Rethinking the Value and Emission Implications of Green Bonds[±]

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Abstract

Our analysis of green bonds issued between 2013-2022 reveals a distinctive shareholder preference for such assets, particularly among financial institutions. In the secondary market, green bonds issued by financial firms' trade at a 'greenium' of 8.2 basis points compared to matched samples, attributed potentially to financial firms' efforts in channeling funds to sustainability linked loans. Past work documenting a positive stock price reaction to issuance of green bonds is isolated to financial firms and to specific issuers. Moreover, issuers of green bonds with higher emissions before the green bond issue report an insignificant reduction in such emissions post-issuance. Our analysis of the sustainable lending practices of these gatekeepers reveals that the 'greenium' earned in the green bond market does not translate to the green loan market. Furthermore, borrowers' performance remains unchanged in the short term, indicating a lack of due diligence by the gatekeepers. This study underscores the complex relationship between financial markets and environmental stewardship.

Keywords: Sustainable Finance; Climate Change; Green Bonds; Corporate Sustainability; ESG
JEL: G12, G14

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Rethinking the Value and Emission Implications of Green Bonds

1. Introduction

Theory suggests that green assets entail low expected returns because (i) green investors relish holding them and (ii) such assets hedge climate risk by encouraging pro-environmental outcomes (Pastor, Stambaugh and Taylor 2021; Baker, Egan, and Sarkar 2022; Serafeim and Yoon 2021; Khan, Serafeim, and Yoon 2016; Bolton and Kacperczyk 2021). In this paper, we evaluate these predictions by asking (i) whether green bonds are associated with significant returns for bond holders and equity investors, both at the time of issuance and after; (ii) whether there exists a greenium (green premium) and the factors associated with such a greenium; and (iii) whether the environmental risk of the issuers of green bonds falls after the issuance of green bonds.

Green bonds represent a noteworthy asset class of their own. Sales of green bonds reached a monthly record of $32 billion in September 2020, bringing the market's overall size to almost $1 trillion (Wall Street Journal, 2020).[1] Governments and companies issued $600 billion in green debt in 2021, which is almost half the total raised since the inception of this asset class (Financial Times, 2021).[2] While investor demand for green bonds has increased, questions related to their efficacy in terms of environmental benefits continue to be raised by skeptics (The Economist, 2020).[3]

Turning to the pricing of green bonds, Pastor et al. (2021) posit that socially conscious investors are willing to trade wealth for societal benefits, which translates to a premium, or lower yields, for green securities (Baker et al. 2018; Flammer 2021; Zhang and Tang, 2020; Zerbib,

[1] https://www.wsj.com/articles/why-going-green-saves-bond-borrowers-money-11608201002
[2] https://www.ft.com/content/021329aa-b0bd-4183-8559-0f3260b73d62
[3] https://www.economist.com/finance-and-economics/2020/09/19/what-is-the-point-of-green-bonds

2019). However, some argue that green bonds should carry higher yields because (i) green investing does not generate positive net present value (NPV) per se (Larcker and Watts, 2020; Factica et al. 2020; Reed et al. 2017) and (ii) the issuance of a green bond is costly compared with conventional bonds because issuers typically need to submit to a third-party validation that the proceeds will be spent on environmentally friendly projects.

The other important question relates to whether green bonds lead to environmentally friendly outcomes. The signaling story suggests a costly environmental commitment made by the issuer to long-term sustainability (Flammer, 2021). Flammer's (2021) evidence is consistent with the view that the carbon emissions of green bond issuers decrease in the future. However, critics counter that green bond issuers do not always fulfill their pledges to invest the proceeds in "green" projects because the penalty for reneging on such a pledge is low (Wall Street Journal, 2021).[4]

In this paper, we propose a relatively novel 'sustainability gatekeeper' hypothesis. We suggest that the bond market potentially trusts the financial sector to screen out "brown" issuers while deploying the funds the bank might raise via green bonds. Moreover, financial firms do not directly emit pollutants, unlike the oil and gas industry. Hence, green bonds issued by financial sector firms are likely to be associated with (i) a positive response from stock market; and (ii) greenium in secondary bond markets.

We take these hypotheses to the data. After excluding supranational and government bonds, our final sample comprises of 5,179 green bonds obtained from the Bloomberg Fixed Income database as of December 31, 2022. Of the 5,179 bonds examined, 4,324 were endorsed by a third party (e.g., Climate Bond Initiative, an ESG assurance provider). Green bonds have become more popular in recent decades, with the majority issued by firms' head-quartered in the U.S.,

[4] https://www.wsj.com/articles/green-junk-bonds-may-not-deliver-green-results-11623236581

China, Sweden, France, and Germany. The corporate issuers of green bonds mainly come from the financial, energy, utility, and industrial sectors.

The average stock price reaction concurrent with the announcement of green bond issue from 2013-2022 is 0.274%. However, this result is primarily attributable to financial sector firms. The 16-day market reaction for financial sector green bonds is 0.330%. Surprisingly, the analogous stock price reaction for green bonds issued by sectors known to pollute the environment is statistically insignificant. These findings are consistent with role of financial firms as 'sustainability gatekeepers' that channel capital to sustainable projects.

It's possible that the observed positive market reactions are linked to the issuing entity rather than the green bonds themselves. To delve into this hypothesis, we conducted a comparative analysis of the market's response to announcements of green bond issuances against those of conventional bonds by the same issuers. This comparison reveals that announcements of green bonds do indeed yield a higher market reaction compared to conventional bonds. However, this distinction is notably more pronounced among financial sector firms.

Previous research has studied the primary market of green bond issuance and found noapparent premium when compared with conventional bonds (Flammer, 2021; Tang and Zhang,2019; Baker et al, 2018; and Larcker and Watts, 2020). However, we also emphasize the critical importance of analyzing the secondary debt market. This emphasis arises from the recognition that various post-issuance reports, such as impact reports, second opinion reports, capital allocation reports, and use of proceeds reports, become available to the market subsequent to bond issuances. As a result, the pricing of debt securities can evolve over time, often differentiating them from primary market pricing. [5]

[5] https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/green-bond-premium-justified-by-strong-secondary-market-performance-flexibility-66696509

Compared with a conventional bond of same issuer in the same year, the 3,689 green bonds in our sample traded at 5.7 basis points of greenium accumulated over one month. The average greenium is mostly explained by the 8.3 bps greenium for green bonds issued by the financial sector. This fact pattern is consistent with the sustainability gate keeper hypothesis.

We find higher yields for green bonds issued by the polluting sectors of the economy (i.e., the utility, energy, material, and industrial segments) suggesting that such bonds are perceived as riskier by investors, and therefore, trade at a discount. This is somewhat surprising because one would expect higher greenium in the polluting sectors, given investors' presumed desire to provide financing to these sectors to improve their environmental impact.

Moreover, we find that the difference in illiquidity between green bonds and conventional bonds explains the differences in greenium across these two sets of bonds and that difference has dissipated over time. Analogously, the difference in positive stock reactions to green bonds relative to that of conventional bonds has also reduced over time.

Next, we evaluate who issues green bonds and whether such bonds are associated with the intended positive social and environmental outcomes. We find that firms with higher environment risk, measured by MSCI's carbon emissions risk exposure score, water stress exposure score, biodiversity risk exposure score, and the toxic emissions exposure score, are more likely to issue green bonds, perhaps to signal that they intend to reduce their future environmental footprint. As Flammer's (2021) results indicate, carbon emissions of the issuers of green bonds decline in the year following the issuance. However, when that time window is expanded, emissions of green bond issuers do not fall after three years following the issuance. This non-result holds up even when we focus only on the emissions data voluntarily disclosed by the issuers rather than on those

estimated by the data vendor. Hence, we do not find robust evidence for the signaling hypothesis that green bond issuers commit to curb future emissions.

In supplementary analysis, we highlight the concentration of green bond issues among certain companies. For instance, both Flammer (2021) and Tang and Zhang (2020) demonstrate that the stock market reacts positively to the issuance of green bonds. The average cumulative abnormal stock returns (CAR) for our U.S. sample of green bond issuers are 0.943% and significant at the 5% level, relative to insignificant stock price reactions in the international sample (0.015%). However, roughly 75% of the U.S. green bonds were issued by Solar City (Tesla's subsidiary) for the 2013-2018 sample (Flammer's sample). Solar City accounts for 31% of all U.S green bond issues when the sample is 2022.[6] The CAR associated with Tesla's green bond issuance is 1.136% (significant at the 5% level), while that associated with the green bonds for the remainder of the U.S. sample is statistically insignificant.

Similar issuer-level clustering (i.e., repeat issuers) in this asset class is observed in other parts of global market as well. For instance, Vasakronan AB issued 25% of Sweden's green bonds, Credit Agricole Corporate & Investment issued 61% of France's green bonds, Deutsche Bank AG issued 22% of Germany's green bonds, and similar clustered patterns are observed in other countries. Researchers that work on corporate green bonds might want to be mindful of the issuer clustering in green bonds. This paper adds to extant knowledge on the pricing of sustainable debt and the environmental implications of this asset class. We find support for the socially conscious investor hypothesis in that the greenium for the average sample is 5.7 basis points. However, consistent with the sustainability gatekeeper hypothesis, this lower yield is concentrated in green bonds issued by financial firms. Finally, the signaling hypothesis, related to firms issuing green

[6] We are highlighting this because past papers used the sample of 2013-2018 in which US green bond market was highly skewed towards Solar City green bonds.

bonds to indicate their commitment to cutting environmental exposure, is not borne out by our data.

The remainder of the paper is organized as follows. Section 2 summarizes the relevant literature. Section 3 presents the data and summary statistics. Section 4 explains the event-study methodology and the related results, while sections 5 and 6 discuss the secondary market results, the value implications for issuers, and the role of institutional investors in green bonds market. Section 7 concludes the paper.

2. Related Literature

Extant research suggests that the pressure on "brown" (polluting) industries to adopt sustainable practices comes from the regulators (Christensen et al. 2018; Dhaliwal et al. 2014), investors (Bauer et al. 2021), and consumers (Barrage et al. 2014; Servaes and Tamayo 2013; Lichtenstein et al. 2004). Several firms have chosen to raise financing to support and fund such demand for sustainable practices. Here, we concentrate on a major source of such financing – the so-called "green bonds"–and investigate shareholders' reaction to the announcement of such bonds and the benefits thereof for the issuing firm and the environment.

Discussing the firm's rationale of issuing green bonds, Flammer (2021) proposes three hypotheses – the signaling hypothesis, the greenwashing hypothesis, and cost of capital hypothesis. The signaling hypothesis posits that investors often lack sufficient information to evaluate the company's commitment to the environment (Lyon and Maxwell, 2011; Lyon and Montgomery, 2015). The signal is likely credible because complying with the demands of green bond holders and regulators requires extensive managerial effort and resources, which are costly to the issuer. Flammer (2021) finds that the carbon emissions of issuers decline following the issuance of green bonds, which is consistent with the idea that the signal is indeed believable ex post. She does not

find support for the cost of capital hypothesis as she documents no differential premium for green bonds relative to conventional bonds of the same issuer in the primary market, consistent with the results of Larcker and Watts (2019).

Flammer (2021) also studied the stock market reaction to green bonds announcement arguing that if corporate green bonds do provide a (credible) signal of companies' commitment to the environment, one would expect a positive stock market reaction. Indeed, she found CARs of 0.49% significant at the 5% level, consistent with her signaling hypothesis. These observations are also in line with Tang and Zhang's (2020) findings that the stock market reacts positively to the announcement of green bonds on account of the attendant media attention that the issuer garners.

However, we note that samples in Flammer (2001) are dominated by the U.S. market, especially by green securities issued by Tesla and its subsidiaries. In fact, once Tesla bonds are excluded, we document that stock price reactions on the announcement of green bonds in the U.S. sample spanning 2013–20 are negative and significant. The same negative and significant results are found with sustainability bonds and sustainability-linked bonds samples.

Past work has also investigated other aspects of green bonds. Baker et al. (2022) considers the attendant pricing and ownership patterns using a simple framework that incorporates assets with non-pecuniary utility. As predicted, the authors find that green municipal bonds are issued at a premium compared to otherwise similar ordinary bonds, while they also confirm that green bonds, particularly small or essentially riskless bonds, are more closely held than ordinary bonds. These pricing and ownership effects are strongest for bonds that are externally certified as green. Larcker and Watts (2020) examine a tightly matched sample of municipal green bonds issued with other bonds on the same day and by the same issuer and fail to identify such a greenium in their

sample. Both Baker et al. (2022) and Larcker and Watts (2020) relied on the primary issues of green bonds.

Unlike the primary market, the secondary market of green bonds receives additional information regarding what the issuer does with the green funds raised via green project performance reports and the assurance reports issued by the ESG rating agency, if any. Hence, it might be useful to understand how the risk and return dynamics of green bonds evolve in the secondary market as the information asymmetry surrounding the use of proceeds of green bonds reduces.

3. Data and Summary Statistics

3.1 Data

Our main sample was constructed using the Bloomberg, Worldscope, Datastream, and MSCI ESG rating databases. The data pertaining to corporate green bonds was obtained from Bloomberg's fixed-income database. Only issues labeled as "green bonds" were retained.[7] As shown in Table 1, 5,188 green bonds were issued between January 1, 2013 and December 31, 2022.[8] Following Flammer (2021), we excluded government-issued and other idiosyncratic green bonds with Bloomberg Industry Classification System (BICS) codes such as "Sovereigns," "Government Agencies," "Government Regionals," "Supernationals," "Government Development Banks," "Winding up Agencies," "Central Bank", and "Government local." We also exclude observations related to (i) bonds issued from tax havens; and (ii) cases where only one

[7] Bloomberg tags bonds with the "Green Bond" label in the use of the proceeds field when an issuer labels its bond as "green" or identities it as an environmental sustainability-oriented bond issued with clear additional statements about the company's commitment to deploying funds for projects and activities related to renewable energy, smart technologies, energy-efficient green buildings and infrastructure, agriculture and forestry projects, and other sustainability-based projects.

[8] The sample starts from 2013 since pre-2013 corporate green bonds were almost non-existent in the Bloomberg database.

bond was found from a particular country or a specific BICS level 2 industry. Following this filter, the final sample comprised a total of 5,179 green bonds.[9]

Given the somewhat ambiguous difference between green bonds and so-called "alternative" green bonds (e.g., sustainability bonds, sustainability-linked bonds, and social bonds), we also examine the issuance of such alternative bonds. Compared with green bonds, the issuance of alternative bonds is a relatively recent phenomenon. The first corporate sustainability bond was issued in 2014 and by then, companies had issued 680 such bonds by 2022, of which 118 comprised of unique issuer-day events, defined as issuance dates for a specific issuing company's bond. We identified 613 sustainability-linked bonds issued in 2018–22. Although the first social bond was issued in 2015, with a total of 372 social bonds issued between 2015 and 2022. The number of issuances for all the categories of sustainable debt peaked in 2021.

Panel A of Table 1 shows that the number of green bonds monotonically increased from 2013 (n = 15) to 2022 (n = 1,463), except for the year 2016 (n = 163), when issuances fell marginally. Total issuance amounts increased drastically from $4.9 billion in 2013 to $354.8 billion in 2022. The cumulative value of the corporate green bonds in the sample is $1.305 trillion. The growth of different sustainability labelled bonds is showed in Figure 1.

As panel B of Table 1 shows, green bonds are mainly concentrated in a small number of industries, namely, the financial (2,834), utilities (999), energy (422), and industrial (366) sectors. Panel C of Table 1 shows the country-level distribution of green bonds, with most of the bonds issued by firms headquartered in China (727), followed by Sweden (581), Germany (491), U.S. (455), and France (380).

As panel D of Table 1 shows, green bonds are mainly concentrated in a small number of industries, namely, the financial (1,340 bonds), utilities (558), energy (302), and industrial (171) sectors. Issuer-level concentration in this asset class can potentially affect the stock market reaction to a bond issue. Figure 2 shows that just ten issuers of green bonds account for 23% of bonds issued and the top 50 issuers account for roughly 40% of the issuance. This issuer level concentration further deepens at the country level. For instance, Vasakronan AB issued 25% of Sweden's green bonds, Credit Agricole Corporate & Investment issued 61% of France's green bonds, Deutsche Bank AG issued 22% of Germany's green bonds, and similar clustered patterns are observed in other countries. For further details, refer to Appendix B.

Somewhat surprisingly, 54.72% of the green bonds were issued by financial institutions, which accounted for around 51.72% of the total amount reported in the sample (panel B). Meanwhile, firms from the "dirty" (polluting) sectors, such as the materials, industrial, energy, and utilities sectors, collectively issued 37.3% of the green bonds, accounting for 37.5% of the total issuance amount. The proceeds from these bonds are mainly earmarked for green loans, green projects, refinancing existing green bonds, or for financing working capital needs. Among the different taxonomies used for identifying the green projects, reliance on green bonds principles (GBP) is the most common.

The GBP requires that proceeds should be invested in projects related to one of the 13 categories - clean transportation, climate change adaptation, terrestrial and aquatic biodiversity, sustainable water and wastewater management, renewable energy, energy efficiency, pollution prevention and control, green buildings, circular-economy-adapted products and services, and sustainable management of living natural resources and land use. For example, financial

institutions such as banks issue green bonds to cover green loans provided to support LEED-certified buildings, solar panels, and other similar sustainable products or activities.

The Climate Accounting Standard Board (CASB) encourages issuers to get green bonds certified either by the Climate Bonds Initiative (CBI) or by CBI-approved third-party agencies (e.g., Sustainalytics, Vigeo Eiris) based on the GBP. As shown in panel D, of the 5,179 bonds in the sample, 3,208 (62%) were certified by the CBI or through a third-party ESG assurance provider. The Bloomberg database does not contain data on an assurance provider for 386 of the bonds.

Green bonds also differ in terms of option-embeddedness, maturity, and credit rank. Out of the 5,179 green bonds, 68% were issued for a fixed term, and only 32% included options such as "call" or "put" options, sinking funds, or convertible features. Approximately 86% of these bonds will mature between three and 10 years, while a few will mature in 15 years or more. Bloomberg provides a composite credit rating only for 2,560 bonds, of which 452 are labeled "not rated." Finally, most bonds fall among the medium credit profiles ranging from A+ to BBB-and considered as investment grade bonds.

4. Sample and Event Study Results

4.1 Summary statistics

As Table 2 shows of the 5,179 green bonds issued in 2013–22, 2,124 bonds (*n* of firms = 751) were issued by private firms and 3,056 bonds by public firms (*n* = 974), either directly or via the private subsidiaries of public firms. Given that the same firm can issue multiple green bonds on the same day, we considered multiple bond issuances by the same issuer on the same day as one event, which yields 2,329 unique issuer-day events of public firms. On average, green bonds

mature in 8.6 years and pay a coupon rate of 2.94%, while the average capital raised by a green bond was $292 billion for a public firm. Around 74% of the green bonds issued by public firms were certified by third-party agencies, including the CBI or green auditors such as Sustainalytics, KPMG, or PricewaterhouseCoopers. The Bloomberg credit rating for these public green bonds varies from AAA to BBB- which falls under investment grade but MSCI ESG rating for these bonds is BB- (average), respectively.

4.2 Event study methodology

To conduct an event study on the announcement of corporate green bonds, we use the standard market adjusted returns model. Firm returns were calculated using the price data obtained from the Global Compustat database. The abnormal return (AR) for security *i* at day *t* was computed as follows:

$$AR_{it} = R_{it} - R_{mt}, \tag{1}$$

where R_{it} is the daily return inclusive of dividends for security *i* in day *t* and R_{mt} is the daily return of Morgan Stanley Capital International's (MSCI) all country world index (ACWI) for the same day.[10]

The CAR *t*-days before the green bond announcement to *t*-days after was estimated as follows:

$$CAR\ (-t, t) = \sum_{T=-t}^{t} AR_{it}. \tag{2}$$

The standard deviation for the estimated CAR can be expressed as

$$\sigma(CAR) = \left(\frac{1}{N} \sum_{t=1}^{N} \left(CAR\ (-t, t) - Avg\ \left(CAR_{pt} \right) \right)^2 \right)^{0.5} \tag{3}$$

where $Avg\ (CAR\ ) = \frac{1}{N} \sum_{n=1}^{N} CAR\ (-t, t)$.

[10] The MSCI ACWI captures large and mid-cap representation across 23 developed markets (DMs) and 27 emerging markets (EMs). With 2,965 constituents, the index covers approximately 85% of the global investable equity opportunity set. We use the MSCI ACWI because Flammer (2021) confirms that using this index as market provides the same results as using separate index for each market.

We estimate the CARs in different event windows from 3-days (-1,1) to 16-days (-5,10) consistent with Flammer (2021) and Tang and Zhang (2019).

4.2 Univariate analysis of CARs

4.2.1. Comparison of 2013–18 and 2013–22 samples

The univariate CARs pertaining to the green bond issuances are shown in panel A of Table 3. Columns 1–3 show the results for the full sample (i.e., 2013–22) and Columns 4–6 tabulate results for the certified bonds only. As shown in Column 1, the stock market reacted positively to a green bond issuance in the 16-day event window (−5, 10) with the CAR of 0.270% for the sample of green bonds issued between 2013 and 2022. Nevertheless, these results are driven by financial sector firms which reports a CAR of 0.330% for the same event window and is statistically significant. These CARs are insignificant for firms in polluting sectors. As suggested earlier, financial sector firms impose minimal environmental negative externalities on their own and financial firms can use green bonds proceeds for granting green loans by screening the borrowers and working as gatekeepers of sustainability concerns.

Because investors cannot verify the details of green projects directly, they depend on certification provided by the ESG assurance providers (such as Sustainalytics, DNV, and others). Investors would likely prefer green bonds with certification. In fact, investors react more strongly when certified bonds are issued with a 16-day CAR of 0.329%. Again, this is mainly driven by financial sector firms which reports a 16-day CAR of 0.368%. We did not find significant results for polluting sector firms.

To further inspect the robustness of these results, we use the same sample period as used in Flammer (2021) i.e., from 2013-2018. We were able to replicate the main results of the paper and found the market reaction of 0.539% for 16-day event window with significant at 5% level.

Again, the market reaction is mainly driven by financial sector firms with CAR of 0.872% for the same event window.

As Figure 2 shows, the green bonds market is concentrated among few issuers due to restriction on use of proceeds. This suggests that the same firms issue green bonds repeatedly for refinancing existing green project or to fund new green projects. Considering these firms as known market players in this area, we believe that the capital market would not just react positively to first issuance but also support repeat issuance of these firms. Panel B, Column 1 show that 16-day event window for repeat issuance is 0.284% and that return is statistically significant. However, we found that even for repeat issuance, the positive market reaction is concentrated in financial sector firms as opposed to firms in the polluting sector. This is unexpected because one would conjecture that capital markets would support polluting firms initiating the transition towards sustainability. [11]

It's possible that the observed positive market reactions are linked to the issuing entity rather than the green bonds themselves. To delve into this hypothesis, we conducted a comparative analysis of the market's response to announcements of green bond issuances against those of conventional bonds by the same issuers. This comparison, illustrated in Figure 3, reveals that announcements of green bonds do indeed yield a higher market reaction compared to conventional bonds. However, this distinction is notably more pronounced among financial sector firms.

4.2.2 Alternative green bonds

[11]Building on the findings of Flammer (2021) and Tang and Zhang (2019), which indicated a rise in institutional investor ownership among firms that issue green bonds, we also conduct a re-examination of this phenomenon. Our analysis confirms that institutional ownership does indeed tend to increase in companies issuing green bonds. However, attributing this uptick directly to the issuance of green bonds is challenging, as these firms typically already have substantial institutional investment prior to the issuance. The increase, as shown in Table B2, is not significant enough to conclusively link it to the green bonds alone. This outcome seems logical considering that issuers of green bonds are often large, profitable entities capable of committing their proceeds to environmentally-focused projects. The pre-existing high levels of institutional investor ownership in these companies are expected, rather than surprising, given their profile and capacity for risk-taking in the pursuit of sustainability.
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The popularity of green bonds has led to the issuance of so-called "alternative" green bonds, which include social bonds, sustainability bonds, and sustainability-linked bonds. The number of these bonds has increased with time. We investigate the stock price reactions to the issuance of these sustainability-linked bonds, with the results shown in Column 14. Here, we found 216 unique events associated with the issuance of these alternative green bonds. The average 16-day market reaction to the issuance of alternative green bonds is 1.447%, with the return significant at the 1% level. Such a positive but insignificant stock market reaction was also observed for the 218 sustainability bonds (Column 15) and for the 81 social bonds (Column 16). We show the event studies results for sustainability-linked, sustainability, and social bonds are similar to the results obtained for green bonds.

In sum, the positive stock price reactions to the issue of green bonds, as documented by prior work (Flammer 2021; Tang and Zhang 2020), are potentially attributable to financial sector firms. This suggests that capital markets appreciate the sustainable debt issuance by financial firms as these firms do not impose negative externalities, but they can play the gatekeeper role by screening for the right borrower to receive the green loans.

4.2.3 Determinants of stock market reaction to green bond announcements

To verify our univariate results, we also conducted multivariate regression analyses, with the results shown in panel C of Table 3. As Columns (1)-(6) shows the regressions results of the market reaction (CAR) in different event windows on *Financial Sector* dummy, *US* dummy, *Certified* dummy, dummy for *Repeat Issuance*, and *Pollution* sector dummy without the firm controls. We cluster errors at the firm level and at the year level. We find that indicator variables for financial sector firms and for *US Domiciled* are positive and significant. The CARs for financial firms are positive 0.270% and *US Domiciled* firms are 0.458% without firm controls. The market

reaction to *Certified* indicator and *Polluting* indicator are positive and insignificant, but for repeat issuances, the reaction is negative and insignificant.

Columns (7) – (10) show the regression results after including control variables such as *Size, Leverage, ROE,* and *Sales Growth*. We find that the *Financial Sector* dummy explains the CARs strongly across all event windows and is statistically significant. We also found that the *US* dummy is a significant factor in explaining CARs but only in long event windows, but it lacks explanatory power in short event windows. This suggests that *US* green bonds are greeted more positively by the stock market although this result is not significant in all event windows.

We assess whether repeat issuances and certification explain abnormal returns. We find that certification is positive and associated with abnormal returns. However, coefficients are insignificant in all the event windows. Results suggest that repeat issuances are associated with low abnormal returns compared to that for the first issuance. This is in line with Flammer (2021) who finds that market reaction is higher for first-time issuances.

Of the control variables, only *Leverage* explains the CARs and is negatively associated and significant in all event windows. This result is intuitive suggesting that if the overall leverage is high, abnormal returns for green bonds announcement are lower.

5. Secondary Market Performance of Green Bonds and Dynamics of Greenium

As information about the outcomes of the green projects and/or third-party opinion reports are released, one would expect information asymmetry associated with green bonds to diminish over time. In turn, the reduced information asymmetry should be reflected as lower-risk premiums priced into the bonds by the secondary market. This pricing can be different from primary market as at the time of issuance only the framework related to use of funds for green projects is usually revealed. Projects are yet to be implemented and outcomes of the projects are to be registered and

verified. Additional information in the form of second opinion report, impact reports, use of proceeds report (or capital allocation report) and others are released voluntarily after the issuance. Hence, it becomes important to examine the secondary market of green bonds for evidence of greenium.

We acknowledge that the impact of the issuance of green bonds on the secondary market outcomes and environmental performance is endogenous due to certain firm-level non-observables, which means estimating a simple ordinary least squares regression would generate biased results. As a ready natural or quasi-natural exogenous shock is unavailable, we rely on the propensity score matching technique to mitigate endogeneity concerns. Our matching process is similar to the one followed by Crabbe and Turner (1995), Larcker and Watts (2020), and Flammer (2021) in a number of ways. We compare green bonds with conventional bonds issued by the same issuer on the same year. Our matched green bonds sample has the same characteristics as conventional bonds except for the sustainability focus of green bonds. As these bonds are issued by the same firm and in the same year, variation in firm characteristics and time should not affect the comparison between green and conventional bonds. To mitigate the effect of firm and time unobservable variables, we have used firm and month-year fixed effects.

Specifically, the sample of 5,179 green bonds is matched with the non-green bonds for the same issuer and in the same year. We found the match for 3,689 green bonds. We verified that the treated group (green bonds) and control group (non-green bonds) are comparable in terms of bond level characteristics. To investigate the risk and returns of green bonds compared with those of conventional bonds in the secondary market, we gather monthly data on yield and prices for both the green bonds and the matched conventional bonds, with the monthly return estimated as a logarithm of current price to last month's price.

To examine the risk-return trade-off in the secondary market, we use the following difference-in-differences regression:

$$y_{ft} = \alpha_f + \alpha_t + \beta\ Green\ Bond_{ft} + \varepsilon_{ft}, \qquad (4)$$

where, α_c, α_t, and α_i are fixed effects for country, year, and industry (two digit-SIC) membership and *Green Bond* is a dummy variable that takes the value of 1 if the firm issues a bond that has a green label as per the Bloomberg database and is set to zero for non-green bonds. The dependent variables (*y*) are yield and holding period returns. The coefficient of interest is β which captures the difference in yield and returns between green bonds with respect to non-green bonds (conventional bonds).

Panel A of Table 4 shows the regression results. We find that the coefficient of the *Green Bond* dummy is -0.113 for the yield regression, indicating that the yield for the green bonds is 11.3 basis points (bps) lower than that of the conventional bonds. This premium decreases to a negative 11.7 bps for the financial sector but increases to negative 9 bps for the brown sectors. One would expect to observe lower yields in the brown sectors as investors directly finance improvements in the environmental footprint of, for example, the utilities, energy, materials, and industrial sectors. However, we find lower yields for green bonds issued by the financial sector, where the link between the use of proceeds and the actual environmental outcomes is less clear relative to such arrangements in the brown sectors. As Flammer (2021), Tang and Zhang (2020), and Reed, Cort, and Yonavjack (2019) all demonstrate, green bonds certified by the CBI or another third-party appear to be viewed favorably in the capital markets, and we re-examine our sample to ascertain whether this was indeed the case. We find that our results were largely robust to whether the green bonds were certified by third-party agencies. The detailed results are presented in Appendix.

5.1 Illiquidity in bond markets

Because bond markets are inherently illiquid, past literature suggests that investors ask for liquidity premium. Bao, Pan, and Wang (2011) find that illiquidity is by far the most important factor in explaining the monthly changes in the U.S. aggregate yield spreads of high-rated bonds (AAA through A), with an R2 ranging from 47% to 60%. One can argue that greenium is over-estimated without adjusting for liquidity premium. The theory behind measuring illiquidity is the lack of liquidity in an asset gives rise to transitory components in its prices, and thus the magnitude of such transitory price movements reflects the degree of illiquidity in the market. Because transitory price movements lead to negatively serially correlated price changes, the negative of the autocovariance in relative price changes, which we denote by γ, gives a meaningful measure of illiquidity. Roll (1984) first considered the simple case in which the transitory price movements arise from bid–ask bounce, where square root of negative covariance equals the bid–ask spread. But in more general cases, γ captures the broader impact of illiquidity on prices, above and beyond the effect of bid–ask spread. Moreover, it does so without relying on specific bond pricing models.

Following Bao, Pan, and Wang (2011), p_t denotes the log price. The p_t consists of two components:

$$p_t = f_t + u_t \tag{5}$$

The first component f_t represents its fundamental value—the log price in the absence of frictions, which follows a random walk; the second component u_t comes from the impact of illiquidity, which is transitory (and uncorrelated with the fundamental value). In such a framework, the magnitude of the transitory price component u_t characterizes the level of illiquidity in the market. The measure of illiquidity γ is aimed at extracting the transitory component in the observed price p_t. Specifically, let $\Delta p_t = p_t - p_{t-1}$ be the price change from

t − 1 to t. We define γ by,

$$Illiquidity\ (\gamma) = \sqrt{-\ Cov\ (\Delta\ p_t, \Delta\ p_{t+1})} \quad (6)$$

The above assumes that the fundamental value f_t carries no time varying risk premium, and illiquidity can be viewed as a manifestation of these frictions.[12]

$$y_{ift} = \alpha_f + \alpha_t + \varphi\ Illiquidity_{ift} + \varepsilon_{ift}, \quad (6\ (i))$$

$$Residual_{ift} = \alpha_f + \alpha_t + \beta\ Green\ Bond_{ift} + \eta_{ift}, \quad (6\ (ii))$$

The residual in Eq 6(i) captures the liquidity adjusted yield (LAY) at the bond level and is used as the dependent variable in 6(ii). The coefficient of interest is β which captures the greenium, the differential in LAY of green bonds relative to conventional bond issued by the same firm.

The results from Eq 6 (ii) are provided in Table 4 Panel B. Column (1) reports the results for the complete sample. The coefficient β for the full sample is negative 0.057 which suggests a residual greenium of 5.7 basis points. However, the coefficient is statistically insignificant. Column (2) reports the results for financial sector firms where β is negative 0.082 suggesting a significant residual greenium of 8.2 basis points which is statistically significant at the 5% level. The last column shows the results for polluting sector firms where β negative 0.049 but statistically insignificant.

5.2 Dynamics of Greenium:

[12] A more precise separation of f_t and u_t must rely on a pricing theory incorporating frictions or illiquidity. See, Huang and Wang (2009) and Vayanos and Wang (2009) for the details.

To develop the time series of greenium (β), we estimate the regression in equation 6 for each year. Figure 4 suggests that greenium have reduced with time and have fallen to close to zero after 2019. The figure also demonstrates that differences in illiquidity between green bond and conventional bond by the same issuer, are correlated with the evolution of greenium.

6. Environmental Performance Pre and Post Green Bond Issuance

Thus far, we have discussed the investor or the demand-side reaction to green bonds. However, it is equally interesting to discuss the issuer's motives, especially in terms of their desire to signal improved environmental impacts in the future. Therefore, we reassess the signaling hypothesis, discussed by Flammer (2021) and others that firms issue sustainable debt, to signal their positive environmental performance in the future. We measure environmental performance using several proxies including metrics from the MSCI ESG rating database such as carbon emissions risk, water stress risk, toxic waste risk, and biodiversity risk scores. For robustness, we also examine environmental performance using carbon intensity. As suggested by Aswani, Raghunandan, and Rajgopal (2024), we evaluate the results for disclosed versus estimated carbon emissions values. We focus on the risk dimensions from MSCI, as opposed to opportunities metrics, because risk uses the past and current information, which is more reliable and verifiable, unlike data on environmental opportunities information which is forward looking and unverifiable. For the same reason, we avoid using score variables from MSCI because scores include unweighted or weighted data on opportunities.

We estimate firm-year level regressions by matching green bond issuers with comparable firms based on the country, industry, firm characteristics, and year. The overlapping kernel density curves of the propensity score (based on the covariates) for the green bonds and the matched conventional bonds validate the matching process (Figure 5 Appendix B). The only major

difference between the treatment group (green bond issuers) and control group (non-green bond issuers) lies in the intended green use of bond proceeds and firms' environmental performance.

To examine the impact of green bonds on environment risk, we use the following difference-in-differences regression:

$$y_{it} = \alpha_c \times \alpha_t + \alpha_i \times \alpha_t + \beta\, Green\, Bond_{it} + \gamma\, X_{it} + \varepsilon_{it}, \qquad (7)$$

where, α_c, α_t, and α_i are fixed effects for country, year, and industry (two digit-SIC). y is present or future environment risk exposure for firm i. *The Environment Risk Exposure Risk is measured as Carbon Emissions Risk, Water Stress Risk, Biodiversity Risk, and Toxic Waste Risk scores. Green Bond* is a dummy variable that takes the value "1" if firm *i* issues at least one green bond in year t; and to zero otherwise. X is a vector of firm level controls: *Size, Leverage, ROE,* and *Sales Growth*. The error term ε is i.i.d and is assumed to follow a normal distribution. For this analysis, β is our coefficient of interest.

6.1 Environmental performance at the issuance of green bonds

Panel A of Table 5 reports the environmental risk of an issuer at the time of issuing green bonds. We have 3,911 firm-year observations to test this model. The coefficient of interest is the one on *Green Bonds Issuer (β)*. Under column (1) where the dependent variable is *Carbon Emissions Risk,* the coefficient on β is 0.183 and significant at the 1% level, suggesting that Carbon Emissions Risk for green bonds issuer is 0.183 points higher than non-green bonds issuer at the time of issuance. The same is true for *Water Stress Risk, Biodiversity Risk, and Toxic Waste Risk* which measures the risk score from MSCI ESG rating database related to different negative externalities. These results suggest that environment risk exposure for the green bonds issuer is

ex-ante higher than for a non-green bonds issuer. Next, we check whether the issuer reduces their environment risk in the future with the issuance of green bonds.

6.2 Future environment performance of green bond issuer

We examine future environment risk metrics of green bond issuer relative to comparable firms. As three-year ahead and five-year ahead future environment performance measures are not available for issuers which issued green bonds recently, we focus only on those green bond issuers for which this data are available. The regression results for three-years post green issuance is provided in Table 5 Panel B. The β on *Carbon Emissions Risk* is positive 0.370 but insignificant. The inferences are similar for *Water Stress Risk, Biodiversity Risk,* and *Overall Environment Risk*. These results suggest that future environmental performance of green bonds issuers is not different from comparable firms in the same industry and with similar firm characteristics which never issued green bonds.

For robustness, we also examine the impact of green bond issuing firms on carbon intensity and found that there is no improvement in carbon intensity of green bond issuers with respect to the matched firms. These results further strengthen for disclosed emissions relative to vendor-estimated emissions. Results are provided in Table B1.

The composition of the green bonds market provides a clear illustration of its current state. Financial institutions, which are responsible for approximately 50% of green bond issuances, generally don't have significant environmental impacts themselves, yet they play a pivotal role as gatekeepers of sustainability. Meanwhile, industries known for their environmental footprints — specifically those in the industrial, material, utility, and energy sectors — account for around 40% of the market. The remaining 10% is made up of various other sectors.

Given that firms within polluting industries require substantial time and investment in long-term projects to meaningfully reduce their negative environmental externalities, it's plausible that the impact of green bonds on environmental risk might not be immediately evident. Indeed, over a short span of three to four years, green bond issuances may not yet demonstrate significant strides toward mitigating environmental challenges. Due to this reason, we acknowledge that green projects are long-term projects leaving open the possibility that environmental risk will reduce in the future.

7. Sustainable Lending and Borrowers Environment Performance

Finally, we examined whether green bond-issuing banks share the 'greenium' in the loan market. Table 6, Panel A highlights the green categories in which banks issue green loans, with the majority allocated to renewable energy and green building projects. This trend remains consistent regardless of whether the green bond-issuing bank is private or public.

Panel B tracks the environmental performance of borrowers over time. Following the methodology proposed by Aswani et al. (2023), we measure environmental performance using carbon intensity metrics for Scope 1 emissions, Scope 2 emissions, and their combination (direct emissions). Our findings indicate that borrowers' environmental performance has not improved over time, revealing a lack of due diligence by banks in monitoring the environmental metrics of their borrowers.

Lastly, Panel C compares green loans to traditional loans issued by green bond-issuing banks. While green loans tend to have lower spreads than traditional loans, this difference is statistically insignificant. This suggests that while green bond-issuing banks benefit from a premium ('greenium') in the bond market, this advantage is not transferred to the loan market.

8. Conclusions

Influential extant theory (e.g., Pastor et al. 2021) suggests that socially conscious investors are willing to trade wealth for societal benefits, which translates into a positive premium, or lower yields, for green securities. In this paper, we revisit the market pricing of green bonds in primary and secondary markets and examine the attendant environmental implications for both issuers and society. Contrary to past work (e.g., Flammer 2021; Tang and Zhang 2019), we demonstrate that the positive shareholders' reaction to the announcement of green bonds is mainly driven by financial sector firms and by Tesla in the U.S. The market reaction for polluting sector firms is insignificant. This is surprising as we would expect the market to appreciate the efforts of polluting sector firms to curb future emissions by issuing green bonds.

Unlike in the primary market, investors in the secondary market of green bonds have access to additional information, such as green project performance reports and green auditors' second-opinion reports on how the proceeds from the green bonds were used. We find that green bonds trade at a greenium of 5.7 basis premium in the secondary market, while this is mainly attributable to the green bonds of the financial sector which report a greenium of 8.3 basis points. Green bonds issued by the four main polluting or "brown" sectors, namely, the energy, industrial, materials, and utilities industries, earn smaller and insignificant greeniums compared with those pertaining to the financial sector. This is again somewhat surprising because we expected investors to reward polluting firms for cutting their emissions rather than rely on financial firms to provide loans to the polluters to indirectly improve their environmental impact.

Green bonds are more likely to be issued by firms with high environment risk exposure, measured as high carbon emissions risk, water stress risk, biodiversity risk, and toxic emissions risk as per MSCI. Despite an implicit motivation to improve their environmental record, we found no change in the environmental performance of the issuers of the green bonds compared with their matching counterparts, even after three years.

To the best of our knowledge, this is the first paper to demonstrate that positive market reaction and greenium in secondary bond market is mainly due to financial sector firms suggesting support for our proposed 'Sustainability Gatekeeper Hypothesis.' The greenium values in the secondary market are surprisingly lower for green bonds issued by polluters than for those issued by financial firms that will presumably lend to these polluters to improve their environmental impact. These good intentions do not seem to pan out ex post as the emissions for the issuers of green bonds remain unchanged compared with that of matched firms, even after three years following issuance. Overall, we provide a sobering correction to the narrative that green bonds are effective instruments for all issuers to signal their commitment to improving their environmental impact.

Exploring the sustainable lending of these gatekeepers and borrowers' environmental performance, we found that green bond issuer banks earn premium ('greenium') in the bond market but does not pass-through in the loan market. We also found that environmental performance of borrowers has not changed with time, and this shows the lack of due diligence by the banks in monitoring the environmental parameters of the borrowers.

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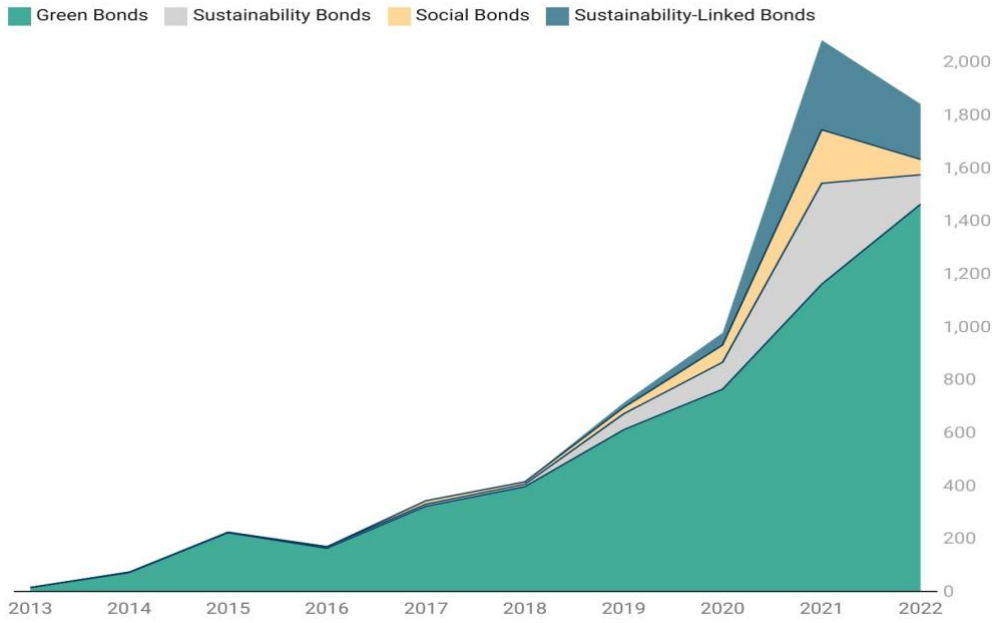


Figure 1: Yearly Trend in Sustainable Debt. This figure shows the yearly growth in issuance of green bonds, sustainability bonds, social bonds and sustainability-linked bonds from 2013 to 2022. These are four major categories of sustainable debt.

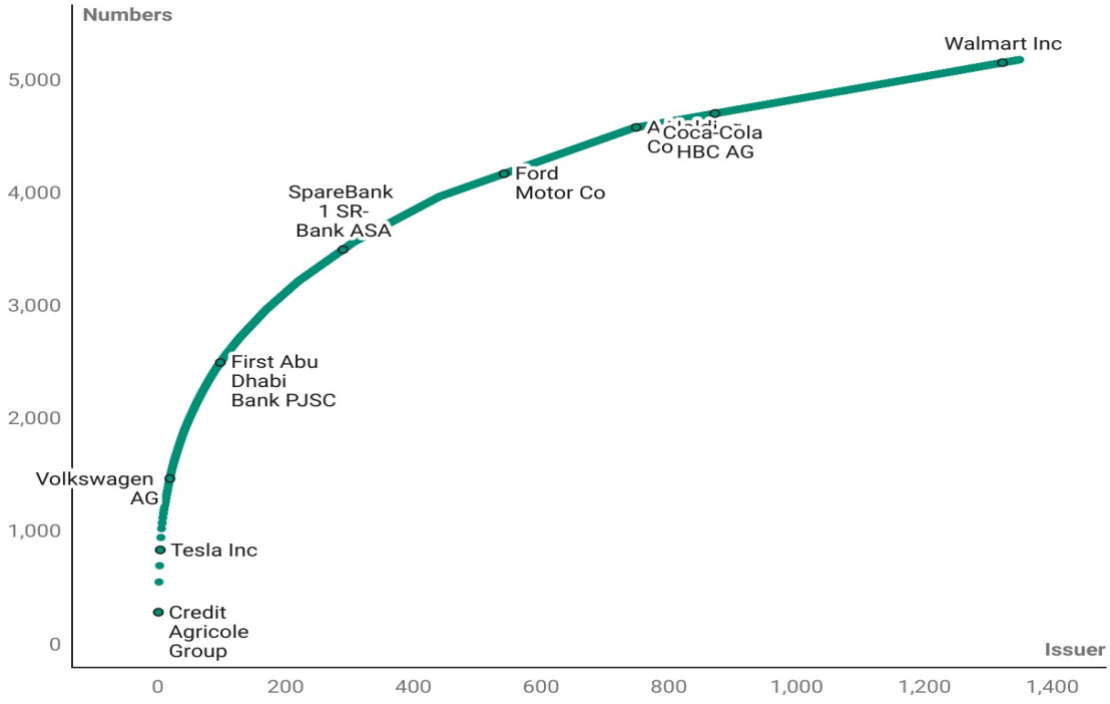


Figure 2: **Green Bonds Repeat Issuance and Issuer-level Concentration.** This figure show the concentration in the green bonds market at the issuer –level and the relation between number of issuers and cumulative number of green bonds. For instance, Top 200 issuers issue about 60% of total green bonds issued from 1st January 2013 to 31st December 2022.

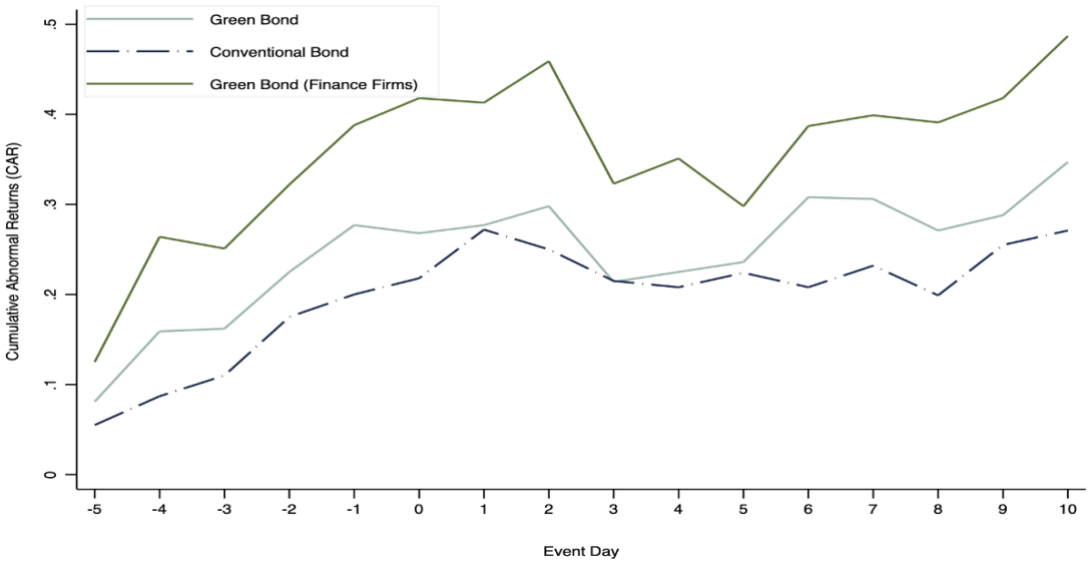


Figure 3: Green Bonds vs. Traditional Bonds. This figure captures the event study results (measured by cumulative abnormal returns (CARs) for green bonds vs. transitional bonds issued by the same firm from 1st January 2013 to 31st December 2022. Event is an issuance of bond and event window is from 5-day prior to event to 10-day after the event.

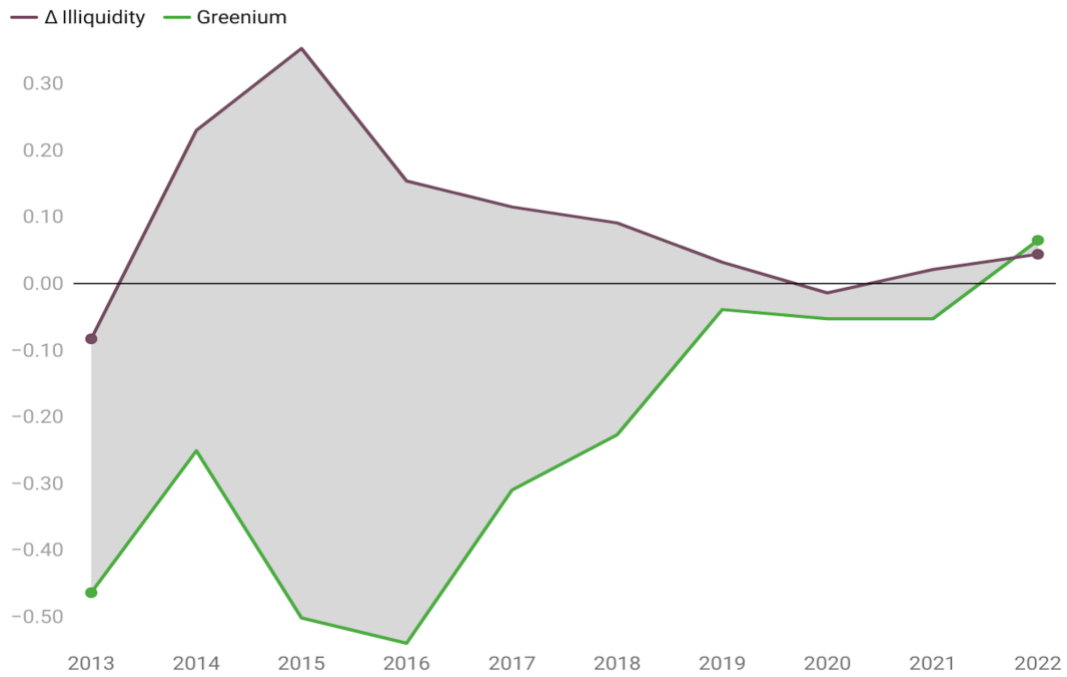


Figure 4: Dynamics of Greenium. This figure shows the greenium in the secondary market and how it changes with differential illiquidity. Greenium is yield differential of green bond from the conventional bond issued by the same firm and in the same year. Differently illiquidity is difference in illiquidity between these bonds. The sample has green bonds from 1st January 2013 to 31st December 2022.

Table 1: Trends in Green Bonds Issuance

This table presents the details of the filtering criteria used for the sample selection and the distribution of green bonds issued from 1st January 2013 to 31st December 2022. Panel A shows the yearly distribution in green bond issuance. Panel B shows the industry-level (Bloomberg Industry Classification System [BICS] level I) distribution of green bond issuance. Panel C shows the country-level distribution of green bond issuance. Panel D shows the number of green bonds certified by ESG (environmental, social, and governance) assurance providers.

Panel A: Yearly Distribution of Green Bonds

Panel A presents the yearly distribution and total amount of green bonds issued from 2013 to 2022. Column 1 shows the year of issuance, Column 2 the frequency of green bond issuances in that year, and Column 3 the value of these green bonds in billions of USD.

Year	Frequency	Total Amount Issued (in billions of USD)
(1)	(2)	(3)
2013	15	4.9
2014	71	14.1
2015	222	28.7
2016	163	68.9
2017	322	85.1
2018	396	92.3
2019	611	160.8
2020	764	174.5
2021	1,152	321.5
2022	1,463	354.8
Total	5,179	1,305

Panel B: Industry-Level Distribution

Panel B reports the industry-level distribution and the total amount of green bonds issued between 2013 and 2020. The industry classification used is BICS level 1. The total amount issued is in billions of USD. Column 1 shows the name of the industry, while Columns 2 and 3 report the frequency and the total amount of green bonds aggregated at the industry level, respectively.

Industry (BICS Level 1)	Number of Green Bonds		Amount Issued	
	(Number)	(in %)	(In Billion USD)	(In %)
Financials	2,834	54.72	668.6	51.24
Utilities	999	19.29	322.2	24.69
Industrials	360	6.95	73.4	5.63
Consumer Discretionary	240	4.63	71.6	5.48
Materials	151	2.92	47.4	3.63
Energy	422	8.15	47.1	3.61
Communications	40	0.77	26.8	2.06
Technology	62	1.20	26.1	2.00
Consumer Staples	58	1.12	17.8	1.37
Health Care	13	0.25	4.7	0.36
Total	5,179	100	1,305	100.00

Panel C: Country-Level Distribution

Panel C shows the country-level distribution of green bonds. Following Flammer (2021), "country" is defined as the country of domicile. Column 1 shows the name of the country, while Column 2 shows the frequency of green bonds aggregated at the country level, and Column 3 shows the percentage of green bonds with respect to total green bonds issued.

Country	Number of Green Bonds	Amount Issued (in Billion USD)
China	727	206.6
Sweden	581	52.6
Germany	491	110.2
United States	455	180.2
France	380	92.0
Japan	302	47.8
Norway	215	40.5
Korea, Republic of	207	34.2
Netherlands	181	130.6
Malaysia	170	1.6
Luxembourg	131	31.3
Spain	125	47.6
United Kingdom	124	41.8
Hong Kong	112	29.8
Brazil	90	8.2
Taiwan, Province of China	78	5.7
Canada	68	22.0
Austria	58	11.2
Italy	57	32.3
Denmark	53	17.1
Thailand	47	2.9
India	40	12.6
Finland	37	15.0
Australia	35	12.5
Singapore	33	9.1
Belgium	32	7.4
Switzerland	32	5.2
Other	318	97.5
Total	5,179	1,305

Panel D: Certified Green Bonds

Panel D reports the distribution and the total amount of green bonds issued (in billions of USD) based on whether the bonds were certified by ESG assurance providers. The ESG assurance providers were the Climate Bond Initiative (CBI) think-tank and the third-party rating agencies approved by the CBI. Column 1 shows the categorization, i.e., certified, not certified, or information not available. Columns 2–3 present the frequency and the total amount of green bonds issued aggregated at the category level, respectively.

Certified Green Bonds	Frequency	Amount Issued (in billion USD)
(1)	(2)	(3)
Not Certified	480	66.5
Certified	4,324	1120.7
Information NA	375	118.3
Total	5,179	1,305

Table 2: Bond-Level Descriptive Statistics

This table reports the bond-level descriptive statistics for green bonds issued from 1st January 2013 to 31st December 2022. Column 1 provides descriptive statistics for the overall sample. Columns 2 and 3 provide the descriptive statistics for green bonds issued by private and public issuers, including those issued by public firms' subsidiaries. *#Green Bonds* denotes the number of green bonds and *#Green Bond issuer-days* denotes the number of the unique issuer-day combination when green bonds are issued. For instance, if an issuer issues one green bond or multiple green bonds in a single day, both are considered as one event (or unique issuer-day). *#Green Bond issuer-years* denotes the number of the unique issuer-year combination when green bonds are issued. *Maturity* is measured as the difference in the year of maturity and the year of issuance. *Yield* is an offer yield to maturity, measured in percentage (%). *The coupon* is the coupon rate on green bonds, measured in percentage (%). *The average amount* pertains to green bond issuance in billions of USD. *Option Embedded* denotes the percentage of green bonds embedded with options such as "call," "put," "sink," "convertible." *Certified* is the dummy variable, which takes a value 1 if the ESG assurance provider certified the green bond and 0 if not. *ESG Rating* is the MSCI ESG rating of firm from AAA to CCC. AAA and AA ESG ratings are considered Leaders, A to BB ESG ratings are considered Average, and B and CCC ESG ratings are considered Laggards.

	(1)	(2)	(3)
	All	Private	Public
# Green Bonds	5,179	2,124	3,056
# Green bond issuer-days	3,895	1,566	2,329
# Green bond issuer-years	2,617	1,086	1,531
# Green bond issuers	1,725	751	974
Yield (in %)	2.232	2.211	2.256
Coupon (in %)	2.94	3.13	2.64
Amount Issued (in million USD)	256	234	292
Option Embedded (in %)	32	33	31
Maturity (in years)	8.626	7.932	8.127
Certified (in %)	89	93	81
ESG Rating (MSCI)	Average	Average	Average

Table 3: Issuance of Green Bonds and Stock Market Reaction

This table reports the stock market reaction to the issuance of green bonds issued from 1st January 2013 to 31st December 2022. The cumulative abnormal returns (CAR) is a proxy for market reaction computed as a sum of abnormal returns. The market-adjusted returns are deemed abnormal returns. Panel A shows the univariate results for cumulative abnormal returns (CARs) (unique events) in different event windows in different samples. Panel B shows the regression estimates of CARs in terms of determinants. CAR (–1, 1) is the CARs with an event window of one day before the event to one day after. CAR (–2, 2) is the CARs with an event window of two days before the event to two days after. CAR (–3, 3) is the CARs with an event window of two days before the event to two days after. CAR (–4, 4) is the CARs with an event window of four days before and four days after. CAR (–5, 5) is the CARs with an event window of five days before the event to five days after. CAR (–5, 10) is the CARs with an event window of five days before the event to 10 days after. *N* is the number of unique events. A unique event is an event when the firm issues a green bond on a particular day. For instance, if an issuer issues one green bond or multiple green bonds in a single day, both are considered as one event (or unique issuer-day). The same firm issuing multiple green bonds on the same day is counted as a single unique event. *Polluting* is a dummy variable that takes the value of 1 if the issuer belongs to the polluting sector (material, industrial, utility, and energy industries) and 0 if not. *Certified* is a dummy variable that takes a value of 1 if the bond was certified by the CBI or a CBI-approved third party. *Repeat Issuances* include the sample of green bonds excluding the first issuance of each issuer. If the issuer issues only one green bond from 2013-2022 that issuer not counted in repeat issuances. *Size* is firm size measured as natural logarithm of total assets. *Leverage* is firm's leverage measured as total debt to equity ratio. *ROE* is return of equity measured as net income to total common equity value. *Sales Growth* is growth in sales with respect to last year. Standard errors are in parentheses. ***, **, * denote the significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Sectoral Analysis, Certification, and Flammer (2021)

Panel A reports the univariate CAR results in different event windows for green bonds issued between 2013 and 2022. Column 1 presents the CARs for all the unique events in the sample, Column 2 the CARs for the financial sector firms, Column 3 the CARs for the polluting sector firms, Column 4 the CARs for all the certified green bonds, Column 5 the CARs for the certified green bonds issued by financial sector firms, Column 6 the CARs for the certified green bonds issued by polluting sector firms, Columns 7-9 show the CARs for the full sample, financial sector firms, and polluting sector firms using the sample from 2013-2018 same as Flammer (2021).

	Full Sample (2013-2022)						**Sample: 2013–2018 (Flammer's Sample)**		
	Full Sample	Financial Sector	Polluting Sector	Full Sample **Certified**	Financial Sector **Certified**	Polluting Sector **Certified**	Full Sample	Financial Sector	Polluting Sector
Variable\Events	N=2081	N=1274	N=618	N=1382	N=903	N=363	N=405	N=253	N=141
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
CAR (−1,1)	-0.048	0.024	0.180	0.030	0.051	0.051	0.059	0.088	-0.003
	(0.070)	(0.079)	(0.158)	(0.081)	(0.092)	(0.190)	(0.105)	(0.139)	(0.165)
CAR (−2,2)	-0.040	-0.010	-0.127	-0.001	0.024	-0.039	-0.022	0.092	-0.142
	(0.087)	(0.107)	(0.173)	(0.104)	(0.124)	(0.228)	(0.141)	(0.185)	(0.227)
CAR (−3,3)	-0.028	0.044	-0.116	-0.036	0.048	-0.119	0.010	0.212	-0.242
	(0.103)	(0.127)	(0.205)	(0.122)	(0.146)	(0.256)	(0.163)	(0.218)	(0.243)
CAR (−4,4)	0.034	0.027	0.199	-0.001	0.027	0.201	0.102	0.193	0.032
	(0.118)	(0.148)	(0.230)	(0.141)	(0.170)	(0.300)	(0.177)	(0.220)	(0.312)
CAR (−5,5)	0.149	0.216	0.199	0.149	0.214	0.227	0.231	0.437*	-0.026
	(0.129)	(0.161)	(0.258)	(0.154)	(0.184)	(0.338)	(0.195)	(0.236)	(0.359)
CAR (−5,10)	0.274*	0.330*	0.354	0.329*	0.368*	0.452	0.539**	0.872***	-0.097
	(0.157)	(0.194)	(0.318)	(0.187)	(0.219)	(0.423)	(0.239)	(0.292)	(0.432)

Contd.

Panel B: Repeat Issuances and Alternative Green Bonds

Panel A reports the univariate CAR results for repeat issuances and alternative green bonds such as sustainability bonds, sustainability-linked bonds, and social bonds. Columns 1-3 show CARs for repeat issuances for full sample, financial sector firms, and for polluting sector firms. Columns 4-6 show CARs for alternative green bonds (i.e., sustainability-linked bonds, sustainability bonds, and social bonds). Column 4 show CARs for sustainability-linked bonds. Column 5 shows CARs for sustainability bonds. Column 6 shows CARs for social bonds.

	Repeat Issuances			**Alternative Green Bonds**		
	Full Sample	Financial Sector	Polluting Sector	Sustainability-Linked	Sustainability	Social
Variable\Events	N=1742	N=1072	N=509	N=216	N=218	N=81
	(11)	(12)	(13)	(14)	(15)	(16)
CAR (−1,1)	-0.038	0.084	0.268	0.107	-0.174	0.354
	(0.078)	(0.086)	(0.182)	(0.180)	(0.210)	(0.314)
CAR (−2,2)	-0.035	0.045	-0.222	0.386*	0.028	0.372
	(0.096)	(0.117)	(0.196)	(0.235)	(0.241)	(0.464)
CAR (−3,3)	-0.018	0.108	-0.214	0.695**	-0.019	0.501
	(0.114)	(0.139)	(0.233)	(0.305)	(0.266)	(0.565)
CAR (−4,4)	0.046	0.091	0.092	1.119***	0.051	0.495
	(0.131)	(0.163)	(0.259)	(0.344)	(0.282)	(0.590)
CAR (−5,5)	0.161	0.280	0.103	1.365***	0.328	0.440
	(0.143)	(0.178)	(0.287)	(0.400)	(0.298)	(0.660)
CAR (−5,10)	0.284*	0.390*	0.291	1.447***	0.533	1.067
	(0.176)	(0.216)	(0.361)	(0.489)	(0.379)	(0.908)

Panel B: Determinants of Market Reaction

Panel B reports the results for the multivariate regression of CARs in relation to their determinants. Columns 1–6 presents the regression results for CARs in different event windows on *Financial Sector, Pollution Sector, Certified, Repeat Issuances, and US Dummy.* Columns 7–12 presents the regression results for CARs in different event windows on *Financial Sector, Pollution Sector, Certified, Repeat Issuances, and US Dummy* and firm fundamentals such as *Size, Leverage, ROE, and Sales Growth.* All variables are as defined in Appendix A. All regressions include error clustering at firm level and year level. Standard errors are in parentheses. ***, **, * denote the significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
VARIABLES	CAR (-1,1)	CAR (-2,2)	CAR (-3,3)	CAR (-4,4)	CAR (-5,5)	CAR (-5,10)	CAR (-1,1)	CAR (-2,2)	CAR (-3,3)	CAR (-4,4)	CAR (-5,5)	CAR (-5,10)
Financial Sector	0.270*	0.113	0.424	0.802**	0.782*	0.720	0.270*	0.038	0.345**	0.840***	0.764***	0.742**
	(0.120)	(0.211)	(0.244)	(0.250)	(0.367)	(0.453)	(0.133)	(0.147)	(0.135)	(0.203)	(0.196)	(0.245)
US Dummy	0.458**	0.533**	0.659**	0.587**	0.777*	1.121**	0.352	0.535	0.793*	0.730**	0.962*	1.289*
	(0.189)	(0.211)	(0.277)	(0.245)	(0.381)	(0.368)	(0.234)	(0.304)	(0.399)	(0.321)	(0.463)	(0.698)
Certified	0.439	0.433*	0.271	0.155	0.206	0.407	0.404	0.408	0.245	0.124	0.244	0.129
	(0.299)	(0.198)	(0.272)	(0.429)	(0.539)	(0.682)	(0.328)	(0.290)	(0.375)	(0.517)	(0.593)	(0.881)
Repeat Issuance	-0.094	-0.181	-0.290	-0.311	-0.209	-0.085	-0.033	-0.032	-0.039	-0.093	-0.007	-0.159
	(0.200)	(0.233)	(0.228)	(0.273)	(0.240)	(0.321)	(0.230)	(0.298)	(0.318)	(0.309)	(0.352)	(0.362)
Pollution Sector	0.240*	0.037	0.214	0.871*	0.671	0.569	0.147	0.004	0.181	1.038**	0.838*	0.610
	(0.130)	(0.210)	(0.274)	(0.404)	(0.426)	(0.572)	(0.129)	(0.183)	(0.256)	(0.376)	(0.419)	(0.503)
Size							-0.048*	0.000	0.038	0.031	0.004	0.004
							(0.022)	(0.042)	(0.070)	(0.068)	(0.060)	(0.082)
Leverage							-0.009**	-0.012**	-0.015**	-0.014*	-0.022***	-0.011
							(0.003)	(0.005)	(0.005)	(0.007)	(0.007)	(0.009)
ROE							0.004	0.004	0.008	0.014	0.019	0.039*
							(0.004)	(0.007)	(0.010)	(0.016)	(0.019)	(0.019)
Sales Growth							-0.001	-0.001	0.002	-0.002	-0.003	0.000
							(0.003)	(0.004)	(0.005)	(0.007)	(0.008)	(0.008)
Constant	-0.650**	-0.507*	-0.619	-0.881	-0.738	-0.722	0.899	-0.137	-1.225	-1.504	-0.426	-0.601
	(0.282)	(0.245)	(0.384)	(0.590)	(0.689)	(0.895)	(0.754)	(1.152)	(2.016)	(2.096)	(1.699)	(2.280)
Observations	1,482	1,482	1,482	1,482	1,482	1,482	1,252	1,252	1,252	1,252	1,252	1,252
R-squared	0.002	0.001	0.002	0.003	0.002	0.002	0.005	0.004	0.007	0.006	0.008	0.008
Clustering Error												
Firm	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 4: Risk–Return Trade-off in Secondary Market: Green Bonds vs. Conventional Bonds

This table shows the risk and return of green bonds in relation to conventional bonds in the secondary market from 1st January 2013 to 31st December 2022. The risk is measured as offer yield to maturity (Yield) and the return is the holding period return at one, three, or six months. Panel A the regression results for yield and holding period returns on the green bonds indicator, and panel B shows the regression results for liquidity adjusted yield (LAY) on the indicator of green bond indicator. The polluting sectors comprise the energy, industrial, material, and utility sectors. Yield and returns are in monthly frequency. *Return 1m* is one month bond returns, *Return 3m* is three months holding period returns, and *Return 6m* is six month holding period returns. *Liquidity Adjusted Yield (LAY)* is residual bond yield after excluding the liquidity risk measured using Roll (1984). Green Bond is dummy variable which takes value 1 if the bond is labelled green and 0 for conventional bonds. All regressions include firm fixed effects and month-year fixed effects. All variables are as defined in Appendix A. Standard errors are reported in parentheses. ***, **, and * denote statistical significance at the two-tailed 1%, 5%, and 10% level, respectively.

Panel A: Yield and Return between Green Bonds and Conventional Bonds in the Secondary Market

Panel B shows the green bond yield and holding period returns vs. conventional bonds issued by the same firm in same year. Columns 1–4 show the results for the complete sample, Columns 5–8 show the results for the financial sector firms, and Columns 9–12 show the results for the polluting sector firms.

	Full Sample				**Financial Sector Firms**				**Polluting Sector Firms**			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
VARIABLES	Yield	Return 1m	Return 3m	Return 6m	Yield	Return 1m	Return 3m	Return 6m	Yield	Return 1m	Return 3m	Return 6m
Green Bond	-0.113***	0.199	0.391	0.657	-0.117***	0.150**	0.334***	0.515***	-0.090	0.255	0.376	0.638
	(0.038)	(0.194)	(0.349)	(0.512)	(0.039)	(0.068)	(0.106)	(0.162)	(0.094)	(0.625)	(1.131)	(1.657)
Constant	3.257***	-0.345**	-0.958***	-1.803***	2.785***	-0.343***	-1.022***	-1.888***	4.149***	-0.317	-0.675	-1.295
	(0.030)	(0.152)	(0.274)	(0.402)	(0.027)	(0.047)	(0.074)	(0.113)	(0.091)	(0.608)	(1.099)	(1.610)
Observations	147,293	147,293	147,293	147,293	85,837	85,837	85,837	85,837	51,345	51,345	51,345	51,345
R-squared	0.717	0.031	0.066	0.107	0.797	0.231	0.439	0.520	0.659	0.022	0.049	0.083
Firm	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month-Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Panel B: Liquidity Adjusted Yield (LAY) and Green Bonds

Panel C compares the liquidity adjusted yield (LAY) of green bonds vs. conventional bonds issued by the same firm in same year. Columns 1 show the results for the complete sample, Columns 2 shows the results for the financial sector firms, and Columns 3 shows the results for the polluting sector firms.

	Full Sample	**Financial Firms**	**Polluting Firms**
	(1)	(2)	(3)
VARIABLES	LAY	LAY	LAY
Green Bond	-0.057	-0.082**	-0.040
	(0.038)	(0.038)	(0.093)
Constant	0.047	0.044*	0.073
	(0.029)	(0.027)	(0.091)
Observations	142,917	83,229	49,966
R-squared	0.023	0.090	0.049
Firm	Yes	Yes	Yes
Month-Year	Yes	Yes	Yes

Table 5: Issuance of Green Bonds and Environmental Performance

This table reports the regression results of environmental performance of green bond issuer with respect to matched firm from 1st January 2013 to 31st December 2022. The green bond issuer matched with comparable firms based on industry, year, and firm characteristics. Environment performance proxied as *Carbon Emissions Risk*, *Water Stress Risk*, *Biodiversity Risk*, *Toxic Emissions Risk*, and *Overall Environment Risk Score* from MSCI ESG Rating database. Panel A shows the regression results of lag environment performance on green bonds issuer with respect to matched firm. Panel B shows the regression results of the future environment performance on green bond issuer with respect to matched firm. *Green Bond Issuer* is a dummy variable which takes value 1 if the firm has issued at least one green bond in that year and 0 for matched firm. Country–year denotes country-by-year fixed effects, industry–year denotes industry-by-year fixed effect, and cluster (industry) denotes clustering errors at the industry (BICS level 2) level. *Size* is firm size measured as natural logarithm of total assets. *Leverage* is firm's leverage measured as total debt to equity ratio. *ROE* is return of equity measured as net income to total common equity value. *Sales Growth* is growth in sales with respect to last year. All variables are as defined in Appendix A. Standard errors are reported in parentheses. ***, **, and * denote statistical significance at the two-tailed 1%, 5%, and 10% level, respectively.

Panel A*:* Past Environment Performance and Green Bond Issuance

Panel A reports the regression results of lag environment performance on green bond issuer with respect to matched firm. Column 1 provides the regression results of the *Carbon Emissions Risk* on the *Green Bond Issuer* indicator, Column 2 provides the regression results of the *Water Stress Risk* on the *Green Bond Issuer* indicator, Column 3 provides the regression results of the *Biodiversity Risk* on the *Green Bond Issuer* indicator, Column 4 provides the regression results of the *Toxic Emissions Waste*, Column 5 provides the regression results of the *Overall Environment Risk Score* on the *Green Bond Issuer* indicator.

	(1)	(2)	(3)	(4)	(5)
VARIABLES	Carbon Emissions Risk	Water Stress Risk	Biodiversity Risk	Toxic Emissions Waste	Overall Environment Risk Score
Green Bond Issuer	0.185***	0.323***	0.141***	0.033	0.212***
	(0.057)	(0.061)	(0.041)	(0.055)	(0.030)
Size	0.018	-0.046**	-0.018	0.016	0.062***
	(0.019)	(0.020)	(0.013)	(0.018)	(0.010)
Leverage	-0.001	-0.009***	0.002**	-0.008***	0.001*
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)
ROE	-0.004***	-0.002	0.003***	-0.002*	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Sales Growth	-0.000	-0.002**	0.000	-0.000	-0.000
	(0.001)	(0.001)	(0.000)	(0.001)	(0.000)
Constant	2.966***	4.585***	2.594***	3.505***	0.657***
	(0.227)	(0.245)	(0.163)	(0.222)	(0.120)
Observations	3,929	3,929	3,929	3,929	3,929
R-squared	0.724	0.709	0.839	0.803	0.778
Industry-Year	Yes	Yes	Yes	Yes	Yes
Country-Year	Yes	Yes	Yes	Yes	Yes

Panel B: Future Environment Performance and Green Bonds Issuance

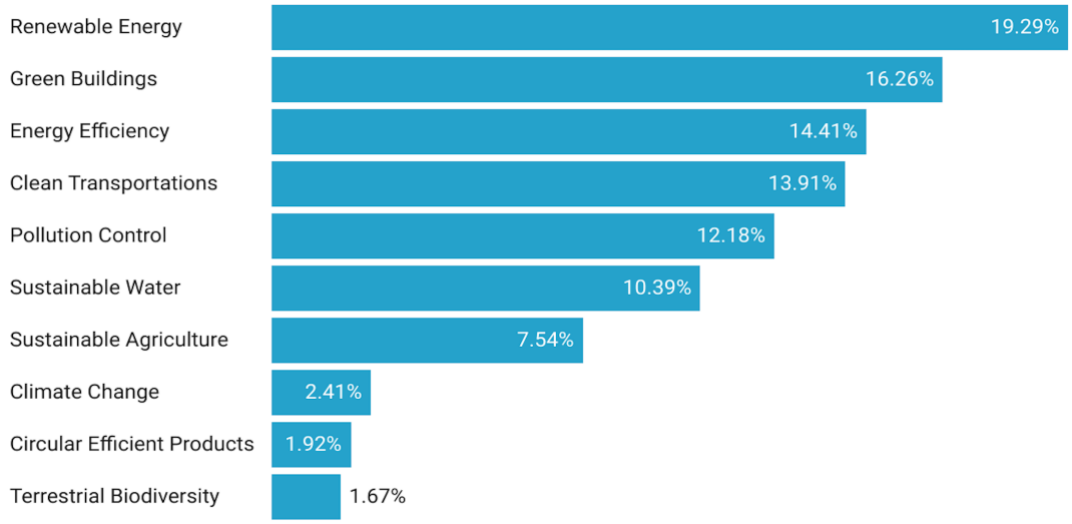
Panel B shows the regression results of the future environment performance on green bond issuer with respect to matched firm. Column 1 provides the regression results of the *Carbon Emissions Risk* on the *Green Bond Issuer* indicator, Column 2 provides the regression results of the *Water Stress Risk* on the *Green Bond Issuer* indicator, Column 3 provides the regression results of the *Biodiversity Risk* on the *Green Bond Issuer* indicator, Column 4 provides the regression results of the *Toxic Emissions Waste*, Column 5 provides the regression results of the *Overall Environment Risk Score* on the *Green Bond Issuer* indicator.

VARIABLES	(1) Carbon Emissions Risk	(2) Water Stress Risk	(3) Biodiversity Risk	(4) Toxic Emissions Waste	(5) Overall Environment Risk Score
Green Bond Issuer	0.370	0.614	-0.162	0.201	0.296
	(0.419)	(0.467)	(0.272)	(0.391)	(0.213)
Size	0.000	-0.047	-0.051***	0.011	0.072***
	(0.029)	(0.033)	(0.019)	(0.027)	(0.015)
Leverage	-0.004*	-0.014***	0.001	-0.013***	0.002*
	(0.002)	(0.003)	(0.002)	(0.002)	(0.001)
ROE	-0.005***	-0.006***	0.001	-0.006***	0.000
	(0.002)	(0.002)	(0.001)	(0.002)	(0.001)
Sales Growth	-0.003**	-0.002	-0.003***	-0.001	-0.001
	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)
Constant	3.102***	4.416***	3.142***	3.477***	0.502*
	(0.564)	(0.628)	(0.366)	(0.527)	(0.288)
Observations	1,811	1,811	1,811	1,811	1,811
R-squared	0.739	0.743	0.862	0.823	0.796
Industry-Year	Yes	Yes	Yes	Yes	Yes
Country-Year	Yes	Yes	Yes	Yes	Yes

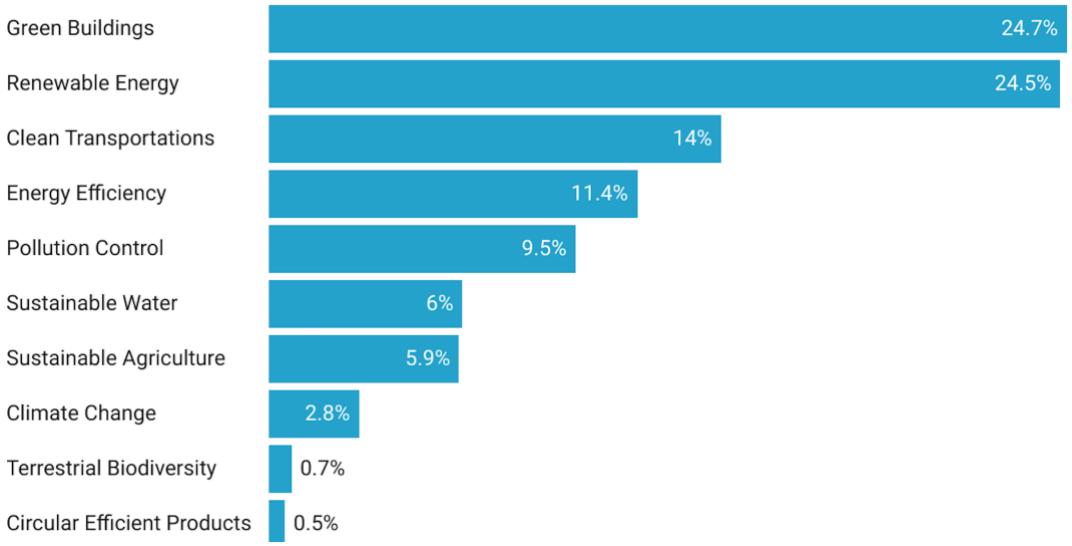
Table 6: Sustainable Gatekeepers' Lending and Borrowers Environment Performance

Panel A. Green Banks' Green Lending

Figure (a) and Figure (b) shows the distribution of green project categories supported by banks which issued green bonds (called as 'Green Banks').



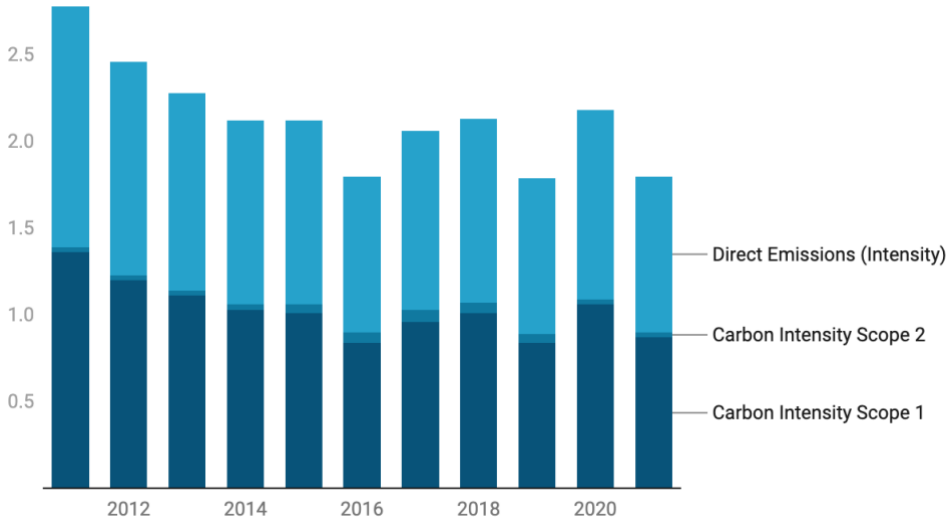
(a) Public Banks



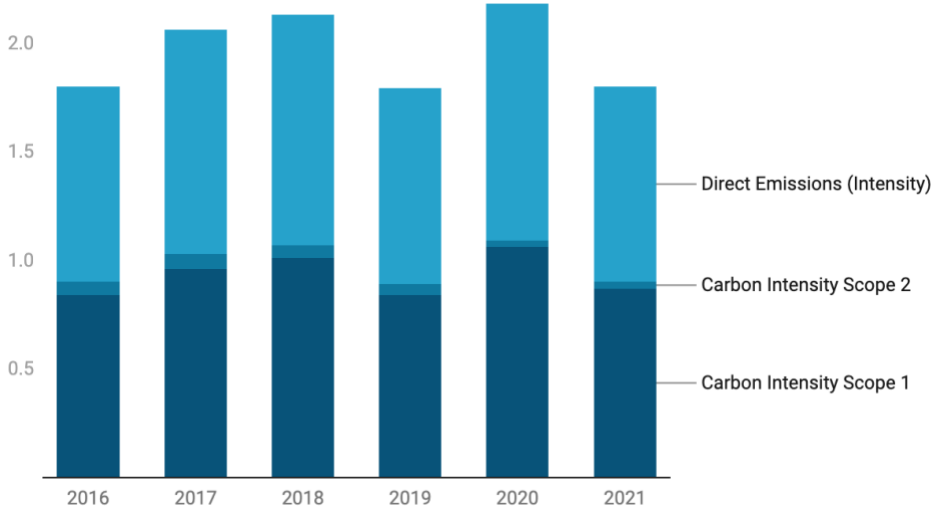
(b) Private Banks

Panel B. Borrower's Environment Performance

Figure (a) and Figure (b) shows the environment performance (measured as carbon intensity) of the borrowers. Figure (a) shows carbon intensity of borrowers from 2011-2021 and Figure (b) shows carbon intensity of borrowers from 2016-2021. The latter includes the period when green loans and sustainability-linked loans started.



(a) Green Banks Borrowers Environment Performance from 2011-2021



(b) Green Banks Borrowers Environment Performance from 2016-2021

Panel D. **Green Loan vs Traditional Loan of Green Banks**

This table compares the green loans with traditional loans of green bond issuer banks. Table shows the regression results of spread and deal amount on green loan indicator. Green Loan is an indicator variable which takes value 1 if the loan is green and 0 for traditional loan. Spread is all in spread drawn, measured in basis points. Deal Amount is loan amount raised, measured in million USD. Spread and Deal Amount are used in logarithmic form. Maturity is loan maturity, measured in years. Secured Dummy is the indicator variable which takes value 1 if the loan is secured otherwise 0. Refinance Dummy is the indicator variable which takes value 1 if the loan is refinance loan otherwise 0.

VARIABLES	(1) Spread (Log)	(2) Spread (Log)	(3) Deal Amount (Log)	(4) Deal Amount (Log)
Green_Loan	-0.057	-0.075	0.045	-0.079
	(0.201)	(0.177)	(0.156)	(0.297)
Maturity		-0.039		0.013
		(0.025)		(0.042)
Secured_Dummy		0.696***		1.201***
		(0.216)		(0.358)
Refinance_Dummy		0.354*		0.376
		(0.210)		(0.358)
Deal Amount (Log)		0.060		
		(0.087)		
Spread (Log)				0.168
				(0.243)
Constant	5.037***	4.530***	5.591***	4.268***
	(0.135)	(0.480)	(0.097)	(1.218)
Observations	57	57	187	57
R-squared	0.186	0.444	0.100	0.358
Year	Yes	Yes	Yes	Yes

Appendix A: Variable Definition Sheet

Variable	Description	Source
Green Bond	Dummy variable takes a value of 1 if the bond is labelled "green" by Bloomberg; otherwise, the value is equal to 0.	Bloomberg
CAR (-t,t)	Cumulative abnormal returns with event window of *t* days prior to the event day to *t* days after. The abnormal returns were computed using a market adjusted model.	Global Compustat
Coupon	Coupon rate on a green (or non-green) bond, measured in percentage (%).	Bloomberg
Maturity	Difference between a year of maturity and year of issuance, measured in years.	Bloomberg
Amount Issued	The amount of green (or non-green) bond issuance, measured in billions of USD.	Bloomberg
Certified	Dummy variable taking a value of 1 if the green (or non-green) bond is certified by ESG assurance provider; otherwise, the value is 0.	Bloomberg
Size	Logarithm of the total assets. The total asset value is in millions of USD.	Worldscope
Leverage	Leverage is the ratio of total long-term debt to total assets.	Worldscope
ROE	Return on equity (ROE) is a ratio of net income to total common equity value. Measured in percentage.	Worldscope
Sales Growth	Growth of firm sale with respect to last year.	Worldscope
Carbon Emissions Risk	Carbon emissions risk score from MSCI ESG Rating database.	MSCI ESG
Water Stress Risk	Water stress risk score from MSCI ESG Rating database.	MSCI ESG
Biodiversity Risk	Biodiversity risk score from MSCI ESG Rating database.	MSCI ESG
Toxic Emissions Waste Risk	Toxic emissions waste risk score from MSCI ESG Rating database.	
Overall Environment Risk Score	Overall environment risk score from MSCI ESG Rating database.	MSCI ESG
Yield	Offer yield to maturity, measured in percentage (%).	Bloomberg
Option Embedded	Percentage of green bonds embedded with options such as call, put, sink, and convertible.	Bloomberg
Yield (secondary market)	Monthly yield of a green bond in the secondary market, measured in percentage (%).	Bloomberg API
Return – XM	Holding period returns of a green bond in the secondary market. *X* can be 1, 3, or 6, signifying one-month, three-month, or six-month holding period returns. Returns are in percentage (%).	Bloomberg API
US Dummy	Dummy variable taking a value of 1 if the green (or non-green) bond is issued by US domiciled issuer; otherwise, the value is 0.	Bloomberg
Financial Sector	Dummy variable taking a value of 1 if the green (or non-green) bond issuer belongs to financial sector; otherwise, the value is 0.	Bloomberg
Polluting Sector	Dummy variable takes a value of 1 if the green (or non-green) bond issuer belongs to the polluting sectors comprise energy, utility, industrial, and material.	Bloomberg

Appendix B

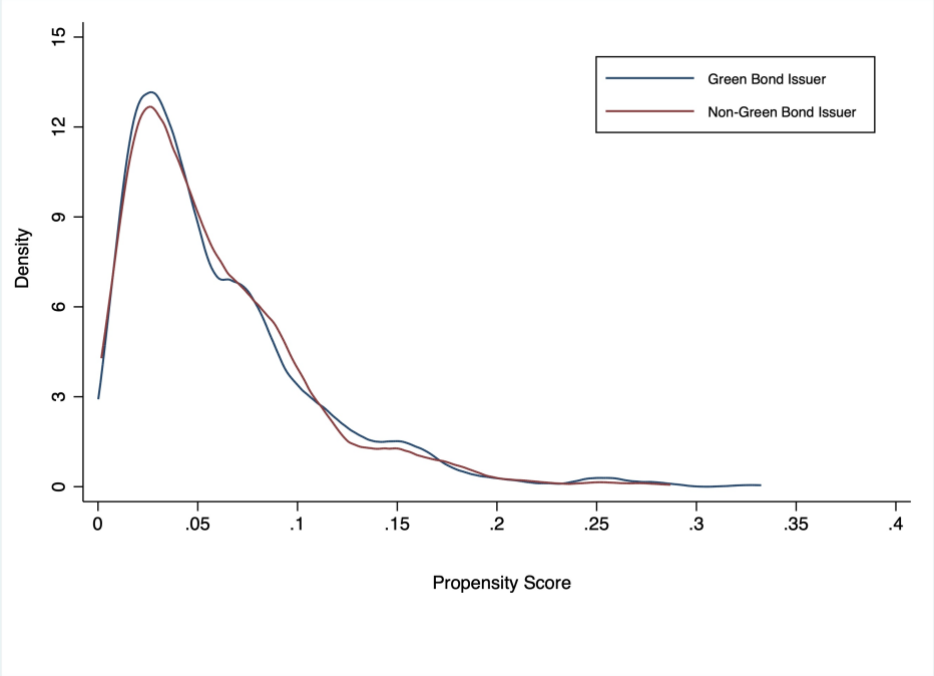


Figure 5: Kernel Density of Propensity Score: Green Bond Issuer vs Non-Green Bond Issuer. This figure shows the kernel density of propensity score for green bond issuer and matched firms. The green bonds are issued from 1st January 2013 to 31st December 2022.

Table B1: Impact of green bonds on Carbon Intensity – Disclosed vs. Estimated

This table reports the regression results of carbon intensity on green bond issuer with respect to matched firm from 1st January 2013 to 31st December 2022. The green bond issuer matched with comparable firms based on industry, year, and firm characteristics. Carbon Intensity is ratio of carbon emissions to revenue measured as tonnes per USD. Estimated is an indicator variable which takes value 1 if the carbon emissions value are vendor-estimated and 0 for disclosed. *Green Bond Issuer* is a dummy variable which takes value 1 if the firm has issued at least one green bond in that year and 0 for matched firm. Country–year denotes country-by-year fixed effects, industry–year denotes industry-by-year fixed effect, and cluster (industry) denotes clustering errors at the industry (BICS level 2) level. *Size* is firm size measured as natural logarithm of total assets. *Leverage* is firm's leverage measured as total debt to equity ratio. *ROE* is return of equity measured as net income to total common equity value. *Sales Growth* is growth in sales with respect to last year. All variables are as defined in Appendix A. Standard errors are reported in parentheses. Standard errors are reported in parentheses. ***, **, and * denote statistical significance at the two-tailed 1%, 5%, and 10% level, respectively.

	(1)	(2)	(3)
	Full Sample	Disclosed	Estimated
VARIABLES	Carbon Intensity	Carbon Intensity	Carbon Intensity
Green Bond Issuer	5.017	5.143	13.093**
	(5.003)	(7.343)	(6.109)
Size	8.245***	10.676***	-0.701
	(1.668)	(2.372)	(2.486)
Leverage	-0.016	-0.160	0.285*
	(0.132)	(0.193)	(0.163)
ROE	-0.133	-0.407**	0.175
	(0.107)	(0.164)	(0.213)
Sales Growth	0.015	0.084	-0.078
	(0.062)	(0.106)	(0.058)
Constant	-35.483*	-45.284	28.111
	(20.411)	(29.755)	(29.640)
Observations	3,761	2,610	1,151
R-squared	0.660	0.703	0.820
Industry-Year	Yes	Yes	Yes
Country-Year	Yes	Yes	Yes

Table B2: Green Bond Issuances and Institutional Ownership

This table reports the regression results of institutional ownership on green bond issuer with respect to matched firm from 1st January 2013 to 31st December 2022. The green bond issuer matched with comparable firms based on industry, year, and firm characteristics. *Institutional Ownership* is ratio of institutions ownership in total market capital. Chg. *Institutional Ownership* is change in institutional ownership between contemporaneous and one-year ahead. *Percent* Chg. *Institutional Ownership* is percentage change in institutional ownership between contemporaneous and one-year ahead. *Green Bond Issuer* is a dummy variable which takes value 1 if the firm has issued at least one green bond in that year and 0 for matched firm. Country–year denotes country-by-year fixed effects, industry–year denotes industry-by-year fixed effect, and cluster (industry) denotes clustering errors at the industry (BICS level 2) level. *Size* is firm size measured as natural logarithm of total assets. *Leverage* is firm's leverage measured as total debt to equity ratio. *ROE* is return of equity measured as net income to total common equity value. *Sales Growth* is growth in sales with respect to last year. All variables are as defined in Appendix A. Standard errors are reported in parentheses. Standard errors are reported in parentheses. ***, **, and * denote statistical significance at the two-tailed 1%, 5%, and 10% level, respectively.

	(1)	(2)	(3)
VARIABLES	Inst. Ownership	Chg. Inst. Ownership	(Percent Chg. Inst. Ownership (%)
Green Bond Issuer	0.013***	0.006***	-0.831
	(0.004)	(0.002)	(2.594)
Size	0.027***	-0.002***	-1.138
	(0.001)	(0.000)	(0.721)
Leverage	-4.139***	0.405	214.141
	(0.892)	(0.376)	(599.135)
ROE	0.057***	0.008**	0.050
	(0.007)	(0.003)	(4.929)
Sales Growth	-0.004	0.002	2.442
	(0.003)	(0.001)	(2.095)
Constant	-0.130***	0.018***	14.908*
	(0.012)	(0.005)	(8.137)
Observations	6,459	5,369	5,369
R-squared	0.805	0.238	0.329
Industry_Year	Yes	Yes	Yes
Country	Yes	Yes	Yes