 2. *In the separating equilibrium, the green-aligned project's underlying assets become unaffected to changes in the adjustment costs for brown assets, κ, after the announcement of a green bond: $\frac{\delta V(c|g)}{\delta \kappa} = 0$. In other words, changes in the perception of future climate policies do not affect the market valuation of the green bond's underlying assets.*

This result follows because, in the separating equilibrium, the green bond effectively reveals the firm's project type ($j = g$) and its green commitment ($p = c$). The underlying project avoids adjustment costs associated with brown assets (κ). Therefore, after the green bond announcement, the market valuation of these assets becomes insensitive to changes in the adjustment costs for brown assets κ, $\frac{\delta V(c|g)}{\delta \kappa} = 0$.

In conclusion, there is a separating equilibrium where the choice of bond type signals whether a firm is committed to green implementation of its project. The commitment has the advantage that it renders the firm immune to future green regulation. For this reason, the model predicts that green bonds are associated with a higher valuation of the underlying assets and that these assets become insensitive to changes in the perception of future green regulation.

3 Data and methodology

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

3.1 Green bond sample construction

The underlying dataset is the green bond list from the Refinitiv Eikon database.[10] The list includes 11,798 green bonds from 2,958 issuers. This study focuses on the US and EU green bond market (i.e. green bond issuers from the US or EU countries) over a time period from January 1, 2016 to June 22, 2024. The start of the time period ensures that the study covers a well established green bond market. The Eikon green bond list covers 4,834 green bonds from 924 organizations for the US and EU green bond market over the defined time period.

In order to conduct the empirical analysis, the green bond list is subjected to additional criteria. First, a total of 1,365 green bond announcements are excluded from the analysis due to missing data on the issuer's credit rating (either Moody's or Fitch).[11] The data on credit ratings is gathered from Eikon. Second, the list from Eikon includes securities that do not qualify as traditional bonds, such as certificates and non-tradeable registered notes. To ensure a coherent bond sample, 539 securities with maturities of under one year (e.g., commercial papers, discount notes, and certificates) and non-tradable registered securities are dropped. Third, some issuers announce multiple bonds either on the same date or within a short time period. This study focuses on dates where, first, issuers announce exclusively green bonds, second, the announced green bonds share the same seniority,[12] 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

[10]The green bond list was downloaded on June 22, 2024.

[11]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." In cases where no rating is available for the issuer itself, credit ratings of parent companies are aggregated and assigned to the respective announcement.

[12]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.

and a size weighted average residual maturity. The remaining dataset covers 1,102 green bond announcement dates from 460 issuers.

3.2 Comparable conventional bond announcements

To control for the standard impact of a debt announcement on the valuation of the issuer's extant securities, the event studies around green bond announcements are compared with results from a comparable conventional bond announcement made previously by the same issuer. The process of identifying and matching a comparable conventional bond announcement is outlined as follows.

Initially, conventional bonds issued by the same issuer between 1 month and 5 years prior the green bond announcement are gathered from the Eikon database. As done for the green bond sample, I drop short term securities with a residual maturity of less than one year and non-tradable registered securities to ensure a coherent sample of conventional bond announcements. I keep only announcement dates where, first, issuers announce exclusively conventional bonds, second, the announced bonds share the same seniority, and third, the issuer has no other close announcement within a twenty day window $[-10, 9]$. For each announcement date the total issued face value in US Dollars and a size weighted average residual maturity are calculated.

Then, a conventional bond announcement is matched to a green bond announcement based on the following criteria: (1) the conventional bond is issued by the same issuer, (2) it has been announced between 1 month and 5 years prior to the green bond, (3) it has the same seniority as the green bond, (4) its residual maturity at issuance falls within 0.5x and 1.5x that of the green bond, and (5) its total issued face value falls within 0.25x and 4x the size of the green bond. This matching procedure identifies 449 green bond announcements from 227 issuers with at least one matched comparable conventional bond announcement.

Shifts in economic conditions might impact firm's bond announcements (see subsequent section on underlying assumptions for more details). To ensure matched bond pairs fall within similar economic environment, the dataset is split into three periods, defined by two major events: the Covid-19 crisis and the recent surge in inflation.

First, 163 pairs are excluded because either the green bond or its matched conventional bond was announced during significant market volatility during the Covid crisis. Specifically, both announcement must occur outside the period from February 20 to April 7, 2020, and must either both precede or follow the Covid crisis. The resulting dataset includes 286 green bond announcements from 166 issuers.

Second, due to significant changes in interest rates driven by rising inflation, bond announcements between March 1, 2022 and November 1, 2022, are also excluded. Both announcements in each matched pair must occur either before or after this period. Lastly, matched conventional bonds are only considered if announced after January 1, 2014.

This process defines three specific periods during which matched bond pairs occur: (1) January 1, 2014, to February 20, 2020; (2) April 7, 2020, to March 1, 2022; and (3) November 1, 2022, to June 22, 2024. These periods are displayed in Figure 1, which plots interest rates on EU corporate debt across three risk classes for bonds with maturities between 5 and 7 years. The final dataset contains 194 green bond announcements from 130 issuers, each with at least one matched conventional bond.

Insert Figure 1 here.

Lastly, in cases where multiple candidates match the same green bond announcement, I keep only the closest bond based on the announcement date, resulting in a dataset of 194 bond announcement pairs from 130 issuers.

3.3 Underlying assumptions for identification

This section discusses the underlying assumptions of the applied identification strategy. The process involves comparing bond announcements from the same issuer at two different points in time. Each green bond is paired with a previously announced conventional bond with similar features. The premise is that market reactions to both debt announcements should be similar, assuming no changes in other external conditions.

However, market conditions can change significantly over time, potentially influencing the results. To account for this, the final sample includes only matched bond pairs announced during periods of similar economic conditions, explicitly excluding those during the Covid crisis and the recent surge in inflation rates (see Figure 1). Furthermore, Table IA.1 in the Internet Appendix shows that there is no significant structural relationship between the length of the interval between the two announcement dates and the empirical results. Additionally, Table IA.5 confirms that the findings are not driven by changes in other macroeconomic variables, such as the inflation rates, consumer confidence, investor sentiment, or commodity prices, confirming the robustness of the event studies regarding shifts in market conditions between announcements.

Second, the market's reaction may vary if investor's assessments of the issuer has changed over time. Although the matching criteria in this study control for this by ensuring the issuer maintains the same credit rating at both announcement dates, credit ratings can be sticky and may not fully capture changes in investor perceptions. To address this concern, I also test for changes in the total face value of the issuer's extant bonds at both announcement dates, because shifts in the issuer's capital structure could influence investor's assessments. Descriptive statistics in the Internet Appendix (Table IA.2) show an increase in the total size of extant bonds between the conventional and green bond announcement, indicating that issuers typically increase leverage. Additionally, Table IA.3 shows that this change in the size of extant bonds does not drive the empirical results, confirming the robustness of the event study regarding shifts in issuer characteristics between announcements.

3.4 Data - bond event study

To conduct the bond event study I download data on all conventional bonds of the issuers that are extant during the bond announcements from Refinitiv Eikon. These conventional bonds are filtered for exclusively unsecured straight bonds in order to exclude any financial side effects. Furthermore, the dataset is limited to bonds with a residual maturity between 1 and 30 years. This range is chosen to align the maturities with the bond indices, which are later matched as benchmarks in the event studies. The US and EU datasets are individually pruned for weekends and holidays in order to apply the event studies on business days. Pricing data for the extant conventional bonds is collected from Refinitiv Datastream. For each extant bond, a ten business day event window [-5,4] around the anncouncement is considered. The dataset is pruned for missing pricing data (i.e., data on the ask- or bid-price is missing), and for stale prices (i.e., no movement in ask- and bid-price from the previous day).

Data on bond indices is used as benchmark for the extant conventional bonds, following the matching portfolio approach suggested by Bessembinder et al. (2009) applied on bond yields. For the EU, I use data on the iBoxx bond index family provided by the International Index Company. For the US, I collect data from the ICE Bank of America bond index family. Time series data are downloaded from Refinitiv Datastream. The indices are selected to match extant conventional bonds regarding their continental origin, sector, currency, credit rating and maturity. The index families provide indices for specific sectors (sovereign and corporate), credit ratings and maturity spans for issuers from EU countries and the US. The maturity ranges covered by the indices are 1-3 years, 3-5 years, 5-7 years, 7-10 years, and >10 years. To avoid severe mismatches, I drop observations where the yield to maturity differential between the bond and the matched index exceeds 3%. Bonds that do not have all ten observations are excluded from the analysis.[13]

In summary, there is pricing data available for 1,620 extant conventional bonds around 108 green bond announcements from 75 issuers, resulting a dataset covering 19,980 bond-day observations. Additionally, pricing data is available for 1,594 extant conventional bonds around 91 comparable conventional bond announcements, leading to a dataset covering 17,820 bond-day observations. Note that some comparable conventional bond announcements serve as benchmark for more than one green bond announcement and that some conventional bonds are extant at more than one bond announcement.

3.5 Data - stock event study

For the stock event study, stock prices are collected from Refinitiv Datastream. The dataset for the stock event study is limited to publicly traded firms.[14] Similar to the bond dataset, the US and EU datasets are individually adjusted to exclude weekends and holidays, ensuring that only business days are used in the subsequent analysis. The stock price data is pruned for missing price data and stale prices, following the same procedure applied to the bond price data. The empirical analysis employs total returns, and observations with missing total return data are excluded. To conduct the analysis, stock price data must be available for each day within a twenty-business-day event window [-10,9] surrounding the bond announcements. Furthermore, for the beta estimation prior the announcement,

[13]This approach ensures that there are no biases from illiquidity that impact the empirical analysis. Given potential ambiguity about whether the quotes from Refinitiv Datastream are actual market prices or theoretical estimates, I also retrieve market price quotes for these Bonds from Bloomberg. Specifically, I specify the price source as "BGN" in Bloomberg, which ensures that the quotes are market prices. For the subset of bonds with available BGN prices, I replicate the analysis to test the robustness of main results concerning the impact on debt, as presented in the Internet Appendix Table IA.7.

[14]In cases where a green bond announcement is linked to a subdivision of a firm, which is not publicly traded, I check the the availability of stock prices for the parent firm. For 33 announcement pairs where stock price data is not available for the issuer, stock price data of the parent firm is used.

stock price data must be available for at least 75% of the days in the estimation window [-250,-21]. Sufficient stock price data meeting these criteria is available for 74 green bond announcements with 52 matched conventional bond announcements from 61 issuers. As benchmark data for the stock event study total returns of country-level stock indices are used.[15]

3.6 Descriptive statistics on the final dataset

Table 1 provides an overview of the final green bond dataset used in the bond and stock event studies. Panel A presents the number of matched announcement pairs. The bond event study includes 108 announcement pairs from 75 issuers, while the stock event study comprises 74 announcement pairs from 52 issuers. Panel B displays the distribution of announcements and issuers across countries and sectors. Panel C shows the distribution of announcement pairs and issuers across six harmonized rating classes. To ensure consistency, the credit ratings from Moody's and Fitch are consolidated into a harmonized credit rating system. Panel C illustrates how credit ratings are grouped into six rating classes, with class 1 representing the highest ratings.

Insert Table 1 here.

Table 2 provides descriptive statistics on the matched announcement pairs and compares key bond characteristics. Panel A provides description of the dataset used in the bond event study, and Panel B for the stock event study.

Insert Table 2 here.

The two panels start with describing the distribution of announcement across issuers, revealing that most issuers have one or two announcements within the dataset.

Then, they show the distribution of green bond announcement relative to their matched comparable conventional bond announcements. A few comparable conventional bond announcements are identified as control events for more than one green bond announcement. Also, the announcement dates of most matched bond pairs are relatively close, occurring within 1 year.

[15] The stock indices correspond to the leading stock indices for the countries where the green bond issuer are based. Examples are the CAC40 for France, DAX30 for Germany, IBEX35 for Spain, and so on. If there is no data available for a country-level total return index I use the STOXX Europe 600 index.

Then, the two panels present key bond characteristics of the green bonds and their matched comparable conventional bond. The residual maturities of the matched bonds are generally similar, with green bonds having on average a slightly longer residual maturity at issuance compared to their comparable conventional bonds. The size of the matched bonds is also similar, but green bonds are on average relatively smaller than their comparable conventional bonds.[16]

Table 3 presents the dataset of extant conventional bonds around the bond announcements, which serve as the underlying data for the bond event studies. Panel A displays the distribution of the number of extant conventional bonds around bond announcements. Panel B showcases the distribution of announcement pairs with extant bonds across residual maturity buckets. Extant bonds are well distributed across the maturity spectrum, allowing for the study of the impact of green bond announcements across different maturity buckets.

Insert Table 3 here.

Lastly, Table 4 displays the relative sizes of announced green bonds across different sectors in the bond (Panel A) and stock (Panel B) event studies. The sectors described in Panel B of Table 1 are grouped into three main categories: (1) "non-financials", (2) "financials", and (3) "public sector."[17] Each Panel is divided into three sections: (1) the distribution of the green bond sizes in million USD, (2) the distribution of the total size of the issuer's extant bonds, and (3) the relative size of green bonds to the issuer's extant bonds.

For the bond event study, non-financial issuers account for 33 announcements, averaging 975 million USD, financials for 42 announcement, averaging 859 million USD, and the public sector for 33 announcements, averaging 2,919 million USD. In the stock event study, non-financials have 50 announcements, averaging 793 million USD, while financials have 24 announcements, averaging 919 million USD. Green bonds from non-financial issuers comprise around 12.1% (17.6%) in the bond (stock) market sample of the issuer's extant bonds. Green bonds from financial and public sector issuers have a relative size of around

[16]Table IA.4 in the Internet Appendix demonstrates that these remaining differences in bond characteristics do not drive the subsequent empirical results.

[17]Specifically, the public sector includes issuers classified as "Agency", "Sovereign", "Supranational", and "Municipal", financials covers "Banks" and "Other-Financials", and non-financials cover all remaining sectors described in Panel B of Table 1.

7.5% in the bond market sample, and 3.65% for the financials in the stock market sample.

Insert Table 4 here.

4 Impact on debt

To study the impact of green bond announcements on the valuation on the issuer's extant debt across its maturity spectrum, I conduct a triple difference analysis on bond yields.[18]

In a first step, I calculate the difference between the issuer's extant conventional bond, j, and the matched control bond index, p, for a ten business day event window around a bond announcement, $t \in [-5, 4]$:

$$\Delta y_{j,t} = y_t^j - y_t^p \tag{13}$$

where y^j denotes the yield to maturity of an extant bond, y^p denotes the yield to maturity of the matched bond index, and t indicates the time within the event window. As mentioned earlier, the bond index is matched based on the issuer's continental origin, sector, credit rating, and the bond's residual maturity.

To address the presence of multiple extant bonds from the same issuer during a bond announcement, I apply the firm-level approach proposed by Bessembinder et al. (2009) on bond yields. Specifically, I calculate the size-weighted difference in yields across all J extant conventional bonds for day, t, around each bond announcement, n,:

$$\Delta \bar{y}_{n,t} = \sum_{j=1}^{J} \Delta y_{j,t} \times w_j \ , \tag{14}$$

where J denotes the total number of extant conventional bonds around bond announcement n, t indicates the time within the event window, and w_j is the weight for bond j, calculated using the total issued face value. This results in a daily average yield differential between the issuer's extant bonds and the matched control bond indices around each bond announcement. Additionally, extant bonds are grouped into three maturity buckets: Short-term (with residual maturity of < 5 years), medium-term (≥ 5 and < 10 years) and long-term (≥ 10 years). The same calculations are conducted for each maturity bucket

[18]For the download from Datastream I use the field "RY", which provides time series data for the yield to maturity of a security as well as the size and duration weighted average yield to maturity of a bond index.

individually, which allows to study results across the issuer's maturity spectrum.

To assess the differential impact of green versus conventional bond announcements, I implement a pooled triple difference regression analysis:

$$\Delta\bar{y}_{n,t} = \beta_1 \mathbb{1}_{Post,t} + \beta_2 \mathbb{1}_{Post,t} \times \mathbb{1}_{Green,n} + \gamma_n + \epsilon_{n,t} \,. \tag{15}$$

In this model, $\Delta\bar{y}_{n,t}$ represents the size-weighted average daily difference in yields between the issuer's extant bonds and their matched bond indices, $\mathbb{1}_{Green,n}$ indicates whether bond announcement n is a green bond. $\mathbb{1}_{Post,t}$ indicates if the observation t occurs on or after the bond announcement date. γ_n represent bond announcement fixed effects. The effects of green bonds compared to conventional bonds on the issuer's cost of debt are captured by the interaction term $\mathbb{1}_{Post,t} \times \mathbb{1}_{Green,n}$.

Insert Figure 2 here.

Figure 2 displays the trends of the yields differentials $\Delta\bar{y}_{n,t}$ over the ten day event window around green bond (Panel A) and conventional bond (Panel B) announcements across three maturity buckets (column 1 to 3), and the difference in the difference in yields, $\Delta\Delta\bar{y}$, around the two matched bond announcements (Panel C). The plots for the "$5-10$" and ">10" year buckets preview the main results: around conventional bond announcements, the yields of the issuer's extant bonds increase relatively to the market, while around green bond announcements they remain flat or even decline at the long end of the issuer's maturity spectrum. The third row previews the results of the triple difference regression: Compared to a conventional bond announcement, yields are significantly lower after a green bond announcement.

Insert Table 5 here.

The results of estimating Equation (15) with ordinary least squares (OLS) and standard errors clustered at the bond announcement level are displayed in Table 5. The $\mathbb{1}_{Post,t}$ indicator documents how the issuer's yields behave relative to the market after the announcement of conventional bonds. The positive and significant coefficients at the medium- and long-term maturity buckets indicate that the issuer's cost of debt increases in response to conventional bond announcements. This finding aligns with Chen and Stock (2018), suggesting that debt announcements are unfavorable for existing debtholders, as they typically make extant debt more risky.

The triple difference, represented by the $\mathbb{1}_{Green,n} \times \mathbb{1}_{Post,t}$ interaction, demonstrates the distinct behavior of yield differentials between the issuer and control bond indices following green bond announcements, compared to conventional bond announcements. The results show significantly lower yields, particularly in bonds with residual maturities of $5-10$ and >10 years, with yields reduced by approximately 1.33 and 2.96 bps, respectively, relative to conventional bond announcements.[19]

The decline in the issuer's cost of debt at the medium and long ends of the issuer's maturity spectrum suggests that investors place greater value on the information disclosed by green bonds concerning the medium to long-term future, rather than the short term. This finding supports the signalling hypothesis, where green bonds mitigate climate risk information asymmetries. This is because climate risks are expected to materialize primarily in the medium to long term. If green bonds reduce investor uncertainty about the firm's exposure to climate risks, we would expect bonds with longer maturities to respond more significantly, as confirmed by the results.

4.1 Financial and non-financial issuer

The results presented so far represent average outcomes across the full sample, which includes issuers from the financial, non-financial, and public sectors. However, corporate finance literature typically treats financial and non-financial firms separately, given the distinct characteristics of their business environments and structure of assets and liabilities. Table 6 provides the triple difference results, broken down by sector: non-financial firms in Panel A, financial firms in Panel B, and public sector issuers in Panel C.

Insert Table 6 here.

The findings indicate that non-financial firms are the primary drivers of the previous result, with yields decreasing by 7.1 bps at the long end of their maturity spectrum. In contrast, financial firms show no significant impact from green bond announcements. Public sector issuers demonstrate a weaker, but still significant, effect, with yields decreasing by

[19]Notably, without controlling for the conventional bond announcement, the issuer's yields decline significantly at the long end around a green bond announcement. Table IA.6 in the Internet Appendix documents results of an individual DiD around green bond announcements and shows that yields decline by about 1.48 bps at the long end of the maturity spectrum.

1.4 bps at the long end.

The difference in results between financial and non-financial firms might be due to credibility concerns. Non-financial firms typically invest in physical assets, making it difficult to repurpose green bond proceeds for non-green assets after maturity. In contrast, financial firms, which may use green bond proceeds for green loans, can more easily redirect funds to non-green activities after maturity. This flexibility might raise investor skepticism about the long-term green commitment of financial firms, undermining the credibility of their green bond issuances.

Comparing these results to the existing green bond premium literature, reveals that the announcement of green bonds has an additional impact on the issuer's cost of debt beyond the premiums observed in the green bond pricing itself. Previous studies, which primarily focus on pricing differentials between green and conventional bonds in primary and secondary markets, report premiums such as Zerbib (2019)'s 4 bps premium, Pástor et al. (2022)'s 2-7 bps range, Caramichael and Rapp (2024)'s 3-8 bps range, and Kapraun et al. (2021)'s 5-18 bps premium. Other studies report no significant pricing difference (Larcker and Watts, 2020, or Flammer, 2021). However, this study demonstrates that the announcement of a green bond affects the pricing of extant conventional bonds, thereby amplifying the overall impact of green bonds on the issuer's cost of debt as reported in the existing literature.

Pope et al. (2023) report a long-term downward pressure in conventional bond yield spreads for green bond issuers, noting an average decline of 8 bps based on time-series regression of monthly yield spreads from 2013 to 2021. Specifically, they implement a staggered difference-in-difference model with bond, credit rating, and time fixed effects, where the conventional bond yield spreads of green bond issuers are compared to conventional bond yield spreads of issuers that have not yet issued their green bond. The analysis presented here differs from their study in two significant ways. First, it investigates the effects of green bond issuance across the issuer's maturity spectrum, rather than an average effect. Second, by utilizing short event windows and constructing bond portfolios matched by sector, credit rating, and maturity, the analysis minimizes potential biases from curve roll effects, which can particularly impact long event window regressions (Nyborg and Woschitz, 2024).

4.2 Issuer riskiness

Furthermore, I investigate the role of the issuer's credit risk by focusing on green bond announcements from non-financial and public sector issuers, where a significant market response is observed. Investor uncertainty about a firm's intention may be more severe among low-rated firms, making green bonds more effective in mitigating information asymmetries.

To investigate this, I analyse the estimated triple-difference coefficient, $\beta_{2,n}$, for each announcement pair n, which captures the $\mathbb{1}_{Post,t} \times \mathbb{1}_{Green,n}$ interaction, for all non-financial and public sector green bond announcements. Across the samples (all, short, medium, and long end) I calculate the median credit rating class and define a credit risk dummy $\mathbb{1}_{HighRisk,n}$ that equals 1 if the announcement n is above or equal to the sample's median credit rating class. A higher credit rating class corresponds to lower credit quality (see Panel C in Table 1). To test whether the impact of green bond announcements differs between riskier and safer issuers, I regress the estimated triple-difference coefficient on the credit risk dummy: $\beta_{2,n} = \alpha + \beta\mathbb{1}_{HighRisk,n} + \epsilon_n$. This regression is estimated using OLS with standard errors Huber-White corrected for heteroskedasticity. Table 7 presents the results.

The coefficients of the credit risk dummy are negative across all maturities, indicating that green bond announcements have a larger impact on riskier issuers compared to safer ones. This effect is particularly significant at the long end of the maturity spectrum, suggesting that the decline in yields is especially pronounced for riskier issuers. This result is likely due to the greater sensitivity of their debt securities and heightened investor uncertainty surrounding low-rated firms, making green bonds a more effective tool.

Insert Table 7 here.

5 Impact on equity

To study the impact of green bond announcements on the valuation of the issuer's equity I use classical event study methodology. Following Fama et al. (1969) and Brown and Warner (1985) I employ the market model. This involves regressing daily stock returns on daily country-level stock index returns using OLS. The regression coefficients are estimated over a one year period using an event window from [-250,-21] days before the bond announcement.

For each bond announcement n, I estimate the following specification using the stock return $R_{n,t}$ of the issuer and the market index $R_{m,t}$ employing OLS:

$$R_{n,t} = \alpha_n + \beta_n \times R_{m,t} + \epsilon_{n,t} \, . \tag{16}$$

The estimated coefficients are then used to calculate an estimated return of the issuer's stock: $\hat{R}_{n,t} = \hat{\alpha}_n + \hat{\beta}_n \times R_{m,t}$. The abnormal daily return, $AR_{n,t}$, is then calculated as the difference between the actual daily return and the estimated return.

$$AR_{n,t} = R_{n,t} - \hat{R}_{n,t} \tag{17}$$

For each event window, the abnormal returns are then summed up to compute a cumulative measure of the abnormal returns (CAR) of the issuer's equity around the announcements.

$$CAR_{n,t_0,t_1} = \sum_{t_0}^{t_1} AR_{n,t} \tag{18}$$

Insert Table 8 here.

Table 8 presents t-tests on the estimated CARs around green bond (left) and conventional bond announcements (right). These results capture the market's reaction to each type of bond announcement and serve as an intermediate step for identifying the impact of green bonds.

The results show non-significant positive abnormal returns over a five-day event window for green bond announcement. This finding aligns with Aswani and Rajgopal (2024) and Bhagat and Yoon (2023), who report non-significant abnormal results over short event windows around green bond announcements. Other studies report positive abnormal stock returns over longer event windows: Flammer (2021) uses a sixteen day window, while Baulkaran (2019) and Tang and Zhang (2020) employ a twenty-one day window.

In contrast, conventional bonds show negative abnormal returns over the five day event window. This outcome is consistent with findings of Dann and Mikkelson (1984), Eckbo (1986) and Howton et al. (1998), who document that announcements of straight debt tend to have negative effects on the issuer's stock price.

To isolate the impact of green bonds, I calculate the difference in CARs between green bonds and their matched conventional bonds, denoted as the difference in abnormal returns (DAR). Let m represent the matched bond announcement pair, and let $convCAR$ denote the cumulative abnormal return around the matched conventional bond announcement. The DAR is calculated as follows:

$$DAR_{m,t_0,t_1} = CAR_{m,t_0,t_1} - convCAR_{m,t_0,t_1} \ . \tag{19}$$

Insert Table 9 here.

Panel A in Table 9 documents t-tests on the DAR of the full sample, essentially employing a triple difference analysis on abnormal stock returns. The DAR is significantly positive over the five day event window, indicating that green bonds have a significant positive effect on the issuer's stock price after controlling for the standard impact of a debt announcement. Specifically, stock prices show a significant abnormal return of 1.08% over this period. This result is primarily driven by the negative reaction to conventional bond announcements, a response not observed with green bond announcements.

Methodologically, the study by Wang et al. (2020) on the Chinese green bond market offers a somewhat comparable analysis on the impact on equity, but their methodology differs significantly. They compare mean CARs for green and conventional bond announcements over a seven day event window and find a statistical significant difference at the 10% level. However, their sample construction for bond announcements differs: they match each green bond with one or two comparable conventional bonds, which may not be issued by the same issuer and may have been announced after the green bond. The identification strategy applied in this paper is more specific regarding market, issuer, and bond factors, as outlined in Section 3.2 and 3.3.

5.1 Financial and non-financial issuer

As done above, this subsection studies the effects of green bonds across financial and non-financial issuers. Panel B and C in Table 9 present the t-tests on the DAR for non-financials and financial issuers. The results show that non-financial firms (Panel A) drive the positive stock market reaction, with an average abnormal return of 1.478% over the five day event window. In contrast, financial firms (Panel B) show no significant impact on equity prices, mirroring the findings from the debt analysis.

As discussed earlier, this difference across sectors may arise from investors perceiving green bonds from non-financial firms as a more credible signal, as the proceeds are typically allocated to physical assets, which are less likely to be repurposed. In contrast, green bonds issued by financial firms, which primarily invest in financial assets, may be viewed as less credible due to the flexibility in reallocating funds.

5.2 Issuer riskiness

This subsection investigates the role of issuer credit risk in the impact of green bond announcements on the equity valuation of non-financial firms, following a similar approach to the debt analysis. To compare the equity reactions for safe and risky issuers, green bond announcements are classified based on the issuer's credit rating. Specifically, I calculate the median credit rating class and create a dummy variable, $\mathbb{1}_{HighRisk,m}$, which equals one if the issuer's rating is equal to or above the median (indicating higher credit risk). The following specification is then estimated for all bond pairs m of non-financial issuers to assess the relationship between credit risk and the equity response: $DAR_{m,-2,2} = \alpha + \beta \mathbb{1}_{HighRisk,m} + \epsilon_m$.

Table 10 presents the OLS regression results with standard errors Huber-White corrected for heteroskedasticity. The findings show that abnormal stock returns are significantly stronger for riskier issuers, suggesting that the equity market reacts more positively for green bond announcements from firms with higher credit risk. This is consistent with the earlier debt analysis, where the impact on debt valuations was also more pronounced for riskier issuers. The results reinforce the notion that green bonds are a more effective tool for risky firms due to heightened investor uncertainty, which allows these firms to benefit more from signalling their green commitments through green bond issuances, as this likely helps reduce investor uncertainty.

Insert Table 10 here.

6 Mitigation of climate risk information asymmetries

This paper argues that green bonds serve as credible signal of a firm's reduced exposure to climate risks, thereby mitigate climate risk information asymmetries (see Proposition 2).

In this section, I investigate whether green bond issues are associated with a reduction in the issuer's sensitivity to climate risk, supporting this argument. To do so, I proxy the issuer's sensitivity to climate risks by the response of issuer's stock return volatility to climate concern shocks. In a second step, I compare this sensitivity among green bond issuers to that of peer firms over the same time period that did not issue a green bond.

To measure climate concerns, I use the Media Climate Change Concerns index (MCCC) developed by Ardia et al. (2023).[20] The MCCC tracks climate change coverage from major US newspapers from January 2003 to August 2022. I focus on the monthly measure because it provides a smoother and more stable representation of trends in climate concerns, minimizing the noise from daily fluctuations and accounting for a potential lagged effect of concerns reflected in newspaper articles. The index measures concern by analysing 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.

Following Ardia et al. (2023) and Pástor et al. (2022), I measure climate concern shocks as prediction errors using an AR(1) autoregressive model. The MCCC index for each month is predicted based on the prior 36 months of data, and the prediction error is calculated as the difference between the actual and forecasted MCCC values. While Ardia et al. (2023) and Pástor et al. (2022) use this measure to study the stock performance of green and brown firms measured in returns in response to climate concern shocks, this paper examines the response in stock volatility to answer whether green bonds effectively mitigate climate risk information asymmetries.

I begin with the 1,107 identified green bond announcements from 461 issuers as described Section 3.1, which forms the green bond sample prior to identifying a comparable conventional bond. Between January 2016 and August 2022 there are 235 green bond announcements from 120 issuers with available stock price data. For each month over a 2 year event window $(-12, 11)$ around each green bond announcement, I calculate monthly

[20]The authors provide the data on their updated MCCC index here: `https://sentometrics-research.com/`

stock return volatilities using the daily returns within a given month. I exclude data from February to April 2020 during the Covid crisis and keep announcements with at least 12 months of available data. If multiple green bond announcements from the same issuer have overlapping event windows, I keep only the first announcement. This results in a dataset of 113 green bond announcements from 97 issuers. For each issuer, I match the corresponding country stock index, as done in the stock event studies, and calculate the monthly stock market return volatilities.

Next, I draw a list of peer firms provided by Refinitiv and collect the same stock return volatility data for these peer firms. For each firm Refinitiv provides an list of peers using a proprietary peer selection algorithm that "combines competitor lists from filings, analyst cross coverage, business classification, and revenue proximity." Peer firms that have issued a green bond or that are located outside of the EU and US are excluded from the sample. Additionally, peer firms must have stock price data available for the entire time period to ensure that no firms enter or exit the datasest, which could introduce bias into the analysis. For 75 green bond announcements from 65 issuers, I retrieve stock data for 1,014 individual peer firms that have not issued any green bond. Across the 75 green bond announcements, the average number of merged peer firms is roughly 15.

Then, I assess how the issuer's stock return volatility is affected by climate concern shocks using the following pooled panel regression:

$$\Delta\sigma^i_{n,t} = \beta_0 + \beta_1 \mathbb{1}_{Post,n,t} + \beta_2 \Delta\sigma^m_{n,t} + \beta_3 \mathbb{1}_{Post,n,t} \times \Delta\sigma^m_{n,t} + \beta_4 \Delta C_{n,t} + \beta_5 \mathbb{1}_{Post,n,t} \times \Delta C_{n,t} + \gamma_n + \theta_t + \epsilon_{n,t} \,, \quad (20)$$

where $\Delta\sigma^i_{n,t}$ is the change in the monthly stock return volatility in month $t \in (-12, 11)$ around green bond announcement n, $\Delta\sigma^m_{n,t}$ is the change in the monthly return volatility of the matched stock market index, $\mathbb{1}_{Post,n,t}$ is an indicator variable for the post green bond announcement period, and ΔC represent the climate concern shocks. Fixed effects are applied at the bond announcement level, γ_n, and calendar year level, θ_t, to account for heterogeneity within bond announcements and broader time-varying factors that could influence climate risk sensitivity. The same specification is run for the peer firms, where the issuer and stock market volatilities are replaced by the average values across all identified peer firms per green bond announcement.

Table 11 presents the results of estimating Equation (20) using OLS with standard errors clustered clustered at the bond announcement level. Panel A (left) shows the results for green bond issuers, while Panel B (right) presents results for the peer firms. Each panel shows results over the full two year event window and the pre and post period individually.

Market volatility is the primary driver of stock volatility, as noted by the highlight significant $\Delta\sigma^m$ coefficient. However, climate concerns also significantly impact green bond issuers, particularly before the green bond announcement. A positive shock in climate concerns increases stock volatility, as documented by the significant ΔC coefficient. The $\mathbb{1}_{Post,n,t} \times \Delta C_{n,t}$ interaction term for climate concerns indicates a negative, though statistically insignificant, coefficient. A closer examination of the "Pre" and "Post" periods reveals that climate concerns significantly impact stock volatility in the "Pre" period, but not int the "Post" period. This result indicates a reduced sensitivity to climate concern shocks after the announcement of a green bond. In contrast, peer firms (Panel B) that have not issued green bonds do not show a similar reduction in sensitivity to climate concerns over the same time periods.

This result supports the signalling hypothesis that green bonds credibly signal a firm's reduced exposure to climate risks. However, it is important to note that this result does not imply that green bonds make firms immune from climate concerns. The effects may vary based on time periods, firm-specific factors, or the characteristics of the green bond itself. However, the limitations of the sample size prevent more detailed statistical testing of these variations. The key takeaway is that green bond issues are generally associated with a reduction in the issuer's sensitivity to climate risks, consistent with Proposition 2.

Insert Table 11 here.

7 Conclusion

This paper demonstrates that green bonds serve as an effective tool for issuers to signal their commitment to sustainable investments, thereby indicating a reduced exposure to climate risks. The empirical analysis reveals that green bond announcements lead to beneficial valuation effects for both equity and debt securities. Equity prices increase, and bond yields decrease, with the most pronounced reductions observed at the longer end of the maturity spectrum. These effects have broader implications for the cost of capital, suggesting that green bonds contribute to lowering issuers' overall financing costs.

The findings highlight that non-financial firms experience the most significant benefits from issuing green bonds, while financial firms show no significant impact, possibly due to credibility concerns. Additionally, issuers with weaker credit ratings benefit more, indicating that green bonds are particularly effective where investor uncertainty is higher.

Furthermore, the study finds that firms issuing green bonds become less sensitive to climate concerns following the announcement, supporting the signalling hypothesis. By committing to sustainable investments through green bond issuance, firms can credibly reduce their exposure to climate risks and benefit from a lower cost of capital.

These results have important implications for both issuers and policymakers. For issuers, green bonds offer a strategic instrument to improve their cost of capital by addressing investors' demand for greater transparency and credible commitments to managing climate risks. For regulators, fostering the development of green bond markets and establishing clear standards can enhance the effectiveness of green bonds in promoting sustainable investment.

In conclusion, this paper advances the understanding of how green bonds can positively influence issuers' valuations and cost of capital through a signalling mechanism. By mitigating climate risk information asymmetries, green bonds emerge as a valuable tool in the transition toward a more sustainable economy.

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Table 1: Green bond sample for event studies.

This table outlines the final green bond dataset for the bond and stock event studies. The sample includes green bond announcements from January 1, 2016, to June 22, 2024. These were obtained from Thomson Reuters Eikon and result after pruning the sample as described in Section 3.1. The dataset is separately displayed for the bond and stock event studies. Panel A presents the number of green bond announcements and issuers, Panel B the distribution of green bonds and issuers across countries and sectors, and Panel C overviews the credit rating class of the announcements and issuers.

Panel A: Green bond announcements and issuers

	Total number of	
event study	GB ann	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	GB ann.	issuers	GB ann.	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	GB ann.	issuers	GB ann.	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	
Harm.	Number of		Number of			
rating class	GB ann.	issuers	GB ann.	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 provides an overview of the final green bond dataset displayed in Table 1, along with their matched conventional bonds. Panels A covers the dataset of the bond event study and Panels B the stock event study. The table present descriptive 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	min	p25	median	p75	max
Issuer statistics							
Bond pairs per issuer	75	1.44	1	1	1	2	4
Bond pair statistics							
Green bonds per conv. bond	91	1.19	1	1	1	1	3
Announcement date diff. (yrs)	108	1.01	0.09	0.38	0.72	1.33	4.22
Bond characteristics statistics							
Residual maturity							
green bond (years)	108	8.66	2.00	6.00	8.00	10.00	25.06
conv. bond (years)	91	7.95	1.17	5.00	7.00	10.00	30.05
difference (years)	108	0.86	-5.72	-0.31	1.00	2.00	10.23
rel. diff. (× green bond)	108	0.09	-0.42	-0.04	0.14	0.28	0.50
Size							
green bond (mn USD)	108	1,523.80	21.40	536.60	751.24	1,073.20	23,943.16
conv. bond (mn USD)	91	2,328.38	5.58	536.60	1,082.90	2,170.40	26,219.61
difference (mn USD)	108	-641.70	-11,932.88	-1,096.60	-505.10	103.36	13,038.04
rel. diff. (× green bond)	108	-0.69	-2.96	-1.50	-0.52	0.21	0.74
Panel B: Stock event study sample	N	mean	min	p25	median	p75	max
Issuer statistics							
Bond pairs per issuer	52	1.42	1	1	1	2	4
Bond pair statistics							
Green bonds per conv. bond	61	1.21	1	1	1	1	4
Announcement date diff. (yrs)	74	1.22	0.09	0.39	0.76	1.87	3.99
Bond characteristics statistics							
Residual maturity							
green bond (years)	74	11.29	3.00	6.50	8.00	11.00	30.66
conv. bond (years)	61	10.09	2.00	5.00	7.00	10.00	33.00
difference (years)	74	0.50	-9.87	-0.50	0.56	2.00	8.82
rel. diff. (× green bond)	74	0.07	-0.48	-0.06	0.09	0.27	0.50
Size							
green bond (mn USD)	74	833.81	10.74	536.60	698.79	1070.00	4109.81
conv. bond (mn USD)	61	1180.65	42.93	461.28	1000.00	1622.63	5366.02
difference (mn USD)	74	-334.81	-2111.45	-804.90	-333.50	257.52	1047.08
rel. diff. (× green bond)	74	-0.70	-3.00	-1.50	-0.51	0.34	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, which are used in the bond events studies. Panel A describes the distribution of the number of extant conventional bonds from the same issuer across bond announcements, Panel B shows the number of bond pairs with extant conventional bonds across maturity buckets.

Panel A: Distribution of extant bonds across bond announcements

		Number of extant conv. bonds across bond announcement					
Bond announcement	N	mean	min	p25	median	p75	max
green bond	108	18.50	1	4	7	16	209
conv. bond	91	19.58	1	4	7	16	181

Panel B: Announcements pairs with extant bonds across maturity buckets

		Residual maturity of extant bonds		
	N	1 to 5y	5 to 10y	≥ 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	min	p25	median	p75	max
Non-financials							
Size green bond (mn USD)	33	975	322	537	751	1,073	3,220
Size extant bonds (mn USD)	33	13,356	1,100	4,226	9,001	16,950	79,095
Rel. size green bond (%)	33	12.09	2.76	5.60	8.95	16.79	48.77
Financials							
Size green bond (mn USD)	42	859	21	537	689	805	4,110
Size extant bonds (mn USD)	42	34,842	860	7,828	19,571	51,337	130,624
Rel. size green bond (%)	42	7.56	0.16	1.56	3.90	6.90	74.85
Public sector							
Size green bond (mn USD)	33	2,919	73	537	751	1,073	23,943
Size extant bonds (mn USD)	33	210,400	1,460	7,510	21,617	103,664	2,843,297
Rel. size green bond (%)	33	7.52	0.18	1.03	2.70	8.26	45.08
Panel B: Stock market Sector							
Non-financials							
Size green bond (mn USD)	50	793	119	525	699	1,069	2,146
Size extant bonds (mn USD)	50	19,509	112	6,797	11,187	19,386	154,728
Rel. size green bond (%)	50	17.61	0.69	3.90	6.32	9.85	478.21
Financials							
Size green bond (mn USD)	24	919	11	537	751	1,073	4,110
Size extant bonds (mn USD)	24	81,206	2,961	11,798	25,251	122,302	318,578
Rel. size green bond (%)	24	3.65	0.09	0.52	2.34	6.19	18.12

Table 5: The impact of green bonds on the issuer's cost of debt.
This table shows results of running a triple difference regression as given in Specification 15: $\Delta\bar{y}_{n,t} = \beta_1 \mathbb{1}_{Post,t} + \beta_2 \mathbb{1}_{Post,t} \times \mathbb{1}_{Green,n} + \gamma_n + \epsilon_{n,t}$. The dependent variable $\Delta\bar{y}_{n,t}$ is the size-weighted average daily 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- ($1-5$ years residual maturity), medium- ($5-10$ years), and long-term (> 10 years) 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
$\mathbb{1}_{Post,t}$	0.0121	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 green bonds on the issuer's cost of debt across sectors. This table presents results of running the same triple difference regression as in Table 5 but split up across sectors. Panel A documents the results for non-financials, Panel B for financials, and Panel C for public sector issuers. The triple difference Specification 15 is: $\Delta\bar{y}_{n,t} = \beta_1 \mathbb{1}_{Post,t} + \beta_2 \mathbb{1}_{Post,t} \times \mathbb{1}_{Green,n} + \gamma_n + \epsilon_{n,t}$. 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- $(1-5$ years residual maturity), medium- $(5-10$ years), and long-term (> 10 years) 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
Panel A: Non-Financials				
$\mathbb{1}_{Post,t}$	**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
Event FE	Yes	Yes	Yes	Yes
Number of bond announcement pairs	33	30	24	11
Panel B: Financials				
$\mathbb{1}_{Post,t}$	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
Event FE	Yes	Yes	Yes	Yes
Number of bond announcement pairs	42	41	23	9
Panel C: Public Sector				
$\mathbb{1}_{Post,t}$	-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
Event FE	Yes	Yes	Yes	Yes
Number of bond announcement pairs	33	26	30	25

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

Table 7: Issuer riskiness and the impact on debt.
This table presents regression results that study the relationship of the issuer's credit riskiness and the green bond's impact on the cost of debt using the following specification: $\beta_{2,n} = \mathbb{1}_{HighRisk,n} + \epsilon_n$, where $\beta_{2,n}$ captures the triple difference coefficient $\mathbb{1}_{Post,t} \times \mathbb{1}_{Green,n}$ for the impact green bonds on the cost of debt. $\mathbb{1}_{HighRisk,n}$ indicates the credit riskiness of the green bond issuer which equals 1 if the issuer's credit risk is above or equal to the sample's median credit rating class (a high credit risk class indicates a low credit quality). Standard errors are Huber-White corrected for heteroskedasticity. 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.

	$\beta_{2,n}$			
		Maturity bucket		
	all	1-5y	5-10y	> 10y
$\mathbb{1}_{HighRisk,n}$	-0.01780	-0.01354	-0.01871	**-0.04683^b**
	(-1.273)	(-0.929)	(-0.998)	(-2.305)
Constant	-0.00508	-0.00229	-0.00658	-0.00680
	(-1.171)	(-0.503)	(-1.492)	(-1.476)
N	66	56	54	36
R^2	0.016	0.013	0.019	0.124

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

Table 8: The impact of bond announcements on equity.
This table presents the results of the stock event study around bond announcements, focusing on the cumulative abnormal returns (*CAR*) around green bond announcements (left) and their comparable conventional bond announcements (right). Results are presented as t-tests on the estimated *CAR* over one event window before the announcements [-10,-6] and two windows during the announcement [-2,2] and [-5,4]. 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.

	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 9: The impact of green bonds on equity.
This table displays the results of the stock event studies after controlling for the standard impact of a bond announcement, studying the difference in cumulative abnormal returns between a green bond and its matched conventional bond announcement (*DAR*). Panel A reports the results for all issuers, Panel B for non-financials, and Panel c for financials. Results are presented as t-tests on estimated *DAR* over one event window before the announcements [-10,-6] and two windows during the announcement [-2,2] and [-5,4]. 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.

	pre-event	event windows	
	[-10,-6]	[-2,2]	[-5,4]
Panel A: All issuers			
DAR	-0.374	**1.078**^{b}	0.815
	(-0.870)	(2.183)	(1.178)
N	74	74	74
Panel B: Non-financials			
DAR	-0.185	**1.478**^{b}	1.275
	(-0.415)	(2.343)	(1.547)
N	50	50	50
Panel C: Financials			
DAR	-0.767	0.246	-0.144
	(-0.803)	(0.324)	(-0.114)
N	24	24	24

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

Table 10: Issuer riskiness and the impact on equity.
This table presents regression results that study the relationship of the issuer's credit riskiness and the green bond's impact on equity using the following specification: $DAR_{m,-2,2} = \mathbb{1}_{HighRisk,m} + \epsilon_m$, where $DAR_{m,-2,2}$ captures the impact of the green bond announcement on the issuer's equity over a five-day event window. $\mathbb{1}_{HighRisk,m}$ indicates the credit riskiness of the green bond issuer which equals 1 if the issuer's credit risk is above or equal to the sample's median credit rating class (a high credit risk class indicates a low credit quality). Standard errors are Huber-White corrected for heteroskedasticity. 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.

	$DAR_{-2,2}$
$\mathbb{1}_{HighRisk}$	$\mathbf{3.269^a}$
	(2.944)
Constant	-0.549
	(-0.775)
N	50
R^2	0.129

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

Table 11: Sensitivity to climate concerns.

This table displays the results of testing firm sensitivity to climate concerns for green bond issuers (Panel A) using Specification (20). The dependent variable, $\Delta\sigma^i_{n,t}$, represents the change in the monthly stock return volatility, which is regressed on following variables: $\mathbb{1}_{Post}$, is an indicator variable for the post green bond announcement period, $\Delta\sigma^m$, the change in the monthly return volatility of a matched stock market index, ΔC, the identified climate concern shock in a given month, and interaction terms. The estimation is conducted over 24 month event windows $[-12, 11]$ around green bond announcements, and over the pre and post period individually. Climate concern shocks, ΔC, are measured as prediction error from rolling AR(1) models applied to the MCCC index (following Ardia et al. (2023)). Fixed effects are applied at the bond announcement (event) level, γ_n, and calendar year level, θ_t, to account for heterogeneity within bond announcements and broader time-varying factors that could influence climate risk sensitivity. Standard errors are clustered at the announcement level. 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. Panel B provides the same analysis for peer firms of the green bond issuer over the same time periods, which did not issue any green bonds. Peer firms are identified using the list provided by Refinitiv. For each green bond announcement, the values are replaced by the average across all merged peers.

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: $p < 0.01$

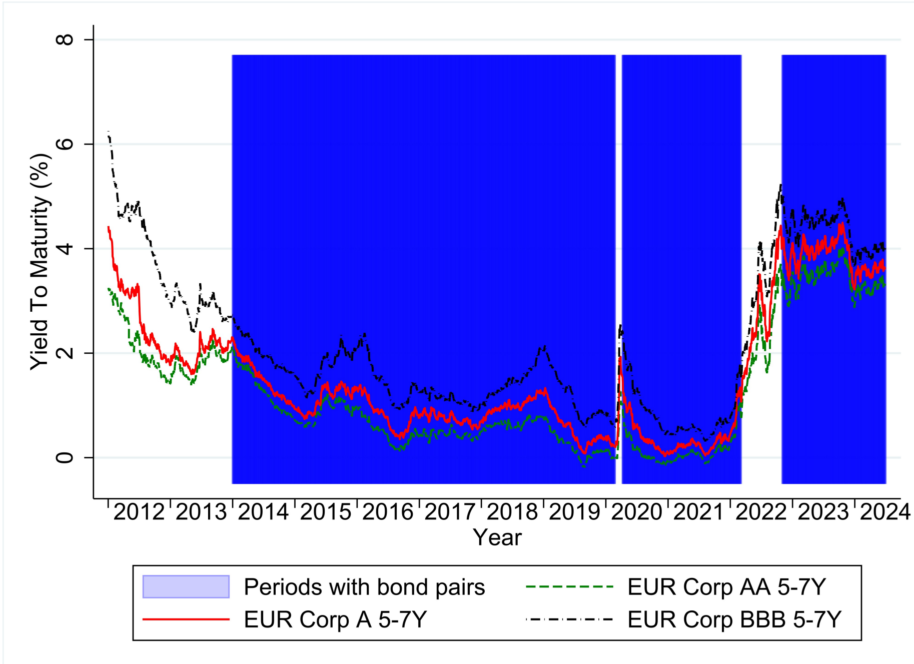


Figure 1: Economic conditions and bond pairs
This figure highlights the three distinct periods, shaded in blue, within which matched bond pairs can occur. The periods are separated by the Covid crisis (February 20 to April 7, 2020) and the recent surge in inflation rates (March 1 to November 1, 2022).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

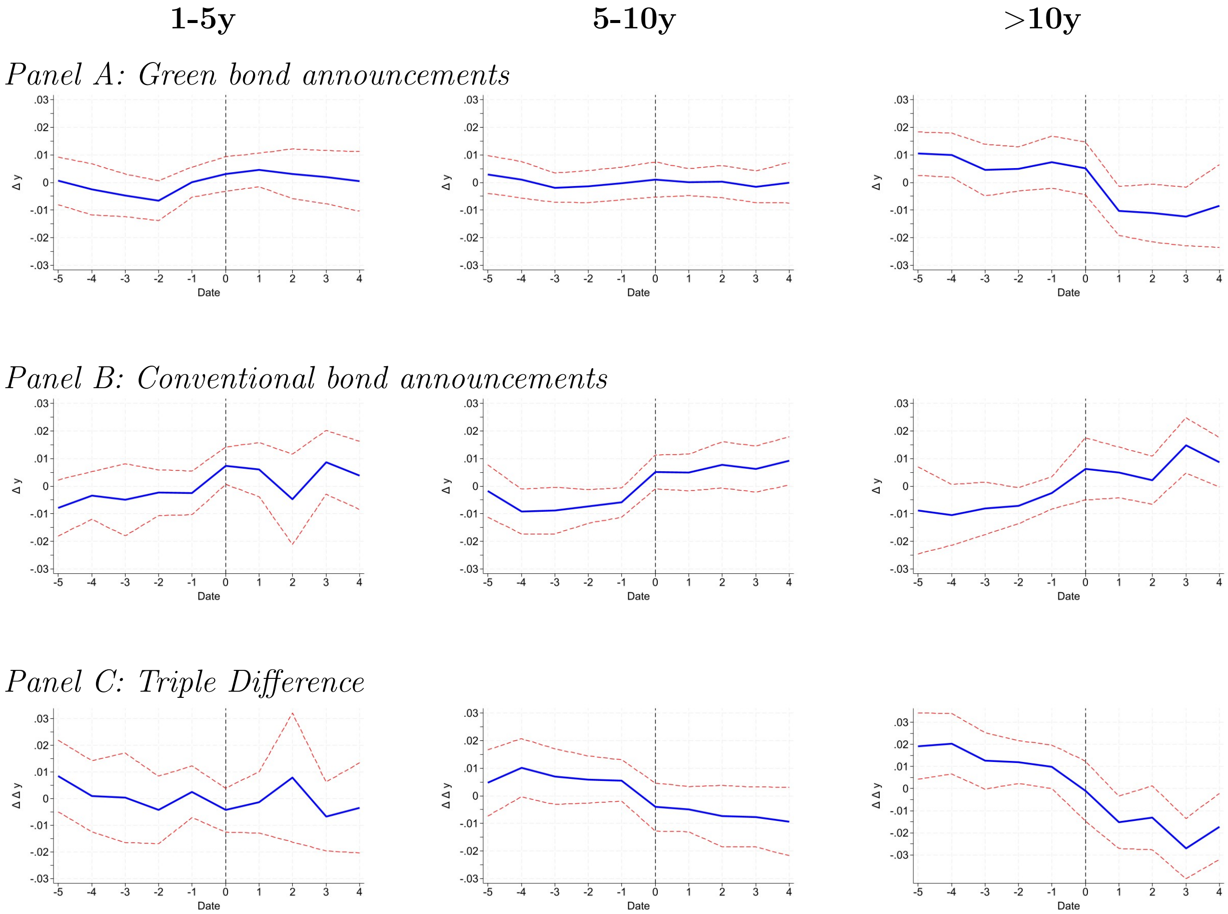


Figure 2: Trends around bond announcements and the triple difference.
This figure illustrates the trends of the difference in the issuer's extant bond yields and their matched bond index, $\Delta\bar{y}$, over the ten day event window $[-5, 4]$ around bond announcements, for short- $(1-5$ years), medium- $(5-10$ years), and long-term $(>10$ years) bond as indicated. Panel A shows the trends around green bond announcements, Panel B around the conventional bond announcement, and Panel C the difference between the green and conventional bond announcement, $\Delta\Delta\bar{y}$. The trends are displayed as residuals after applying bond announcement fixed effects, with the blue line representing the mean and the shaded area the 95% confidence intervals across all bond announcements.

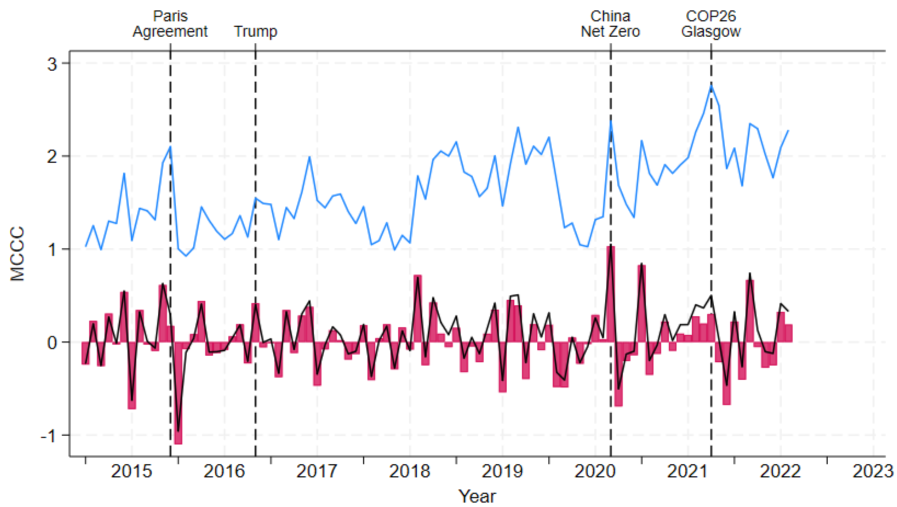


Figure 3: Media climate change concern index and identified climate concern shocks. This figure presents the Media Climate Change Concern Index (MCCC) developed by Ardia et al. (2023). The blue line represents the monthly MCCC measure, while the red bars show monthly changes in the index. The black line plots the identified AR(1) shocks to climate concerns, following the methodology by Ardia et al. (2023) and Pástor et al. (2022). Displayed are the monthly MCCC measure (blue), the monthly changes (red), and the identified shocks (black). Some key dates, such as the Paris Agreement (2015), Trump's election (2016), China's Net Zero pledge (2020), and COP26 in Glasgow (2021), are marked to highlight significant climate-related events that influenced the index.

A Appendix

A.1 Appendix for model

A.1.1 Proofs - expected value of net returns

This section derives the expected value of the project's net return for both project types. Recall that returns are random variables drawn from a normal distribution and firms benefit from a consistent implementation of a project:

$$R_i^j \sim \begin{cases} N(\mu + \gamma, \sigma^2), & \text{if } i = j. \\ N(\mu - \gamma, \sigma^2), & \text{if } i \neq j. \end{cases} \tag{21}$$

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 return, denoted by $S(p|j)$, is as follows: for a brown-aligned project with an inconsistent green implementation, the expected return is

$$S(c|b) = \mathbb{E}[R_{g,t}^b] = \mu - \gamma\ .$$

For a green-aligned project with a consistent green implementation, the expected return is

$$S(c|g) = \mathbb{E}[R_{g,t}^g] = \mu + \gamma\ .$$

Flexible policy Under the flexible policy, the firm selects the implementation with the highest return. Let X_1 and X_2 represent the returns from the green and brown implementation, respectively, with $X = \max(X_1, X_2)$. The expected maximum of two independent normally distributed variables with the same variance σ is given by (Nadarajah and Kotz, 2008):

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

Substituting the values for the green and brown implementation:

$$\begin{aligned}
E(X) &= (\mu+\gamma)\Phi\left(\frac{(\mu+\gamma)-(\mu-\gamma)}{\sqrt{2\sigma^2}}\right) + (\mu-\gamma)\Phi\left(\frac{(\mu-\gamma)-(\mu+\gamma)}{\sqrt{2\sigma^2}}\right) + \sqrt{2\sigma^2}\phi\left(\frac{(\mu+\gamma)-(\mu-\gamma)}{\sqrt{2\sigma^2}}\right) \\
&= (\mu+\gamma)\Phi\left(\frac{2\gamma}{\sqrt{2\sigma^2}}\right) + (\mu-\gamma)\Phi\left(\frac{-2\gamma}{\sqrt{2\sigma^2}}\right) + \sqrt{2\sigma^2}\phi\left(\frac{2\gamma}{\sqrt{2\sigma^2}}\right)
\end{aligned}$$

Using the properties of the standard normal distributions $\Phi(-x) = 1 - \Phi(x)$ and $\phi(-x) = \phi(x)$, this simplifies to:

$$E(X) = \mu - \gamma + 2\gamma\Phi\left(\frac{2\gamma}{\sqrt{2\sigma^2}}\right) + \sqrt{2\sigma^2}\phi\left(\frac{2\gamma}{\sqrt{2\sigma^2}}\right)$$

The expected value for the two project types is identical because the standard distribution and the random returns are symmetric. Thus, the expected value under the flexible policy for both project types is:

$$S(f) = \mathbb{E}[max(R^j_{g,t}, R^j_{b,t})] = \mu - \gamma + 2\gamma\Phi\left(\frac{2\gamma}{\sqrt{2\sigma^2}}\right) + \sqrt{2\sigma^2}\phi\left(\frac{2\gamma}{\sqrt{2\sigma^2}}\right)$$

In the special case where $\gamma = 0$, we have $\Phi(0) = 0.5$ and $\phi(0)\frac{1}{\sqrt{2\pi}}$, leading to:

$$E(X|\gamma = 0) = \mu + \frac{\sigma}{\sqrt{\pi}}$$

To find the derivative of $E(X)$ with respect to γ, the following properties can be used:

$$\frac{d}{dx}\Phi(x) = \phi(x), \quad \frac{d}{dx}\phi(x) = -x\phi(x)$$

To differentiate $E(X)$ with respect to γ, let $z = \frac{2\gamma}{\sqrt{2\sigma^2}}$, so $\frac{d}{d\gamma}z = \frac{2}{\sqrt{2\sigma^2}}$.
First, the derivative of $\mu - \gamma$ with respect to γ is:

$$\frac{d}{d\gamma}(\mu - \gamma) = -1$$

Next, differentiate $2\gamma\Phi(z)$:

$$\frac{d}{d\gamma}\left[2\gamma\Phi(z)\right] = 2\left[\Phi(z) + \gamma\phi(z)\cdot\frac{2}{\sqrt{2\sigma^2}}\right] = 2\Phi(z) + \frac{4\gamma}{\sqrt{2\sigma^2}}\phi(z)$$

Finally, differentiate $\sqrt{2\sigma^2}\phi(z)$:

$$\frac{d}{d\gamma}\left[\sqrt{2\sigma^2}\phi(z)\right] = -\frac{4\gamma}{\sqrt{2\sigma^2}}\phi(z)$$

Combining the terms gives:

$$\frac{d}{d\gamma}E(X) = -1 + 2\Phi\left(\frac{2\gamma}{\sqrt{2\sigma^2}}\right)$$

Since $\Phi\left(\frac{2\gamma}{\sqrt{2\sigma^2}}\right) > \frac{1}{2}$ for $\gamma > 0$, it can be concluded that:

$$\frac{d}{d\gamma}E(X) > 0$$

This indicates that $(E(X)$ increases as γ increases. Finally, using this derivative and the expected value for $\gamma = 0$, the total expected return under the flexible policy is:

$$S(f) = E(X) = \mu + \frac{\sigma}{\sqrt{\pi}} + \gamma\left[2\Phi\left(\frac{2\gamma}{\sqrt{2\sigma^2}}\right) - 1\right]$$

A.1.2 Expected adjustment costs

In this section, I calculate the expected adjustment costs for both the brown- and green-aligned projects. The goal is to compute the probability that the realized return from a brown implementation, after accounting for the adjustment cost κ, exceeds the return from a green implementation.

Brown-aligned project Let X_1 and X_2 be random variables representing the returns from the inconsistent and consistent implementations, respectively. For the brown-aligned project, X_1 corresponds to the green implementation, and X_2 corresponds to the brown implementation.

The objective is to find the probability $P(X_2 - \kappa > X_1)$. Define $Z = X_2 - \kappa - X_1$, so we need to calculate $P(Z > 0)$.

The distributions of X_1 and X_2 for the brown-aligned project are:

$$X_1 \sim N(\mu - \gamma, \sigma^2)$$
$$X_2 \sim N(\mu + \gamma, \sigma^2)$$

Since $Z = X_2 - \kappa - X_1$, the difference Z is also normally distributed. The mean and the variance of Z are:

$$\text{Mean of } Z = (\mu + \gamma) - \kappa - (\mu - \gamma) = 2\gamma - \kappa$$
$$\text{Variance of } Z = \sigma^2 + \sigma^2 = 2\sigma^2$$

Thus, $Z \sim N(2\gamma - \kappa, 2\sigma^2)$.

To find the probability $P(Z > 0)$, standardise Z to a standard normal distribution:

$$P(Z > 0) = P\left(\frac{Z - (2\gamma - \kappa)}{\sqrt{2\sigma^2}} > \frac{0 - (2\gamma - \kappa)}{\sqrt{2\sigma^2}}\right)$$
$$= P\left(Z' > -\frac{2\gamma - \kappa}{\sqrt{2\sigma^2}}\right),$$

where Z' is a standard normal variable. Using the properties of the standard normal distribution: $P(Z' > -a) = 1 - \Phi(-a) = \Phi(a)$, it follows that:

$$P(X_2 - \kappa > X_1) = \Phi\left(\frac{2\gamma - \kappa}{\sqrt{2\sigma^2}}\right)$$

Green-aligned project Next, the same calculation is performed for the green-aligned project, where X_1 represents the brown implementation and X_2 represents the green implementation. The random returns X_1 and X_2 are normally distributed:

$$X_1 \sim N(\mu - \gamma, \sigma^2)$$
$$X_2 \sim N(\mu + \gamma, \sigma^2)$$

The goal is to find the probability $P(X_1 - \kappa > X_2)$. Let $W = X_1 - \kappa - X_2$, so we need to calculate $P(W > 0)$. The mean and variance of W are:

$$\text{Mean of } W = (\mu - \gamma) - \kappa - (\mu + \gamma) = -2\gamma - \kappa$$
$$\text{Variance of } W = \sigma^2 + \sigma^2 = 2\sigma^2$$

It follows that, $W \sim N(-2\gamma - \kappa, 2\sigma^2)$.
To find the probability $P(W > 0)$, standardise W to use the standard normal distribution:

$$P(W > 0) = P\left(\frac{W - (-2\gamma - \kappa)}{\sqrt{2\sigma^2}} > \frac{0 - (-2\gamma - \kappa)}{\sqrt{2\sigma^2}}\right)$$
$$= P\left(W' > \frac{2\gamma + \kappa}{\sqrt{2\sigma^2}}\right)$$

where W' is a standard normal variable. Using the properties of the standard normal distribution: $P(W' > a) = 1 - \Phi(a)$, it follows that:

$$P(X_1 - \kappa > X_2) = 1 - \Phi\left(\frac{2\gamma + \kappa}{\sqrt{2\sigma^2}}\right)$$

Overview - expected adjustment costs The expected adjustment costs are a function of the implementation policy and can be calculated as probability-weighted costs. For the brown- and green-aligned project they are:

$$E[K|j = b, p = f] = \left[\Phi\left(\frac{2\gamma - \kappa}{\sqrt{2\sigma^2}}\right)\right]\kappa$$
$$E[K|j = g, p = f] = \left[1 - \Phi\left(\frac{2\gamma + \kappa}{\sqrt{2\sigma^2}}\right)\right]\kappa$$

Next, I examine the relationship between the two expected adjustment costs. For simplicity, let us focus on the comparison between $\Phi(x - y)$ and $1 - \Phi(x + y)$, where $x > 0$ and $y > 0$ can be linked to the two probabilities defined above. The standard normal distribution is symmetric about zero: $\Phi(-z) = 1 - \Phi(z)$, and this property will be useful for deriving the relationship of interest.

Define $z_1 = x - y$ and $z_2 = x + y$. Given $x > 0$ and $y > 0$, it follows that $z_1 < z_2$. Using the symmetry property of the standard normal distribution, $1 - \Phi(z_2)$ can be rewritten as:

$$1 - \Phi(z_2) = 1 - \Phi(x + y) = \Phi(-(x + y)) \,.$$

Now compare $\Phi(x - y)$ and $\Phi(-(x + y))$. Since $-(x + y) < x - y$ for $x, y > 0$, and $\Phi(z)$ is a monotonically increasing function, it results:

$$\Phi(-(x + y)) < \Phi(x - y) \,.$$

Substituting back into the original expression gives:

$$1 - \Phi(x + y) < \Phi(x - y) \,.$$

Therefore, for any $\gamma > 0$ and $\kappa > 0$, the expected adjustment costs for the brown-aligned project exceed those for the green-aligned project:

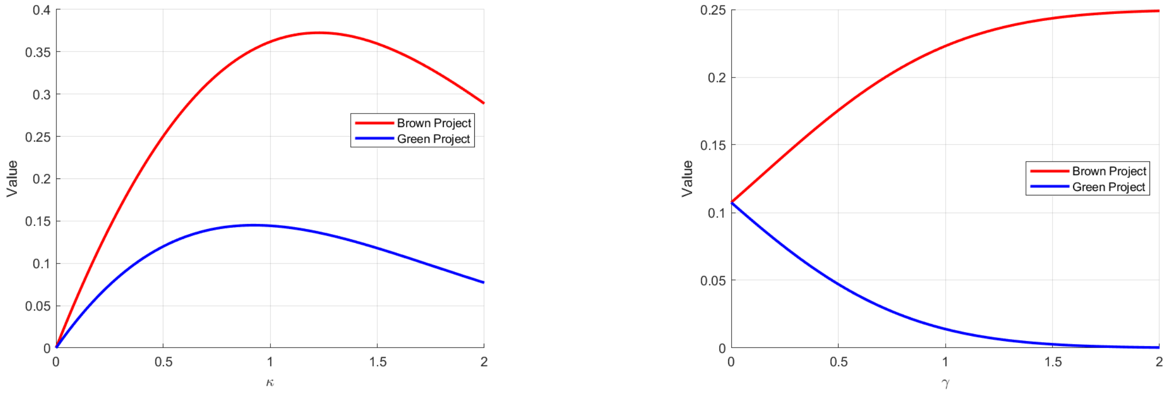
$$E[K|j = g, p = f] < E[K|j = b, p = f]$$

or equivalently:

$$\left[1 - \Phi\left(\frac{2\gamma + \kappa}{\sqrt{2\sigma^2}}\right)\right]\kappa < \left[\Phi\left(\frac{2\gamma - \kappa}{\sqrt{2\sigma^2}}\right)\right]\kappa \,.$$

Figure A.1 displays the expected adjustment costs, with a fixed $\gamma = 0.25$ as κ varies (left), and a fixed $\kappa = 0.25$ as γ varies (right), both with $\sigma = 1$. The red line represents the costs for the brown-aligned project, and the blue line represents the costs for the green-aligned project.

Across κ, the expected adjustment costs decrease at some point because, as κ becomes large, the probability of choosing the brown implementation decreases significantly. As γ increases, for the brown-aligned project, the expected adjustment cost approach κ, as the probability of choosing the brown implementation increases with the comparative advantage for the brown-aligned project. For the green-aligned project, the expected adjustment costs approach zero, as the probability of choosing the brown implementation decreases with increasing γ.



(a) Exp. adj. costs across κ with $\gamma = 0.25$. **(b)** Exp. adj. costs across γ with $\kappa = 0.25$.

Figure A.1: The figure illustrates the expected adjustment costs for two different projects (brown- and green-aligned) under varying parameters. The left subfigure shows the expected adjustment costs for $\gamma = 1$, and the cost parameter κ varies. The right subfigure displays the costs for $\kappa = 1$, and γ varies, both with a volatility parameter σ set to 1. The red line represents the expected costs associated with the brown-aligned project, while the blue line represents the costs associated with the green-aligned project.

A.1.3 Expected true values

The expected true values $V(p|j)$ are a combination of the expected returns and expected conditional adjustment costs. The following expected true values result for the brown- and green-aligned project, depending on whether the firm follows the committed or flexible policy:

$$V(p = c|j = b) = S(c|b) = \mu - \gamma \,,$$

$$V(p = f|j = b) = S(f) - E[K|j = b, p = f] = \mu + \frac{\sigma}{\sqrt{\pi}} + \gamma \left[2\Phi\left(\frac{2\gamma}{\sqrt{2\sigma^2}}\right) - 1 \right] - \left[\Phi\left(\frac{2\gamma - \kappa}{\sqrt{2\sigma^2}}\right) \right] \kappa \,,$$

$$V(p = c|j = g) = S(c|g) = \mu + \gamma \,,$$

$$V(p = f|j = g) = S(f) - E[K|j = g, p = f] = \mu + \frac{\sigma}{\sqrt{\pi}} + \gamma \left[2\Phi\left(\frac{2\gamma}{\sqrt{2\sigma^2}}\right) - 1 \right] - \left[1 - \Phi\left(\frac{2\gamma + \kappa}{\sqrt{2\sigma^2}}\right) \right] \kappa \,.$$

A.1.4 Value of flexibility - Lemma 1

Lemma 1 states that for both project types $j \in \{g, b\}$, the true value of the flexible policy $V(f|j)$ is strictly greater than the value of the committed policy $V(c|j)$. First, for the green-aligned project, the difference in the true values is denoted by $\Delta V(g)$:

$$\begin{aligned}\Delta V(g) &= V(f|g) - V(c|g) \\ &= \left(\mu + \frac{\sigma}{\sqrt{\pi}} + \gamma\left[2\Phi\left(\frac{2\gamma}{\sqrt{2\sigma^2}}\right) - 1\right] - \kappa\left[1 - \Phi\left(\frac{2\gamma+\kappa}{\sqrt{2\sigma^2}}\right)\right]\right) - (\mu - \gamma)\end{aligned}$$

Simplifying the terms:

$$\Delta V(g) = \frac{\sigma}{\sqrt{\pi}} + 2\gamma\Phi\left(\frac{2\gamma}{\sqrt{2\sigma^2}}\right) - \gamma - \kappa\left[1 - \Phi\left(\frac{2\gamma+\kappa}{\sqrt{2\sigma^2}}\right)\right]$$

Let $A = 2\Phi\left(\frac{2\gamma}{\sqrt{2\sigma^2}}\right) - 1$ and $B = \kappa\left[1 - \Phi\left(\frac{2\gamma+\kappa}{\sqrt{2\sigma^2}}\right)\right]$, where $A > 0$ since $\Phi(x) > 0.5$ for $x > 0$. The difference then becomes:

$$\Delta V(g) = \frac{\sigma}{\sqrt{\pi}} + \gamma A - B$$

Since $\frac{\sigma}{\sqrt{\pi}} > 0$, $\gamma A > 0$, and $0 < B < \kappa$, since $0 < \Phi(x) < 1$ for all x, we conclude that:

$$\Delta V(g) > 0$$

Thus, $V(f|g) > V(c|g)$.

Second, for the brown-aligned project, the difference in the true values is denoted by $\Delta V(b)$:

$$\begin{aligned}\Delta V(b) &= V(f|b) - V(c|b) \\ &= \left(\mu + \frac{\sigma}{\sqrt{\pi}} + \gamma\left[2\Phi\left(\frac{2\gamma}{\sqrt{2\sigma^2}}\right) - 1\right] - \kappa\left[1 - \Phi\left(\frac{2\gamma-\kappa}{\sqrt{2\sigma^2}}\right)\right]\right) - (\mu - \gamma)\end{aligned}$$

Simplifying the terms:

$$\Delta V(b) = \frac{\sigma}{\sqrt{\pi}} + 2\gamma\Phi\left(\frac{2\gamma}{\sqrt{2\sigma^2}}\right) - \gamma - \kappa\left[1 - \Phi\left(\frac{2\gamma-\kappa}{\sqrt{2\sigma^2}}\right)\right]$$

Let $A = 2\Phi\left(\frac{2\gamma}{\sqrt{2\sigma^2}}\right) - 1$ and $B = \kappa\left[1 - \Phi\left(\frac{2\gamma-\kappa}{\sqrt{2\sigma^2}}\right)\right]$, where $A > 0$ since $\Phi(x) > 0.5$ for $x > 0$. The difference then becomes:

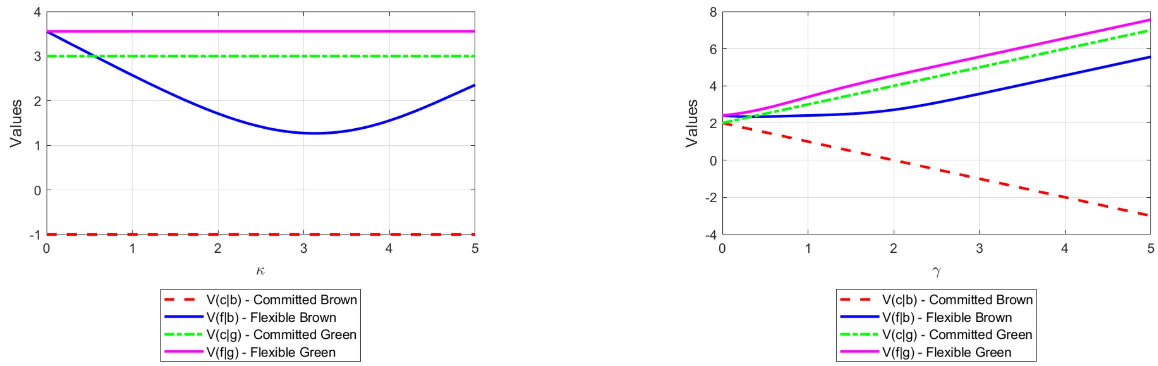
$$\Delta V(b) = \frac{\sigma}{\sqrt{\pi}} + \gamma A - B$$

Since $\frac{\sigma}{\sqrt{\pi}} > 0$, $\gamma A > 0$, and $0 < B < \kappa$, since $0 < \Phi(x) < 1$ for all x, we conclude that:

$$\Delta V(b) > 0$$

Thus, $V(f|b) > V(c|b)$.

This result is also displayed in Figure A.2.



(a) True values across κ with $\gamma = 2$.

(b) True values across γ with $\kappa = 2$.

Figure A.2: The figure illustrates the expected true values for two different projects (brown- and green-aligned) under the committed and flexible policy, as lined out in Appendix A.1.3. The left subfigure shows the true values for $\gamma = 2$, and the cost parameter κ varies. The right subfigure displays the costs for $\kappa = 2$, and γ varies, both with $\sigma = 1$ and $\alpha = 0.5$. The red dotted line represents the true value of the brown-aligned project under the committed policy, the blue line the brown-aligned project under the flexible policy, the green dotted line the green-aligned project under the committed , and the pink line the green-aligned project under the flexible policy.

A.1.5 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 can be written as follows:

$$S(c|g) > 0.5\,[S(f) - E[K|j = b, p = f]] + 0.5\,[S(f) - E[K|j = g, p = f]] \quad \text{(IC1)}$$

$$S(f) - E[K|j = b, p = f] > 0.5\,[S(c|g)] + 0.5\,[S(c|b)] \quad \text{(IC2)}$$

These conditions simplify to:

$$S(c|g) > S(f) - \frac{E[K|j=b,p=f] + E[K|j=g,p=f]}{2} \tag{IC1}$$

$$S(f) - E[K|j=b,p=f] > \frac{S(c|g) + S(c|b)}{2} \tag{IC2}$$

Using the earlier defined true values, the ICs become:

$$\mu + \gamma > \mu + \frac{\sigma}{\sqrt{\pi}} + \gamma\left[2\Phi\left(\frac{2\gamma}{\sqrt{2\sigma^2}}\right) - 1\right] - \frac{\left[\Phi\left(\frac{2\gamma-\kappa}{\sqrt{2\sigma^2}}\right)\right]\kappa + \left[1 - \Phi\left(\frac{2\gamma+\kappa}{\sqrt{2\sigma^2}}\right)\right]\kappa}{2} \tag{IC1}$$

$$\mu + \frac{\sigma}{\sqrt{\pi}} + \gamma\left[2\Phi\left(\frac{2\gamma}{\sqrt{2\sigma^2}}\right) - 1\right] - \left[\Phi\left(\frac{2\gamma-\kappa}{\sqrt{2\sigma^2}}\right)\right]\kappa > \frac{\mu+\gamma+\mu-\gamma}{2} \tag{IC2}$$

These can be simplified to:

$$\gamma > \frac{\sigma}{\sqrt{\pi}} + \gamma\left[2\Phi\left(\frac{2\gamma}{\sqrt{2\sigma^2}}\right) - 1\right] - \frac{\left[\Phi\left(\frac{2\gamma-\kappa}{\sqrt{2\sigma^2}}\right)\right]\kappa + \left[1 - \Phi\left(\frac{2\gamma+\kappa}{\sqrt{2\sigma^2}}\right)\right]\kappa}{2} \tag{IC1}$$

$$\frac{\sigma}{\sqrt{\pi}} + \gamma\left[2\Phi\left(\frac{2\gamma}{\sqrt{2\sigma^2}}\right) - 1\right] - \left[\Phi\left(\frac{2\gamma-\kappa}{\sqrt{2\sigma^2}}\right)\right]\kappa > 0 \tag{IC2}$$

IC1 states that the advantage of a consistent implementation for a green-aligned project must exceed the value of flexibility, minus the average of the expected adjustment costs for both the green- and brown-aligned projects.

IC2 indicates that the value from flexibility must be greater than the expected adjustment costs for the brown-aligned project.

A.1.6 Simulation of valid parameter values in the separating equilibrium

Figure A.3 simulates valid combinations of γ and κ within the separating equilibrium. In the separating equilibrium, the firm with the green-aligned project commits and the firm with the brown-aligned project selects flexibility. 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 favourable to commit for the firm with the green-aligned project.

First, IC1 defines a minimum γ for certain values of κ. This arises because, as κ increases beyond a certain threshold, the expected adjustment costs begin to decline (as shown in Figure A.1.2). When κ becomes large enough, the brown-aligned project begins to favour commitment over flexibility. Therefore, in the separating equilibrium, as κ increases, γ

must also increase.

Second, IC1 describes a minimum value for κ (represented by the vertical region on the left in the graph). A minimum κ is required to ensure positive adjustment costs exist under the flexible policy, making flexibility costly for the green-aligned project.

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 commitment.

Intuitively, if the adjustment cost κ becomes large relative to a certain value of γ, committing to a green implementation becomes more attractive. The curvature of the IC2 boundary results from the interaction between the benefits of flexibility (which increase approximately lineraly with γ) and the expected adjustment costs, which are non-linear and eventually reach an upper bound (as shown in Figure A.1). For certain values of γ, the expected adjustment costs become so high that IC2 no longer holds, which is represented by the red area above the black line in Figure A.3. However, as γ continues to increase while κ remains constant, the value derived from flexibility eventually outweighs the adjustment costs, incentivising the firm with the brown-aligned project to maintain flexibility.

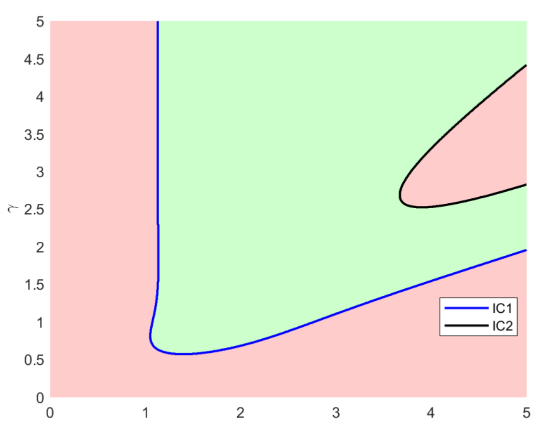


Figure A.3: Validity across values of γ and κ
This figure displays combinations of γ and κ that satisfy the two ICs required for the separating equilibrium lined out by Theorem 1. The blue line represents IC1, ensuring the firm with the green-aligned project commits, and the black line represents IC2, ensuring the firm with the brown-aligned project remains flexible. The green area between the two lines covers valid combinations of exogenous parameters that satisfy the ICs for the separating equilibrium.

A.1.7 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:

$$
\begin{aligned}
S(c|g) &> S(f) - E[K|j=b, p=f]\,, \\
\mu + \gamma &> \mu + \frac{\sigma}{\sqrt{\pi}} + \gamma\left[2\Phi\left(\frac{2\gamma}{\sqrt{2\sigma^2}}\right) - 1\right] - \left[\Phi\left(\frac{2\gamma-\kappa}{\sqrt{2\sigma^2}}\right)\right]\kappa\,, \\
\gamma &> \frac{\sigma}{\sqrt{\pi}} + \gamma\left[2\Phi\left(\frac{2\gamma}{\sqrt{2\sigma^2}}\right) - 1\right] - \left[\Phi\left(\frac{2\gamma-\kappa}{\sqrt{2\sigma^2}}\right)\right]\kappa\,.
\end{aligned}
$$

The intuition here is that the advantage of a consistent implementation for a green-aligned project, γ, must exceed the value of flexibility minus the expected adjustment costs for the brown-aligned project. This condition holds by IC1 in the separating equilibrium (because the conditional expected adjustment costs for the brown-aligned project are larger).

Internet appendix

Table IA.1: Robustness: Time interval between announcement dates.
This table examines whether the time interval between a bond announcement dates significantly affects the results of the bond and stock market event studies. $\Delta AnnDates$ represents the difference in days between the green and mathced conventional bond announcement dates and is regressed on the triple difference coefficient on bond yields, $\beta_{2,n}$, (left-hand side) and the difference in abnormal stock returns , DAR, (right-hand side). The t-statistics 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.

	Bond event study $\beta_{2,n}$				Stock event study $DAR_{-2,2}$
		Maturity bucket			
	all	1-5y	5-10y	> 10y	
Δ*Ann Dates*	0.00000	-0.00001	0.00002	-0.00002	-0.00119
	(0.039)	(-0.249)	(0.933)	(-0.503)	(-0.931)
Constant	-0.00994	0.00034	-0.02193^c	-0.02258	1.60594^b
	(-0.586)	(0.018)	(-1.778)	(-1.294)	(2.135)
N	108	97	77	45	74
R^2	0.000	0.001	0.011	0.006	-0.002

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

Table IA.2: Robustness: Extant bonds at announcement dates.
This table reports statistics on the issuer's total face values of extant bonds at the green bond and the comparable conventional bond announcements, as well as differences between them. $\Delta Bonds$ represents the difference between the total face value of extant bonds between the green bond announcement and its matched comparable conventional bond announcement. T-tests on individual announcements and paired t-tests on the differences are reported right side of the table. Panel A describes the dataset for the bond event study and Panel B for the stock event study.

Panel A: Bond Market Study	Total face value of extant bonds (mn USD)						Paired t-test		
	mean	min	p25	median	p75	max	Std. Dev	95% Conf Interval	
Green Bond	81,919	860	6,938	14,425	42,414	2,843,297	322,331	20,433	143,406
Comp. conv. bond	81,022	325	6,784	13,788	40,252	2,777,642	319,283	20,117	141,927
Δ*Bonds*	897	-35,632	-308	720	2,277	65,655	8,211	-669	2,463
N	108								
Panel B: Stock Market Study	Total face value of extant bonds (mn USD)						Paired t-test		
	mean	min	p25	median	p75	max	Std. Dev	95% Conf Interval	
Green Bond	39,519	112	7,368	13,251	30,180	318,578	70,665	23,147	55,890
Comp. conv. bond	16,338	0	4,510	8,730	13,904	130,806	24,645	10,628	22,048
Δ*Bonds*	23,181	-4,907	519	3,404	20,095	243,673	49,384	11,739	34,622
N	74								

Table IA.3: Robustness: Change in extant bonds.
This table examines whether the change in extant bonds between a green bond announcement and its previously announced comparable conventional bond significantly affects the results of the bond and stock market event studies. $\Delta Bonds$ represents the difference in total face value of extant bonds at the date of the green bond announcement relative to the matched conventional bond announcement and is regressed on the triple difference coefficient on bond yields, $\beta_{2,n}$, (left-hand side) and the difference in abnormal stock returns , DAR, (right-hand side). The t-statistics 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.

	Bond event study $Green_n \times Post_t$				Stock event study $DABR_{-2,2}$
		Maturity bucket			
	all	1-5y	5-10y	> 10y	
$\Delta Bonds$	0.00000	-0.00000	0.00000	0.00000	-0.00000
	(0.21)	(0.000)	(0.000)	(0.000)	(-0.28)
Constant	-0.01630^{c}	-0.00977	-0.01617^{c}	-0.03172^{a}	1.14464^{b}
	(-1.91)	(0.008)	(0.009)	(0.011)	(2.08)
N	66	56	54	36	74
R^2	0.001	0.000	0.002	0.001	0.001

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

Table IA.4: Robustness: Bond size and residual maturity at issuance.
This table examines whether differences in the size (Panel A) and residual maturity (Panel B) of the announced bonds affect the results of the bond and stock market event studies. $\Delta Size$ represents the difference in total face value between the green bond and its matched comparable conventional bond, and $\Delta ResMat$ denotes the difference in the residual maturity at issuance. In Panel A and B these variables are regressed on the triple difference coefficient on bond yields, $\beta_{2,n}$, (left-hand side) and the difference in abnormal stock returns , DAR, (right-hand side). The t-statistics 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.

	Bond event study $\beta_{2,n}$				Stock event study $DAR_{-2,2}$
		Maturity bucket			
	all	1-5y	5-10y	> 10y	
Panel A: Size of announced bonds					
$\Delta Size$	0.00000	0.00000	-0.00000	-0.00000	-0.00000
	(0.275)	(0.284)	(-0.040)	(-0.106)	(-0.289)
Constant	-0.00855	-0.00226	-0.01341	-0.02986^{a}	1.00989^{c}
	(-0.737)	(-0.180)	(-1.563)	(-2.735)	(1.835)
N	108	97	77	45	74
R^2	0.001	0.001	0.000	0.000	-0.013
Panel B: Residual maturity at issuance of announced bonds					
$\Delta Resmat$	0.00312	0.00515	0.00041	-0.00131	0.23558
	(0.715)	(1.080)	(0.137)	(-0.411)	(1.301)
Constant	-0.01211	-0.00777	-0.01365	-0.02814^{b}	0.96149^{c}
	(-1.034)	(-0.608)	(-1.588)	(-2.531)	(1.924)
N	108	97	77	45	74
R^2	0.005	0.012	0.000	0.004	0.009

Table IA.5: Robustness: Macroeconomic variables.

This table examines whether changes in macroeconomic variables between bond announcement dates significantly affect the results of the bond and stock market event studies. Changes in different macroeconomic variables are regressed on the triple difference coefficient on bond yields, $\beta_{2,n}$, (left-hand side) and the difference in abnormal stock returns , DAR, (right-hand side). T-statistics are reported in brackets below the coefficients. The used macroeconomic variables include the inflation rate (*Inflation*), consumer confidence index (*ConsConf*), investor sentiment index (*InvestSent*), and a commodities price index (*Commodities*). Time series for the inflation rate, the consumer and investor indices are from Refinitiv. The inflation rate is measured using the CPI for the EU or US, depending on the issuer's location. The consumer confidence index is derived from the conference board survey for the US and the directorate general for economic and financial affairs survey for the EU. The investor sentiment index is the Sentix Index for the EU, applied for all bond pairs. The commodities price index is the Bloomberg commodity index (BCOM) retrieved from Bloomberg. The symbols a, b, and c indicate significance at the 1%, 5%, and 10% levels (two-sided), respectively.

	Bond event study $\beta_{2,n}$				Stock event study $DAR_{-2,2}$
		Maturity bucket			
	all	1-5y	5-10y	> 10y	
Δ*Inflation*	0.00373	0.00046	0.00710	0.00314	0.01123
	(0.980)	(0.108)	(1.286)	(0.726)	(0.038)
Constant	-0.01760^b	-0.00997	-0.02005^b	-0.03264^a	1.35258^b
	(-2.057)	(-1.222)	(-2.035)	(-2.859)	(2.371)
N	66	56	54	36	50
R^2	0.015	0.000	0.031	0.015	0.000
Δ*ConsConf*	0.00020	-0.00001	0.00211	0.00055	0.00108
	(0.146)	(-0.005)	(1.151)	(0.261)	(0.022)
Constant	-0.01671^c	-0.00977	-0.02012^c	-0.03342^b	1.34577^b
	(-1.784)	(-1.153)	(-2.006)	(-2.471)	(2.038)
N	66	56	54	36	50
R^2	0.000	0.000	0.025	0.002	0.000
Δ*InvestSent*	-0.00026	-0.00020	-0.00003	-0.00016	0.01595
	(-0.648)	(-0.526)	(-0.056)	(-0.300)	(0.588)
Constant	-0.01478^c	-0.00904	-0.01582	-0.02998^b	1.36430^b
	(-1.696)	(-1.118)	(-1.632)	(-2.403)	(2.400)
N	66	56	54	36	50
R^2	0.007	0.005	0.000	0.003	0.007
Δ*Commodities*	-0.00023	-0.00011	-0.00060	0.00064	0.07834
	(-0.344)	(-0.163)	(-0.709)	(0.761)	(1.411)
Constant	-0.01572^c	-0.00956	-0.01498	-0.03493^a	1.48752^b
	(-1.835)	(-1.180)	(-1.574)	(-2.872)	(2.624)
N	66	56	54	36	50
R^2	0.002	0.000	0.010	0.017	0.040

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

Table IA.6: Difference-in-difference around green bond announcements.
This table presents the results of the difference-in-difference on extant bond yields around green bond announcements: $\Delta\bar{y}_{n,t} = \mathbb{1}_{Post,t} + \gamma_n + \epsilon_{n,t}$. 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 only the green bond announcement. $\mathbb{1}_{Post,t}$ indicates post bond announcement date observations. The coefficient for $\mathbb{1}_{Post,t}$ illustrates the response in the yield differences between the issuer's yield and the matched bond indices to the green bond announcement. The results are displayed as average across all, short- ($1-5$ years residual maturity), medium- ($5-10$ years), and long-term (> 10 years) bonds. Standard errors are clustered at the bond announcement level. The constant 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
$\mathbb{1}_{Post,t}$	0.0026	0.0052	-0.0001	**-0.0148^{b}**
	(0.438)	(0.795)	(-0.016)	(-2.166)
N	1080	970	770	450
R^2_{adj}	0.989	0.989	0.994	0.995
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 IA.7: Robustness: Impact of green bond on extant bond yields with BGN quotes.

This table shows results of running a triple difference regression as given in Specification 15, 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: $\Delta\bar{y}_{n,t} = \beta_1 \mathbb{1}_{Post,t} + \beta_2 \mathbb{1}_{Post,t} \times \mathbb{1}_{Green,n} + \gamma_n + \epsilon_{n,t}$. The dependent variable $\Delta\bar{y}_{n,t}$ is the size-weighted average daily 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- ($1-5$ years residual maturity), medium- ($5-10$ years), and long-term (> 10 years) 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