Demand for Greenness

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We are grateful for the comments from Sean Kidney, Darrel Duffie, Lucian Taylor, Jonathan Fletcher, Dimitris Andriosopoulos, Charlie Xia, Meryem Duygun, Mohamed Shaban, Helen Popper, Renatas Kizys, Siddhant Raj Pandey, Prabin B Khadka and the participants at International Finance and Banking Society (IFABS) 2023 Oxford Conference, Strathclyde Post-Graduate Research Colloquium, and International Accounting and Finance Doctoral Symposium (IAFDS).

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Abstract

We investigate whether the unique greenness characteristics of green bonds (GB) explain the cross-sectional variations of corporate bond demand. Leveraging the information on the orderbook size of investment grade fixed coupon corporate bonds issued globally from 2013 to 2022, we find that, on average, the demand for GB is about 35 to 44% higher than comparable non-GB. This implies that the unique greenness characteristics of GB drive variations in the corporate bonds demand. Our results further show the ex-ante better environmental performance (lower CO_2), higher investments in green innovations, and lower ESG risk incidents explain the variations in the demand for greenness.

JEL classifications: G14, G18, G32, M14, Q56

Keywords: Green Characteristics of Green Bonds, Signaling Theory, Green Innovations, ESG Risk Incidents.

1 Introduction

Green and sustainable financing is at the forefront of addressing environmental concerns (Pástor *et al.* 2022). One such initiative is green bonds (GB), a debt instrument whose proceeds are used in eligible green projects, such as renewable energy, green transport, decarbonization practices, and clean water (International Capital Market Association 2018; Baker *et al.* 2022).[1] The Climate Bonds Initiative (2019) defines a GB as a financial innovation that acts as a bridge in achieving the United Nations (UN) Sustainable Development Goals (SDGs).[2] As the proceeds from GB are expected to be invested in environment-friendly projects, at least six SDGs (6, 7, 9, 11, 13, and 15) receive support through GB issuance (Climate Bonds Initiative 2019).[3] Piñeiro-Chousa *et al.* (2021) argue that in addition to standard bond features, the unique characteristics of GB, i.e., the commitment to invest in climate and environmentally friendly green projects, make them desirable for a wide range of investors, including institutional, retail, high-net-worth, and, more importantly, ecologically and socially conscious investors. Given the importance of the unique green features of issuing GB in addressing climate change and other environmental concerns, in this paper, we answer the following questions. First, do the unique greenness characteristics of the GB explain the variations in the demand for bond issuance? Second, what are the potential drivers of the variations in the demand for GB?

In terms of theoretical lenses, we draw from the signaling framework of information asymmetry (IA) to formulate our hypotheses. We argue that the unique green characteristics of GB, which address the issues related to IA for potential investors, should attract *value* and *values-based* investors. *Value* investors include environmental, social, and governance (ESG) factors in their investment decisions to optimize their portfolio's financial risk-return profile

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[1] See https://www.icmagroup.org/sustainable-finance/the-principles-guidelines-and-handbooks/green-bond-principles-gbp/
[2] see https://www.climatebonds.net/files/reports/green-bonds_a-bridge-to-the-sdgs_062018.pdf
[3] see https://www.undp.org/sustainable-development-goals#:~:text=The%20Sustainable%20Development%20Goals%20(SDGs)%2C%20also%20known%20as%20the,people%20enjoy%20peace%20and%20prosperity.

with no intention of having any ESG-related impact (Starks 2023). The objective of the ESG inclusion criteria is to enhance return and/or manage risk. Conversely, *values-based* investors, also known as socially responsible investors (SRI), incorporate ESG dimensions into their investment decisions to have a real ESG impact, even at the expense of some financial returns (Ioannou & Serafeim 2015; Edmans *et al.* 2022; Starks 2023).

Flammer (2021) and Tang and Zhang (2020) contend that the issuance of GB offers a credible signal to potential investors about a firm’s climate and environmental commitments and impacts (Pope *et al.* 2023). Compared to non-GB, the IA frictions surrounding GB issuance are unique and relatively lower, as issuers must issue a prospectus articulating the specific use of the proceeds in explicitly stated environment-friendly green projects, following the principles of GB (International Capital Market Association 2018). This should reduce the potential risk of adverse selection associated with the friction of IA at the pre-subscription stage. Within such a signaling framework, relative to GB issuance, investors face a higher level of IA in a typical initial public offering of non-GB securities, as investors are generally unaware of the specific use of the proceeds in particular projects (Park & Patel 2015). However, in the case of GB issuance, investors must be informed of the proceeds' specific use in climate and environment-friendly green projects.

Further, the International Capital Market Association's (2018) GB principles also state that the post-issuance must be followed with constant reporting on the use of the GB proceeds and include a credible third-party verification of the project's greenness. We argue that the requirement of such unique and transparent standards should reduce the frictions of IA associated with potential moral hazards in the post-subscription stage.

To summarize, the pre-issuance information on the specific use of the GB’s proceeds in ecological projects and the regular post-issuance reporting on the greenness of the projects make the GB unique relative to non-GB. We argue that the lower level of IA-related frictions (adverse selection and moral hazard) associated with GB issuance, relative to non-GB, should appeal to *value*- and *values-based* investors. Since the issuance of GB is for investments in ecological and climate-change mitigation/adaptation projects specifically articulated in the prospectus, we expect that IA-related friction related to the specific use of the proceeds and the associated ESG impact should be significantly lower. Therefore, *values-based* investors should be more attracted to GB than non-GB issues.

As noted earlier, *value-based* investors are attracted to financial instruments that offer higher risk-adjusted financial returns. Since the issuance of GB proceeds is associated with a lower level of adverse selection and moral hazard, we should expect the financial costs and potential risk to be lower. Specific to GB, studies show that investors' response in the equity market is positive to the announcement of GB (Tang & Zhang 2020; Daubanes *et al.* 2021; Flammer 2021). This suggests that GB issuance helps boost firm value, which should offer further confidence to GB creditors. Therefore, the positive financial outcomes associated with the issuance of GB should also attract *value-based* investors.

We argue that the unique greenness of GB should be positively associated with explaining the demand for bonds issued by corporations. Accordingly, we test the hypothesis that the greenness of GB should lead to higher demand for GB relative to non-GB when issued by similar firms. To develop our results, we examine whether information about the issuers' ex-ante sustainability performance and risk should explain the variations in demands among the GB issuers (within) and the differential demand relative to non-GB (across) issuances. Drawing on the literature on ESG finance, we identify two key drivers of GBs' demand. First, firms' ex-ante ESG performance should be one of the essential factors driving the higher demand for GB. Literature suggests that firms with good past ESG performance enjoy a lower cost of equity, lower cost of debt, and higher bond ratings (Sharfman & Fernando 2008; El Ghoul *et al.* 2011; Pedersen *et al.* 2021; Apergis *et al.* 2022). Likewise, Ilhan *et al.* (2021) and

Hoepner *et al.* (20243) state that environmentally vulnerable firms encounter volatile cash flows that could affect debt servicing. As a proxy of past environmental performance, a firm's ex-ante lower CO_2 emission should drive higher demand for GB. Lowering CO_2 emissions and pursuing green investment strategies, such as investment in green innovations, incur significant costs to redirect research and development efforts (Andriosopoulos *et al.* 2022), which serves as a credible signal of a firm's environmental commitment (Daubanes *et al.* 2021; Dutordoir *et al.* 2023). Such a costly to-imitate signal should attract *value* investors as it lowers IA and the *values-based* investors, who are willing to accept lower yields for the greater good of fighting climate change (Flammer 2021). As such, we suggest that the GB issued by firms with lower CO_2 emissions and strategies of higher greening investments should attract higher demands from investors for the issuance of their GB. Second, the demand for GB may be influenced by the desire to invest in firms with potentially lower ESG risk, particularly reputation-based ESG risk[4], as evidence suggests that firms with better environmental risk management practices are associated with a lower cost of equity and lower yield spreads on corporate bonds (Ramelli *et al.* 2021). This indicates that investors may be more attracted to GB issued by firms with lower ESG risk than those with higher ESG risk and similar non-GB. As a result, we posit that issuers with a history of lower ESG risk will likely experience greater demand for GB issuance.

We test our hypotheses using a new comprehensive bond issuance dataset compiled and maintained by Informa Global Markets (IGM), including information on the orderbook and issue size collected by daily worldwide surveys. The orderbook size is the sum of the monetary value of investor orders (demand) submitted by investors to bookrunners around the issuance time. We also collect other characteristics of bonds, such as issue date, coupon rate, ratings, the currency of issue, maturity, green label, bond type, issuer type, issuer, and country.

[4] Dutordoir *et al.* (2023) document that investors consider firms' environmental reputations in their decision-making.

In addition, for a firm that issues GB in a particular year, we identify a matched firm in the same country, industry, and year that is yet to issue GB. We investigate investment grade fixed coupon corporate bonds. Our final sample comprises 451 GB and 1,641 non-GB from 2013 to 2022 issued by 419 firms, which, to the best of our knowledge, is the largest sample size in the literature in the literature of GB.[5]

Our key outcome variable is the subscription ratio of the corporate bond issuance, defined as the number of times the orderbook size (demand) exceeds the amount of bond offering, constructed by scaling the orderbook size by issue size. Our independent variable of interest, reflecting the unique greenness characteristics of GB, is the dummy variable, which takes the value of one if the bond is labeled green and zero otherwise.

The univariate results based on the matched sample show a statistically significant difference in the average subscription ratio of GB compared to non-GB. We find that the average subscription ratio for GB is 3.59 compared to non-GB's 2.90. In a multivariate setting, controlling for all possible factors, we report around 35% to 44% higher demand for GB than its matched counterparts. These results provide strong support for our hypothesis that the greenness of GB explains the cross-sectional variations in the subscriptions of investment-grade corporate bonds.[6]

A battery of checks supports this finding. First, as an alternative matching strategy, we perform a bond-level matching whereby we match the GB with non-GB issued by the same firm within the last two years (alternatively within the same industry) and share similar bond-level characteristics such as issue size, issue year, currency, rating, and maturity (Larcker & Watts 2020; Tang & Zhang 2020; Wang & Wu 2023). Second, we use the natural logarithm of

[5] For instance, Flammer (2021) uses 152 GB issued by 65 unique issuers, Tang and Zhang (2020) use 132 final samples of GB, and Zerbib (2019) uses 110 samples.
[6] Furthermore, we find consistency in higher demand for GB relative to matched non-GB, issued by non-financial firms to finance their green projects and the financial firms that issue GB to finance their clients' green projects or to lend them.

the orderbook amount and the residual subscription as an alternative measure of investor demand. Our main results remain robust. Finally, we conduct a non-parametric test whereby we randomly select 902 placebo non-GB (twice the number of GB in our sample) from the non-GB universe and run our baseline regressions 10,000 times. We find that demand for GB is significantly higher than for placebo non-GB 99.9% of the time, supporting our baseline results.

Our second set of findings focuses on analyzing the factors driving demand for GB. Existing literature shows that firms with better ESG performance and lower ESG risks signal their environmental sustainability commitment to attract investors, and investors also prefer GB issuers with strong ESG performance and lower ESG risks (Kapraun *et al.* 2021; Raghunandan & Rajgopal 2022; Dutordoir *et al.* 2023). As such, we conjecture that the differential demand for GB in firms with better environmental performance should be higher than that of GB and non-GB issued by other firms. Consistent with our expectation, we find that GB issued by firms with lower CO_2 emissions (measured using CO_2 intensity), lower ESG risks (measured using Reputation Risk Index (RRI)) and better greening strategies (measured using number of green patents) is significantly higher compared to GB and non-GB issued by other firms. Economically, we find that one standard deviation reduction in CO_2 increases the GB demand by around 2.0 to 2.5 times, one standard deviation reduction in RRI increases the GB demand by around 1.31 to 1.81 times, and a 10% increase in the number of green patents increases GB demand by 15% to 19%.

This study contributes to two strands of literature. First, it adds to scant but nascent research investigating the primary market offering of GB (Bessembinder *et al.* 2022). We offer first-hand evidence of greenness demand in the primary market using a unique and comprehensive industry-level database on bond subscriptions. The majority of existing studies investigating issues related to GB focus on dissecting its pricing and returns to examine its “greenium,” considered a reputation effect of GB (Flammer 2020; Climate Bonds Initiative 2021; Flammer 2021; Pástor *et al.* 2022). However, to our knowledge, no study examines GB's subscription levels in the primary market. Second, we extend the GB literature by identifying the drivers that could explain the within and cross-sectional variations in the demand for GB relative to non-GB. We document that the bond issuer’s past environment performance such as lower CO_2 emissions, reputation-based ESG risk, and strategies to invest in green innovations drive the demand for GB in the primary debt market. We explain how the signaling theory helps lower information asymmetry on GB issuance and factors that explain the heterogeneous demand within GB issuers.

Our results hold important implications for policymakers and corporations. Given the evidence that GB draws significantly higher subscriptions in the primary markets, regulators could initiate encouraging policies for issuing GB to support the SDGs and potentially help reverse the adverse effects of climate change. Corporations should also improve their ESG performance, reduce CO_2 emissions, and initiate greening strategies to attract higher demands for issuing their GBs.

The remaining paper is organized as follows: Section Two formulates the testable hypotheses. Section Three explains the data and the empirical design. Section Four discusses the empirical results. Finally, we conclude the paper and offer implications in Section Five.

2 Hypotheses Development and Related Literature

We draw on information economics’ signaling equilibrium framework to argue that relative to non-GB issuance, the unique greenness characteristics of GB should attract a much broader category of investors. These investors include *values* and *value-based* investors and those who fall in between. Starks (2023) classifies ESG investors into a broad spectrum, with one end being driven by their *values-based* nonpecuniary preferences and the other by *value-based* pecuniary preferences. Nonpecuniary preferences may include addressing carbon footprint and other environmental concerns, mitigating animal cruelty, eradicating child labor and poverty, etc. Pecuniary preference implies incorporating ESG factors solely to manage the risk-return profile of the investments. We use the signaling framework to offer insights into how GB's unique additional greenness features compared to conventional non-GB may appeal to *values* and *value-based* investors.

2.1 Signaling Theory and Green Bonds

Signaling theory is rooted in IA between two transacting parties (See Arrow 1963; Akerlof 1970; Ross 1973; Spence 1973; Rothschild & Stiglitz 1976; Holmström 1979; Stiglitz & Weiss 1981; Stiglitz 2002). Theoretical and empirical research widely acknowledge that IA exists between transacting parties in the primary security markets (Leland & Pyle 1977; Allen 1991; Dierkens 1991). Issuers possess a superior degree of information that determines the intrinsic value of the issuing securities compared to outside investors. The prevalence of IA generates non-optimal economic outcomes for the issuers and the investors. The first non-optimal outcome for the investors is related to the possibility of adverse selection at the pre-transaction phase, which is the risk of selecting an overvalued security (Blouin 2003). The second concern is the possibility of moral hazard, which is the risk that the issuers may misuse the proceeds after the issuance (Akerlof 1970; Ross 1973; Holmström 1979).

Accordingly, to address the friction of IA and separate themselves from others, quality issuers of securities disseminate credible dissipative signals to potential investors through their actions (Ross 1977). However, these signals must be sufficiently costly for competitors to imitate, as their purpose is to establish a separating equilibrium for the issuer from the pooled equilibrium of all types of issuers (Carter & Manaster 1990; Cohen & Dean 2005). To separate themselves, firms can use observable actions to convey private information about their quality and intentions to external parties.[7]

We argue that the pre-issue information about the greenness of the projects and the post-issuing greenness progress reporting characteristics of GB impart unique additional and credible signals to potential investors concerning the purpose and use of the proceeds relative to issuing non-GB. The GB principles of the International Capital Market Association (2018, 2021) note four unique characteristics of GB issues that convey greenness-specific information to investors. The first is related to the '*Use of Proceeds,*' where the issuer must provide specific (quantifiable, where feasible) information on the environmental benefits of green projects, such as the expected magnitude of renewable energy generation, energy efficiency achieved, and reduced waste. Second, the GB issuer must communicate the '*Process for Project Evaluation and Selection*' to meet the specific environmental sustainability objectives. The project selection process needs justification and complementary information on perceived social and environmental risks. Such details on the '*Use of Proceeds'* and '*Process for Project Evaluation and Selectio*n' are not reported in the issuance of non-GB bonds (Tang & Zhang 2020; Flammer 2021). These two unique greenness-related information components of GB issuance should significantly reduce the possibility of adverse selection concerns for investors.

The third unique component is '*Management of Proceeds*,' where the issuer must create a separate bank account to keep track of GB proceeds used in promised environmental projects. The fourth component is '*Reporting*,' whereby the issuer should regularly report on the progress of the green projects and the specific and detailed use of GB proceeds. This report should be updated and renewed annually with full details on projects and their impact. When

[7] The literature notes various signaling actions, including changes in board composition, hiring more outside directors, dividend smoothing, underpricing, or third-party certifications (in case of securities issuance). These signals play a crucial role by providing otherwise unobservable information about the firm's transparency, financial competency, and socially responsible practices (King *et al.* 2005; Musteen *et al.* 2010; Montiel *et al.* 2012; Karpavičius 2014; Gomulya & Mishina 2016).

possible, the impact reports should be certified by independent second-party verification. The '*Management of Proceeds'* and '*Reporting'* related unique post-issuance information of GB should significantly address the concerns of moral hazard (e.g., greenwashing) for investors. Thus, in equilibrium, GB issuance provides greenness-specific and more credible signals to investors when separating it from non-GB issuance.

2.2 Greenness of Bond Issuance: Demand by Values and Value-based Investors

Within the framework of the signaling theory discussed above, we offer economic arguments justifying why the information related to the unique greenness characteristics of GB issuance should attract the demands of *values* and *value-based* investors more than those of non-GB investors.

Values-based or socially responsible investments have gained significant momentum among investors and asset managers since the U.N. started promoting responsible investment through the Principles for Responsible Investment (PRI) initiative in 2006 (Edmans *et al.* 2022).[8] Evidence suggests that SRI focuses on *values-based* (non-pecuniary preferences) investment objectives and financial returns. They prefer to invest in firms with higher ESG scores, reflecting higher commitments and engagements with ESG issues (Ioannou & Serafeim 2015). As a result, there have been significant investments in socially responsible funds (Pedersen *et al.* 2021).[9]

The issuance of GB directly caters to SRI's preferences by mitigating concerns of adverse selection and potential moral hazard related to environmental impact objectives. Regarding adverse selection, studies argue that firms can attract *values-based* investors by

[8] The PRI is working for sustainable financial system through responsible investment. For details: https://www.unpri.org/about-us/about-the-pri
[9] Responsible institutional investors have grown to 4,902, with total assets under management above $121.3 trillion by March end, 2022 (Principles for Responsible Investment 2021-22).

aligning their greening strategies with SRI criteria through green and clean initiatives (Heinkel *et al.* 2001). As noted above, since the GB prospectus explicitly states how the proceeds will be used in defined green projects, SRI's potential concern of adverse investment selection in non-green projects is materially eliminated.

Regarding the issue of moral hazards for SRIs, as noted above, the prospect of regular issuance of impact reports, generally certified by external agencies, in the post-issuance period should keep investors regularly updated on the progress of the greenness of the pre-identified green projects. Such an update on the greenness-related progress should materially lessen the moral hazard concerns of *values-based* investors in GB. However, such provisions for the constant dissemination of progress-based information do not exist in the case of non-GB.

Furthermore, a sizeable body of empirical evidence is emerging that supports the lower concern of moral hazards connected with the issuance of GB. For example, although GB issues are criticized for potential greenwashing (KPMG 2015; Shishlov *et al.* 2016), empirical evidence suggests otherwise. Flammer (2021), who documents a significant reduction of CO_2 post-issuance of GB, argues that the possibility of greenwashing is lower as firms issue GB to support environmental projects rather than mislead their ecological consciousness (also see Zhang 2023). Studies also suggest that GB boosts the issuers' environmental scores post-GB issuance (Flammer 2021). In a country-level study, evidence indicates that eight out of ten countries' environmental qualities improve after green financing is adopted via the issuance of GB. Alharbi *et al.* (2023) report a significant positive contribution of GB to renewable energy production in 44 countries. These studies on the positive environmental impact of post-issuance corroborate the lower possibility of moral hazard concerns. However, in the case of non-GB, evidence of such positive post-issuance greenness impacts is not well documented. As such, we argue that the potential for a lower possibility of greenness-related moral hazard is higher in the investment of GB than non-GB, attracting *values-based* investors.

Value-based investors, as noted earlier, are driven by higher financial returns and efficient risk management (Starks 2023). In the field of corporate finance, evidence indicates that lower IA, which addresses the potential of adverse selections and moral hazard, is associated with favorable corporate outcomes such as lower cost of capital (Diamond & Verrecchia 1991; Hughes *et al.* 2007; Lambert *et al.* 2012), lower issuance costs (Brugler *et al.* 2022), optimal dividend policy (Khang & King 2006), and enhanced liquidity in the primary and secondary markets (Welker 1995; Nikolova *et al.* 2020). Such outcomes demonstrate that mitigating the friction of IA is associated with a better risk-return profile of the related asset.

Empirical evidence also suggests that GB issuance offers other market and financially attractive signals. For example, equity investors exhibit a positive market reaction to the announcement of GB issuance (Tang & Zhang 2020; Daubanes *et al.* 2021; Flammer 2021). Event study-based research indicates that, on average, the stock's return of GB issuing firms is more than 5% over a window period of five days (Daubanes *et al.* 2021). Even for risk-adjusted returns, the overwhelming evidence shows, on average, positive abnormal returns ranging from 0.5% to 1.5% (Tang & Zhang 2020; Flammer 2021). Thus, compared to conventional debt announcements (Eckbo 1986; Mikkelson & Partch 1986), these studies associate the positive wealth effects with lower IA related to the prospect of environmental and greenness rewards of GB (Klassen & McLaughlin 1996). Thus, the higher firm value on the GB issuance announcement should provide a greater safety net to bond investors, lowering the default potential.

Further evidence suggests that GB's yield spread over non-GB is materially lower (Zerbib 2019). Thus, the lack of any material spread signifies the absence of concerns for value-conscious investors. Lower spreads also indicate that investors are more confident about GB's creditworthiness, suggesting a lower default probability (Daubanes *et al.* 2021).

The positive stock market reaction, lower default probability, and lower yield spread indicate a better risk-return profile for investing in GB than non-GB. Such positive risk-return prospects, supplemented with GB's unique greenness features, should attract *value-based* investors.

The above-noted economic arguments suggest that, on average, given its unique greenness characteristics and positive financial prospects, GB issuance should attract more *values* and *value-based* investors than non-GB issuance. Accordingly, we propose to test the following hypothesis.

H_1: The unique greenness characteristics of GB should lead to higher issuance demand than similar non-GB issues.

2.3 Drivers of GB's Demand

We argue that information about issuers past environmental profile (performance and risk) may act as an additional signal to create a separation from the pooled equilibrium of GB issuers and thus help explain the variation in demand for greenness. Drawing on the literature examining ESG performance and risk implications, we identify possible factors that could explain the within and cross-sectional variations in the demand for GB relative to non-GB issues.

2.3.1 Past Environmental Performance

The literature illustrates the importance of firms' *ex-ante* ESG performance-related factors in investment decisions of all classes of assets (Matos 2020; Edmans *et al.* 2022). Firms with better ESG performance are associated with a lower cost of equity (Sharfman & Fernando 2008; El Ghoul *et al.* 2011; Ng & Rezaee 2015), lower costs of bond and bank loans

(Amiraslani *et al.* 2023; Degryse *et al.* 2023) [10], better bond ratings (Apergis *et al.* 2022), higher bond return (Duan *et al.* 2021), better alignment of financial and environmental goals (Hartzmark & Sussman 2019; Edmans & Kacperczyk 2022)[11], and higher institutional ownership (Pedersen *et al.* 2021)[12].

In addition to GB's unique signaling properties compared to non-GB (discussed in section 2.1), investors seek supplementary credible evidence on firms' environmental performance before they risk their financial resources (Kapraun *et al.* 2021). With respect to GB issuance, Kapraun *et al.* (2021) find that investors prefer GB issuers with strong sustainable reputations, as measured by ESG ratings. Kapraun *et al.* (2021) also argue that investors may perceive GB issued by firms with subpar ESG scores as signs of potential "greenwashing" strategies. Thus, firms that improve their *ex-ante* ESG performance signal their environmental sustainability commitment to attract investors (Dutordoir *et al.* 2023).

We argue that firms with a history of higher ESG performance are more likely to be perceived as more credible GB issuers, appealing to *values* and *value-based* investors. Such higher *ex-ante* ESG performance should further lower the friction of IA between issuers and investors. Thus, we contend that the demand for GB issued by firms with superior *ex-ante* ESG performance should be higher as this serves as an additional signal to investors regarding the credibility of proceeds being employed in greener projects. This also implies that the demand for GB issuance should not only be higher than that of non-GB, as discussed in section 2.1, but also that the variations in demand among GB issuers should be positively explained by better *ex-ante* ESG performance. Accordingly, we propose the following hypothesis.

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[10] Delis *et al.* (2018) report higher bank interest rates to firms using higher fossil fuels. Similarly, Kleimeier and Viehs (2018) note that banks judge higher CO_2-emitting firms riskier when assessing their creditworthiness.
[11] Evidence also suggests that investors are divesting from high CO_2 emitting firms (e.g., Bolton & Kacperczyk 2021; Pástor *et al.* 2022) as carbon-intensive firms' cash flows are vulnerable to climatic change risks, such as regulatory and transition risks (Ilhan *et al.* 2021; Hoepner et al., 2023). Similarly, studies argue that investors who exhibit prosocial behavior seek to invest in firms with parameters of higher social performance (Riedl & Smeets 2017). Evidence also highlights firms' corporate governance as an essential component investors consider in their investment decisions (Schnatterly & Johnson 2014; McCahery *et al.* 2016).
[12] For example, investors are more attracted to invest in firms with lower CO_2 emissions (Azar *et al.* 2021).

H_2: The demand for GB issued by firms with better ex-ante ESG performance is higher compared to GB issued by firms with lower ex-ante ESG performance and similar non-GB issued by all firms.

2.3.2 Potential ESG Risk

In this section, we argue that a firm's potential ESG-related risk could also explain the variation in the demand for GB issuances. We follow Asante-Appiah and Lambert (2022), who define ESG risk as the possibility of media-reported adverse ESG incidents that significantly harm the firm's reputation. Extensive evidence suggests that firms with higher media-reported adverse ESG reputation incidents are associated with increased credit risk, lower revenue, lower capital market-based valuation, tarnished brand value, poor customer confidence, and downgraded analysts' earnings forecasts (Derrien *et al.* 2021). Studies also suggest that firms with better environmental risk management practices are associated with lower costs of equity and lower yield spreads on corporate bonds (Ramelli *et al.* 2021).

Dutordoir *et al.* (2023) note that firms with better ESG reputations are more likely to take positive environmental actions. Investors perceive these firms as having better ESG practices, leading to more transparent and reliable information, which reduces IA between the firm and investors (Alessi *et al.* 2021). Since reputation building and maintenance are challenging (Branco & Rodrigues 2006), firms' better environmental reputation offers a competitive advantage (Dutordoir *et al.* 2023). Legitimacy theory also posits that firms with lower ESG risk are more trustworthy due to reduced adverse selection concerns (Hoepner *et al.* 2023). The concerns of moral hazard should be lower for firms with lower ESG reputations as they are less likely to engage in risky or unethical behavior in the future, making them more attractive to investors concerned about the potential negative impacts of environmental and social risks (Raghunandan & Rajgopal 2022)

The above argument suggests that a firm's potential ESG risk could provide a valuable signal to investors, both *value* and *values-based*. Firms issuing GB, relative to non-GB and classified as exhibiting lower potential ESG risk, should be more attractive to investors than those with higher ESG risk. Accordingly, we propose the following hypothesis:

H_3: The demand for GB issued by firms with lower ESG risk is higher compared to GB issued by firms with higher ESG risk and similar non-GB issued by all firms.

3 Sample, Variables, and Identification Strategy

3.1 Sample and Data Sources

We compile data from several sources. We extract all investment-grade corporate bond data from the London Stock Exchange Group Data & Analytics (LSEG) (formerly Refinitiv) database, which contains all bonds, including the green-labeled bonds. Over 15 years (Jan-2007 to Dec-2022), the database yields 48,896 total corporate bonds, including 7,826 labeled as GB, which we denote as the universe of GB. Columns (1) and (2) of Table 1 show the year-wise distribution of the universe of GB, where we observe a sharp increase in the number of GB and issuance size over the years. In Appendix A, we report the distribution of the universe of GB issued worldwide, where we observe a significant variation in the GB issuance and the issuance size across 82 countries. China leads the GB issuance followed by Germany and the US.

[Insert Table 1 here]

Following the existing literature on GB (Larcker and Watts, 2020), we investigate investment-grade corporate GB with a fixed coupon. After removing non-fixed coupon bonds, we arrive at 1,337 investment-grade fixed coupon corporate GB, representing 17.08% (1,337/7,826) of all the GB issued from Jan-2013 to Dec-2022.[13] Columns (3) and (4) of Table 1 show the year-wise distribution of this sample GB, which again shows a sharp increase in the GB's number and the issuance size. Appendix A and Figure 1 further report the geographical distribution of this sample GB, highlighting variations in the number and the issuance size across 48 countries, with the highest being in the US, followed by the Netherlands, France, and Germany.

[Insert Figure 1 here]

Next, we match the sample of investment-grade fixed coupon corporate GB with the bond-level issuance information obtained from the unique new industry dataset compiled and maintained by IGM. This dataset contains bond-level issuance data, including information on orderbook size that they collect based on daily surveys of bank underwriters. We extract all the bonds' characteristics and related information from IGM. Out of the 1,337 investment-grade fixed coupon GB from LSEG (formerly Refinitiv), we match complete issuance-related information on 817 GB from the IGM database issued between 2013 and 2022, which constitutes approximately 61% (817/1,337) of the investment-grade fixed coupon GB, making it, to our knowledge, the most representative of the total GB population used in the existing

[13] This period also covers notable developments such as the development of GB principles, the Paris Agreement of 2015, Donald Trump's Election of 2016, the USA's exit from the Paris Agreement on June 01, 2017, the USA's re-joining of the Paris Agreement, the COVID pandemic, and many countries' commitments to achieve net zero targets and execution of policies and frameworks.

literature.[14] Hereafter, we denote the sample of investment-grade fixed coupon corporate GB with complete information as the GB sample.

For our GB sample, we collect relevant firm-level variables from LSEG (formerly Refinitiv) and S&P Capital IQ. To merge with the 817 GB IGM dataset, we identify the bond issuer details, such as names, International Security Identification Number (ISIN), and capital IQ ID, from S&P Capital IQ. We extract other relevant data from LSEG, the Organization for Economic Cooperation and Development (OECD), the World Bank, and the International Monetary Fund (IMF).

To test our driver-related hypotheses 2 and 3, we procure data from several sources. We collect CO_2 and CO_2 equivalent emissions from LSEG, the Reputation Risk Index (RRI) as a proxy of media-based ESG risk from RepRisk and the issuing firm's green patents and citation data from the World Patent Statistical Database (PATSTAT) and Orbis Intellectual Property.

3.2 Variables

3.2.1 Dependent and Independent Variable

Our dependent variable is the bond's demand captured by the bond's subscription (B_Subs), i.e., the number of times a bond is subscribed relative to the issue size, measured as the orderbook size scaled by the size of the issue (Wang & Wu 2023). For example, if a company issues a bond worth $100 million and receives a subscription order of $300 million, the subscription is three times.

[14] For instance, studies related to this area of literature considering a global sample of GB by Flammer (2021) use 152 GB issued by 65 unique issuers, Tang and Zhang (2020) use 132 final samples of GB, and Zerbib (2019) use 110 samples.

As noted earlier (see section 2.1), the significant difference between GB and conventional non-GB is GB's unique greenness feature following GB's principles of the International Capital Market Association (2018, 2021). Thus, our key independent variable of interest is $D(Green)$, a dummy variable equals one if a bond is labeled green and zero otherwise. Thus, $D(Green)$ is the dummy variable reflecting the unique greenness features of the GB relative to non-GB.

3.2.2 Firm-level Covariates for PSM

We identify prominent firm-level covariates ($F\_Covariates$) to generate a comparable group of GB and non-GB issuers employing the Propensity Score Matching (PSM) approach (discussed in section 3.3) (See Flammer 2021; Dutordoir *et al.* 2023). First, as a proxy of firm size, we use the natural logarithm of total assets (*F_Size*). Next, we use firms' operating performance, proxied by return on assets (*F_ROA*). Third, we use firm leverage, captured by the ratio of total debt to total assets (*F_Lev*). Fourth, we use the firm's sales growth *(F_Rev_Gr).* These variables are included to ensure that GB issuance is not driven by differences in firm characteristics.

3.2.3 Bond Characteristics

Although PSM may control firm-level characteristics, we also need to control for bond features in our empirical set-up. We include several bond characteristics (B_Ch) as control variables that could simultaneously affect the investor demand for the bond (B_Subs) and the probability of GB issuance ($D(Green)$. The larger the size of the issue, the lower the demand for the bond (Krebbers *et al.* 2023; Wang & Wu 2023). Moreover, the size of the issue is also lower for GB compared to non-GB (Flammer 2021; Dutordoir *et al.* 2023), hence, we control for the bond issue size (*B_Size*) calculated as the natural log of issue amount in US$.

Likewise, higher coupons and higher-rated bonds have higher investor attraction (Krebbers *et al.* 2023), and GB are likely to be issued with lower coupons and higher ratings (Zerbib 2019; Larcker & Watts 2020; Dutordoir *et al.* 2023; Wang & Wu 2023). Accordingly, we control for the coupon rate (*B_Coupon*) of the bond and the bond rating (*B_Rating*), which is a numerical value assigned to the S&P credit rating with the highest value 17 rated for AAA and so on. Furthermore, we also include the number of bookrunners as an additional control variable. The underwriters' role is crucial in primary markets of corporate bonds (Nikolova *et al.* 2020). The large number of total bookrunners may increase the marketability of bonds due to their networks and boost their visibility in the primary market, ultimately leading to higher demand (Krebbers *et al.* 2023). We also posit that due to the complex nature of GB issuance, it may require more bookrunners; thus, we control for their number using the natural log of the number of bookrunners (*B_BR*).

We also incorporate the bond's issue currency (*B_Currency*) and the bond's maturity as fixed effects. We divide the bond's maturity into four buckets and denote it as *B_Maturity*, which takes a value of one if maturity is less than or equal to five years; two if it is between five to 10 years; three if 10 to 30 years bonds; and four if maturity is above 30 years.

3.2.4 Country Characteristics

We also incorporate several country's characteristics (C_Ch) such as flight-to-safety (*C_FTS),* flight-to-quality (*C_FTQ*), and real annual gross domestic product growth rates (*C_GDPGR*) as additional control variables. The *C_FTS* and *C_FTQ* refer to a sudden increase in investors' preference for safe and more liquid assets, respectively. Beber *et al.* (2009) show that investors demand securities with less credit risk, especially during crises, and Longstaff (2004) finds that investors demand securities with more liquidity. As the change in *C_FTS* and *C_FTQ* affects investors' portfolio decisions, they also have an impact on the investors' demand for the bond (Krebbers *et al.* 2021). Moreover, GB are marginally less liquid than conventional non-GB (Mazzacurati *et al.* 2021), yet they are considered safe assets, which may affect the issuance decision. Additionally, the country's green initiatives, environmental considerations, supportive policies, and growth also affect the GB issuance decision of firms (Tang 2021; Alharbi *et al.* 2023). Similarly, higher GDP is positively associated with green (renewable) energy production and consumption (Zhang *et al.* 2021; Alharbi *et al.* 2023), which aligns with the GB proceeds used in renewable energy production and makes them more credible than non-GB, leading to higher demand. Hence, we capture these country-level differences in GB issuance and demand by controlling the GDP growth rates *(C_GDPGR).*

3.2.5 Drivers of GB Demand

We use three different proxies explaining the drivers of variations in the demand for GB. The first two proxies represent past ESG performance, and the third is ESG risk. The first past ESG performance proxy is the firm's rescaled CO_2 intensity (*F_CO2*) measure, defined as total CO_2 emission (scope 1 and 2 CO_2 emission and CO_2 equivalent emission) (equivalent in ton) scaled by the firm's sales revenue. We rescale carbon intensity for tractable interpretation of the regression estimates, whereby a higher value denotes lower carbon intensity.[15]

The second past ESG performance proxy is *F_GRS*, which denotes a firm's greening strategies measured as the natural logarithm of the number of green patents registered. The patent information is collected from the PATSTAT, which covers 40 global intellectual property authorities, including those from the United States Patent and Trademark Office

[15] We rescale the total CO_2 emission by subtracting maximum value of total CO_2 emission in our sample.

(USTPO), the European Patent Office (EPO), the Japan Patent Office (JPO), and World Intellectual Property Organization (WIPO).[16] The database also provides information on typologies of innovation identified according to the International Patent Classification (IPC) and Cooperative Patent Classification (CPC). The IPC and CPC are then mapped to four environmental policy goals: human health impacts of environmental pollution, addressing water scarcity, ecosystem health, and climate change mitigation (see Haščič & Migotto 2015, p. 20). We then identify green patents following the OECD's definition and classification. The detailed mapping of the classification with the environmental policy goals is presented in Haščič and Migotto (2015). For each firm in each year, we count the number of patents classified as green.

The final measure, reflecting a firm's ESG-related reputation risk, is denoted as F_RRI. F_RRI is computed by RepRisk from ESG-related news, and it ranges from one to 100, where a high RRI denotes high ESG risk (Li & Wu 2020). RepRisk is an ESG data science company specializing in ESG and business risk research (He *et al.* 2021). RepRisk screens over 100,000 media, stakeholder, and third-party sources daily in 23 languages, and its core research scope includes 28 ESG-related risk incidents (Kölbel *et al.* 2017). For example, environment-related incidents include climate change, greenhouse gas emissions, pollution (global and local), impact on ecosystems, biodiversity, waste issues, and animal mistreatment. The social-related issues include human rights abuses, impact on communities, local participation issues, social discrimination, forced labor, child labor, discrimination on employment, and poor employment conditions. The governance-related issues include corruption, compensation issues, misleading communication (including greenwashing), fraud, tax evasion, and anti-competitive practices. Issues that relate to multiple categories of ESG are referred to as cross-cutting issues, such as

[16] Following Luong *et al.* (2017) and Boubakri *et al.* (2021), for all approved patents, we use the application date and the number of green patents registered a year before the GB issue to overcome the issue of truncation bias in patent databases are there may be backlog of many recent applications (Dass *et al.* 2017).

controversial products and services, products (health and environmental issues), supply chain issues, violations of national regulations, and international standards.

Once ESG incidents are identified and classified, they are categorized based on their severity, reach, and novelty. Severity is rated as low, medium, or high based on the consequences (such as no consequences, injury, or death for health and safety-related incidents), impact (such as on a single person, group, or larger number of people), and cause (by accident, negligence, intent, or in a systematic way) of the incidents. Reach is rated as limited (local media, small non-government organizations, local government bodies, and social media), medium (such as national and international media, international non-government organizations, state, national, and international government bodies), or high (few truly global media outlets) based on the readership, circulation, or importance of the media. Novelty is rated as a new incident or not based on whether the firm/project is exposed to the incident for the first time. RepRisk quantifies the risk incidents using its proprietary standard and customized risk metrics to calculate F_RRI.[17] We rescale the F_RRI where a higher score denotes lower ESG-related reputational risk.[18] All the variables are defined in Appendix B.

3.2.6 Summary Statistics

Table 2 presents comprehensive details of all the variables, their summary statistics, and the number of observations. Panel A provides a summary of all the investment grade fixed coupon corporate bonds for which we have complete information. They are winorized at a 1% level to eliminate the impact of outliers. On average, a bond is subscribed 3.33 times its issue size, whereas the median subscription is 2.67 times.[19] The average (median) *F_Size* is 281.7 bn US$ (64.33 bn US$) with a mean (median) *F_Lev* of 35.68% (32.5%). Similarly, the average

[17] See https://www.reprisk.com/lab/reprisk_index_for_companies_math.html
[18] We rescale the *F_RRI* by subtracting the maximum value of *F_RRI* in our sample.
[19] The new bonds are often oversubscribed which is consistent with the existing literature (Nikolova *et al.* 2020).

(median) *F_ROA* is 4.17% (2.92%) and *F_Rev_Gr* is 5.15% (2.40%). These values are similar to Flammer (2021) and Tang and Zhang (2020).

Furthermore, an average (median) *B_Size* is 822.74 m US$ (674.84 m US$) with an average (median) *B_Coupon* of 2.34% (2.13%). The mean (median) *B_Rating* is 9.04 (10), suggesting the average (median) rating of BBB (BBB+). The average *B_Maturity* is 2.25 and 2.0 for GB and non-GB in our sample (i.e., five to 10 years). A bond is typically managed by 4.93 (4) bookrunners. These values are similar to Krebbers *et al.* (2021) and Krebbers *et al.* (2023). The average (median) *C_GDPGR* of the countries in our sample is 1.65% (2.20%) with a mean (median) *C_FTS* of 0.65% (0.47%) and *C_FTQ* of 0.13% (-0.04%).

In Panel B of Table 2, we present initial evidence of significantly higher demand for GB than non-GB based on the full sample. The average (median) *B_Subs* for GB is 3.56 times (3.0 times), whereas for non-GB is 3.32 times (2.67 times). The mean (median) difference of 0.24 times (0.33 times) is statistically significant at the 1% level of significance.

[Insert Table 2 here]

Using the Kernel's density plot, we further visualize the GB and non-GB *B_Subs*. Figure 2 shows that the GB distribution exhibits a higher density at higher *B_Subs* than non-GB, suggesting a higher demand for GB. Both distributions taper off as the *B_Subs* increase, with a visible difference in the tail end of the density, as some of the GB are subscribed nearly 50 times more than issued. It further suggests that the highest density for GB is around a *B_Subs* of 3.0 times, whereas it is 2.0 times for non-GB. Overall, we find a significant demand for the greenness of a bond.

[Insert Figure 2 here]

3.3 Identification Strategy

Panel C of Table 2 summarizes the firm and bond characteristics. We observe significant differences in the firm characteristics between GB and non-GB issuers as well as differences in the bond features. The GB issuers are significantly larger (based on *F_Size)* but are poorer in operating performance (captured by *F_ROA*) compared to non-GB issuers, consistent with Flammer (2021). Given the GB issuances are costly due to third party verifications and annual review, the GB are typically issued by larger firms. Likewise, the GB and non-GB significantly differ in bond characteristics as well. Consistent with Larcker and Watts (2020), GB has a smaller issuance amount (*B_Size*), and a lower coupon rate (*B_Coupon*). They also have a lower bond rating (*B_Rating*), but a higher number of bookrunners (*B_BR*).

Therefore we apply the PSM technique to balance covariates to generate near-random and statistically similar treated and control groups, which is similar to the approach used by Flammer (2020, 2021). The treated group includes firms that issue GB, whereas the control group includes firms that issue non-GB only during the sample period. We match the firms from the control group that operate in the same industry and country and are issued in the same year. We match the treated and control groups using the covariates *F_Size*, *F_ROA*, *F_Lev*, and *F_Rev_Gr* measured a year before GB issuance. When applying PSM, we first estimate probit regression before and after matching using Equation (1) below:

$$Treat_{jt} = \alpha + \boldsymbol{\beta_1}.\left(F\_Covariates_{jt-1}\right) + Year\ FE + Industry\ FE + Country\ FE + \varepsilon_{jt} \quad (1)$$

where, $Treat_{jt}$ is a dummy variable that takes the value of one if a firm *j* in the treated group issued a GB in year *t* and zero otherwise.[20] $F\_Covariates_{jt-1}$ refer to the covariates *F_Size*,

[20] Our dataset is pooled-cross-sectional in nature as the same firm may issue GB/non-GB over two or more periods, even within the same year.

F_ROA, *F_Lev*, and *F_Rev_Gr*. We also include year, industry, and country fixed effects and cluster the standard errors at the firm and year levels. All the variables are defined previously and in Appendix B.

Model (1) of Table 3 reports the probit model results of Equation (1) based on 4,473 firm-year observations before matching. The results of Model (1) show that the specification captures significant variation in the dependent variable, as indicated by a pseudo-R^2 of 22.7%. We use the propensity scores from Model (1) to perform one-to-one nearest-neighbor matching from the same country, industry, and year with a caliper of 0.1. The matching estimation generates 672 firm-year observations with 336 unique pairs of treated and control group firms. This corresponds to the treated and control firms' 443 GB and 1,611 non-GB, respectively.

We perform two diagnostics tests to ensure no observable statistical average differences between the matched treated and control firms. First, we re-run probit regression using Equation (1) and restrict it to the matched firm-year observations. The results reported in Model (2) show that none of the matching covariates is statistically significant, suggesting no average statistical differences in the firm characteristics between GB issuing firms and non-GB issuing firms. Likewise, we also observe a considerable drop in the pseudo-R^2 from 22.7% prior to the matching to 0.4% after matching.

[Insert Table 3 here]

Second, we conduct a univariate analysis of matching covariates between the treated and control groups and report their corresponding *t*-statistics in Table 4, Panel A. The post-matched sample mean differences in the firm characteristics are statistically insignificant between the treated and control firms. Overall, the diagnostics tests suggest that our matching strategy removes any meaningful statistical average differences between the treated and control firms (other than differences in the investor demand for corporate bonds issued by these firms).

[Insert Table 4 here]

In Panel B of Table 4, we also report the mean *B_Ch* of the matched treated and control firms. We find that non-GB issues are significantly larger than GB and are managed by fewer bookrunners in the matched sample as well (similar to Panel C of Table 2). While comparing *B_Coupon*, consistent with existing literature that shows GB trade at greenium, we also find a significantly lower *B_Coupon* for GB compared to similar non-GB (Zerbib 2019; Fatica *et al.* 2021; Baker *et al.* 2022; Pástor *et al.* 2022). As other literature does not find greenium (Larcker & Watts 2020; Flammer 2021), we interpret the result cautiously, as the greenium observed in our sample may disappear when considering other bond characteristics, the investigation of which is not the main focus of our study.

4 Empirical Analysis

4.1 Demand for Greenness

We begin our analyses by investigating the distribution of the *B_Subs* of GB and non-GB followed by univariate and multivariate analyses. We present the kernel density of *B_Subs* in Fig. 3, which provides insights into the frequency distribution of investor demand. Fig. 3 shows a consistently higher density of *B_Subs* of GB than non-GB, suggesting a higher demand for greenness. Both distributions taper off as the *B_subs* increase, with a visible difference at the tail end of the density, as some of the GB are subscribed nearly 50 times. It further suggests that the highest density for GB is around *B_Subs* of 3.0 times, whereas for non-GB, it is 2.0 times.

[Insert Fig. 3 here]

In Fig. 4, we plot the annual trend in *B_Subs* of GB and non-GB. Panel (a) compares the *B_Subs* of GB (green line) and non-GB (red line) from 2013 to 2022. Except in 2013 and 2014, we see that *B_Subs* of GB are consistently higher than that of non-GB. Both bond types demonstrate variability over time, with demand peaking in 2015 and 2020, particularly for GB. The higher demand for greenness in 2015 and 2020 coincides with the Paris Agreement in 2015 and quantitative easing during the 2020 pandemic, which increased the investors' attraction towards green investments such as GB.

Panel (b) shows the annual mean difference in *B_Subs* between GB and non-GB. Consistent with Panel (a), we observe statistically higher *B_Subs* after 2015, indicating a gradual increase in demand for the greenness of GB. This trend suggests that there is a growing preference for green financing tools (such as GB) by investors.

[Insert Fig. 4 here]

Next, we conduct a univariate analysis of the demand for greenness. In Panel A of Table 5, we find that the mean (median) difference in the *B_Subs* for GB, relative to non-GB, is 0.69 (0.60), which is statistically significant at 1%. In other words, the demand for GB is 25.8% (i.e., 0.69/2.90) higher than for non-GB, lending support to our *H1*. Since these differences are observed without controlling the relevant firm and bond characteristics, we use the following regression model:

$$B\_Subs_{ijkt} = \beta . D\left(Green_{ijkt}\right) + \boldsymbol{\alpha} . F\_Covariates_{jkt-1} + \boldsymbol{\gamma} . B\_Ch_{ijkt} + \boldsymbol{\delta} . C\_Ch_{kt-1} + FE + \varepsilon_{ijkt} \tag{2}$$

where *i, j,k,* and *t* are indexed as bond, issuer firm, country, and time (year), respectively. *B_Ch* is bond characteristics and *C_Ch* is country characteristics. All other variables are discussed in section 3.2 and defined in Appendix B. Our regression includes several fixed effects to rule out trends such as year, industry, country, *B_Currency*, and *B_Maturity*. ε_{ijkt} is the error term clustered at firm and year levels.

Table 5 panel B presents the results of Equation (2). We compare 451 GB and 1,641 matched non-GB identified using firm-level PSM. Models (1) and (2) use two versions of the fixed effects models as indicated in the table. The coefficient of our main variable $D(Green)$ is positive and statistically significant at 1% level of significance in Model (1) and at 5% level of significance in Model (2), which shows that there is a significantly higher demand for greenness proxied by the bond's subscription in the primary market. GB demand is 35% to 44% points larger than conventional non-GB, supporting our *H1*. This is consistent with the signaling argument that GB signals a firm's commitment to the environment, lowering the information asymmetry about proceeds use and attracting higher investor demand.

In terms of control variables, as expected, we find a statistically significant negative (positive) coefficient of *B_Size* (*B_Coupon*), suggesting that the bonds with higher issuance size (higher coupon) have lower (higher) investor demand. We also find that the higher *C_FTS* contributes to higher *B_Subs*. Statistically, if the *C_FTS* (the difference in long and short-term government debt) is higher by 1%, the corporate bond demand could increase by 18% to 52%. As we consider investment-grade corporate bonds, the positive coefficient of *C_FTS* suggests that investors demonstrate yield-seeking behavior due to historically lower government yield during our sample period and perceive the sample bonds as relatively safe alternatives to government debt.

[Insert Table 5 here]

Our finding is inconsistent with the arguments of Larcker and Watts (2020), who conclude that investors find GB and non-green investments as exact substitutes, their pricing is the same, and investors do not forgo wealth for environmental sustainability. This difference in findings may be due to the different setups: we consider the corporate GB demand, whereas Larcker and Watts (2020) consider the municipal securities and evaluate the greenium. However, our results extend the findings of Pástor *et al.* (2022) that the price for GB is higher than conventional bonds, and we find higher demand for GB in the primary market.

Are there any differences in demand for greenness based on the GB issuer sector? The answer to this question is essential as the motives for issuing GB between banks and non-financial firms differ due to the nature of their business. For example, banks issue GB to provide green loans to customers to finance their green projects or invest in other firms' green projects, whereas non-financial firms have their own green projects funded through GB (Tang & Zhang 2020). Thus, investors may find it difficult to trace the proceeds of the GB issued by banks to specific green projects. Hence, banks may find it difficult to signal their environmental commitment to the investors credibly (Fatica *et al.* 2021). Tang and Zhang (2020) support this argument as they show that the investor reaction to GB issuance by firms belonging to financial sectors is insignificant, whereas GB issuance by firms in corporate sectors is positive and statistically significant. However, Fatica *et al.* (2021) conclude that the financial sectors shift their lending away from polluting activities after the GB issuance, suggesting that banks indeed provide a credible signal to the market that they are becoming greener after GB issuance.

Hence, we conduct two separate sub-sample analyses to investigate whether the demand for greenness in the primary market differs in the non-financial sector compared to the financial sector. The results are presented in Table 6.

[Insert Table 6 here]

Panel A of Table 6 shows that our matched sample covers 11 industries, and about 53% (41% in treated and 56% in control) of observations are from the financial sector. This highlights the importance of analyzing investor demand in different sectors. We re-run Equation (2) for the financial and non-financial firms separately. We report the results in Panel B of Table 6. We find that the demand for GB issued by financial and non-financial firms is consistently higher than for non-GB. The demand for GB issued by financial firms (non-financial firms) is about 32% to 43% (45% to 52%) higher than comparable non-GB. The results suggest that the *value-based* and *value* investors consider the GB issued by financial and non-financial firms as a credible signal of their environmental commitment.

4.2 Robustness Tests

4.2.1 Alternative Matching

Our current matching procedure matches GB and non-GB issued by firms with similar firm characteristics. However, bond-level differences still exist that may affect the bond demand. To address this, we use two alternative matching strategies to identify a matched conventional non-GB identical to the GB. Zerbib (2019) uses a model-free approach to construct counterfactual traditional bonds issued by the same issuer with the same maturity, currency, rating, bond structure, seniority, collateral, and coupon type. Similarly, for each GB, we match a conventional non-GB issued by the same firm, issued in the same currency, with the same rating, bond type, coupon type, and maturity bucket. We further match conventional non-GB, which is issued closest (within two years) to the GB and has an issue size closest to the GB. This exercise identifies one unique conventional non-GB for each GB issued by the same firm. We are able to match 237 GB with 295 non-GB. These bonds are similar except for using proceeds in green or other projects, i.e., their greenness.

We re-run Equation (2) using this matched GB and non-GB sample and present the results in Panel A of Table 7. The coefficient of the primary variable $D(Green)$ is consistent with our main results in both models that use different combinations of fixed effects. It also suggests that the demand for the GB is, on average, 54% to 60% points higher than the comparable non-GB issued by the same firm.

As matching within the same firm significantly reduces the sample size (Helwege *et al.* 2014), we match the GB with conventional non-GB issued by a firm that belongs to the same industry and apply the same matching criteria as above. We identify 524 GB that matches with 706 non-GB. We re-run Equation (2) using alternate matched GB and non-GB samples and present results in Panel B of Table 7. The coefficient of the primary variable of concern, $D(Green)$, is again consistent with our main results in all models that use different combinations of fixed effects. It suggests that the demand for GB is, on average, 48% to 52% points higher than the comparable non-GB issued by firms within the same industry.

[Insert Table 7 here]

Although our matching strategy identifies non-GB identical to GB issued by propensity score matched firm, same firm, or another firm within the same industry, one can argue that if the demand for GB is indeed higher than for conventional non-GB, then the results should not be matching dependent. Similarly, matching is not a replacement for a quasi-natural experiment if possible (Flammer 2021). Hence, we perform another robustness test using a non-parametric approach and confirm that our result is not dependent on the matching strategy. First, we identify 451 GB issued from 2013 to 2022, for which we have complete information. Then, we identify 7,026 non-GB issued after 2010, for which we have complete information.

Next, we randomly select 902 non-GB, denoted as placebo control, from the universe of 7,026 non-GB, equivalent to twice the number of GB with complete information. We re-run Equation (2) in Model 1 of Table 5 for 10,000 times. In Figure 5, we plot the cumulative distribution function (CDF) of beta estimates $D(Green)$. The shaded region denotes the 95% confidence interval of the leading coefficient estimated in Model (1) of Table 5. We find that 99.9% of $D(Green)$ estimated coefficients using placebo control are positive and have a *p*-value lower than 0.10. The red cross in the figure denotes the placebo coefficient with a *p*-value greater than 0.10. We also confirm that 90% of the estimated coefficients lie within the 95% confidence interval of the leading coefficient estimated in Model (1) of Table 5. Overall, our baseline results are consistent in alternative bond-level and non-parametric matching approaches.

[Insert Figure 5 here]

4.2.2 Alternative Proxies of Demand

Additionally, we perform robustness tests using two alternate proxies of investor demand measured using the natural log of the orderbook amount and the residual bond subscription. To address the effect of an increasing number of bonds offered during our sample and the impact of the industry average on investor demand, we regress the subscription ratio on the log number of corporate bonds issued before the concerned bond and the average industry subscription to obtain the residual subscription ratio. This residual demand is used as the primary dependent variable. The results are presented in Table 8.

In Panel A, the primary dependent variable is the natural log of the orderbook amount. The results are consistent with our main results and *H1*. The GB orderbook amount is about 9 to 12% higher than the orderbook demand of a comparable non-GB. Similarly, in Panel B, we report the results using residual subscription as the proxy for demand. The GB residual demand is 35% to 44% higher than that for a comparable non-GB. Overall, all our robustness test results are comparable to our main result, supporting *H1*.

[Insert Table 8 here]

4.3 Drivers of Higher GB Demand

In this section, we test the hypothesis related to drivers of demand for GB (H_2 and H_3) using the following regression Equation (3).

$$\begin{aligned} B\_Subs_{ijkt} = {} & \beta.D\left(Green_{ijkt}\right) \times \left(Drivers_{jkt-1}\right) + \boldsymbol{\alpha}.F\_Covariates_{jkt-1} \\ & + \boldsymbol{\gamma}.B\_Ch_{ijkt} + \boldsymbol{\delta}.C\_Ch_{kt-1} + FE + \varepsilon_{ijkt} \end{aligned} \quad (3)$$

where $Drivers$ denotes drivers related to ESG performance, ESG risk, and greening strategies discussed in section 3.2. All other variables are as previously defined.

4.3.1 Firm's ESG Performance and GB Demand (H_2)

We test H_2 using two proxies. First, we use the inverted measure of carbon intensity to represent the firm's environmental performance, where a high value represents better carbon performance. We argue that the demand for greenness is driven by the desire to invest in firms with lower CO_2 emissions by both *values-based* and *value* investors. Recent literature extensively studies the implications of toxic emissions and notes that investors' awareness of the firm's CO_2 emission and climatic risk has increased over the years, with investors' demand shifting towards low-emitting firms (Ramelli *et al.* 2021). For instance, Bolton and Kacperczyk (2021) and Pástor *et al.* (2022) show that investors are divesting from high CO_2 emitting firms, which is consistent with *values-based* investment strategy.

The CO_2-intensive firms are less attractive to *value* investors as their cash flows are vulnerable due to climatic risks arising from CO_2-reduction regulations and policies (Ilhan *et al.* 2021; Hoepner et al., 2023). A vulnerable cash flow is associated with a greater chance of cash shortfalls, which increases the default probability of bonds (Minton & Schrand 1999), resulting in reduced demand for bonds issued by these firms. Low-emitting firms are also more attractive due to their higher return performance. Duan *et al.* (2021) find higher returns on bonds issued by low emitters due to their predictability of cash flows, creditworthiness, and environmental actions. Finally, institutional investors are more attracted to invest in firms with low CO_2 emissions (Azar *et al.* 2021), as institutional investors view high CO_2 emissions as a significant concern that produces a material risk to firms (Krueger *et al.* 2020). Thus, we argue that GB issued by firms with lower CO_2 emissions is more attractive to investors compared to GB issued by firms with higher CO_2 emissions and other non-GB.

We use a variation of Equation (3) using *F_CO2* as a driver for greenness. The results are presented in Table 9. Models (1) and (2) show that the demand for GB is significantly higher than a non-GB in firms with lower *F_CO2*. Economically, one standard deviation reduction in *F_CO2* increases the GB demand by 2 to 2.5 times ($33.46 \times 0.059 = 2$ and $33.46 \times 0.074 = 2.5$). Thus, we find evidence consistent with our argument that the firm's *F_CO2* serves as a credible signal of its environmental performance to investors in the GB market.

[Insert Table 9 here]

Second, we use the number of green patents to proxy a firm's environmental commitment and performance. Studies note that a firm's strategic approach to environment-friendly business practices can better mitigate and manage climatic risk, thus improving the firm's ESG profile and performance (Krueger *et al.* 2020; Bolton & Kacperczyk 2021; Ilhan *et al.* 2021). One such strategic initiative is investment in green innovation (GI) (Kogan *et al.* 2017; Hegde *et al.* 2022). Evidence suggests that firms use GI to reduce operational expenses such as energy consumption, waste reduction, and raw materials handling (Hart 1995; Ambec & Lanoie 2008). Studies also indicate that investments in GI improve firms' competitive advantage and build a favorable reputation, leading to better environmental, operational, and financial performance (Hart 1995; Ambec & Lanoie 2008). Consequently, a firm's adoption of GI provides evidence of its commitment to transitioning to greener practices, appealing to investors interested in positive environmental change (Dyck *et al.* 2019).

We argue that higher past investments in GI are credible signals to potential investors regarding their commitment to environment-friendly practices as it requires redirecting research and development efforts, which incurs significant costs (Andriosopoulos *et al.* 2022). We argue that firms issuing GB and those with a history of higher investments in GI should exhibit higher appeal to *value* and *values-based* investors. *Values-based* investors are likely to be attracted to firms with higher levels of GI because such a strategic approach aligns with the environmental preferences of investors (Ceccarelli *et al.* 2024). On the other hand, *value* investors should also be attracted as GI mitigates future environmental and climate risks of the firms and adds financial value (Ceccarelli *et al.* 2024).

We use another variation of Equation (3), where F_GRS is the main variable of our interest. The F_GRS is the lag of log (1+number of green patents) as the proxy of the firm's greening strategy. The results are reported in Models (3) and (4) of Table 9. We can see that the coefficients of the interaction terms are positive and significant, suggesting that the investors value firms' greening initiatives in firms issuing GB. Economically, a 10% increase in the number of patents in the firm’s greening initiatives causes 15% to 19% higher demand for GB. Hence, we confirm H_2 that the demand for GB issued by firms with better greening strategies is higher than the GB issued by firms with low greening strategies and non-GB issued by all firms.

4.3.2 Firm’s ESG Risk and GB Demand (H_3)

In this section, we investigate H_3 using a variation of Equation (3), where we use the lagged *F_RRI*, a proxy of the firm’s ESG risk, as a driver. The higher *F_RRI* denotes lower ESG risk. The results are presented in Table 11. In Models (1) and (2), we find the coefficient of the interaction term to be positive and significant, suggesting that the demand for greenness is higher for GB issued by firms with higher *F_RRI* compared to GB issued by firms with lower *F_RRI* and other non-GB. Economically, we find that the GB demand increases by 1.31 times to 1.81 times for one standard deviation (i.e., 16.42) increase in *F_RRI*. Our finding supports *H3* and extends Dutordoir *et al.* (2023). While Dutordoir *et al.* (2023) find that a better reputation drives GB issuance, we find that a lower ESG risk drives demand for the greenness of a bond.

[Insert Table 10 here]

5 Conclusion

Using a unique industry dataset that provides information on orderbook size, which measures investor demand, of a sizable proportion of corporate investment-grade fixed coupon GB issued worldwide, we investigate if the demand for GB is higher compared to similar conventional non-GB and examine the drivers of the higher demand for GB.

We investigate the investor's demand for greenness using a robust matching strategy. We perform a PSM using matching covariates to eliminate any fundamental differences between GB and non-GB issuers. Thus, we examine the difference in investor demand between these two groups of bonds that differ only on their greenness and find that GB is subscribed, on average, 35% to 44% points more than conventional non-GB issued by similar firms. We also report that investor demand for GB is higher across the industries, whether it is a GB issued by financial or non-financial firms. Our findings are consistent with the signaling theory and socially responsible investment principles. The GB issuance provides signals to investors about the firm's commitment to the environment, and this signal is credible due to the transparent procedure of the GB issuance and the use of proceeds in pre-identified environment-friendly projects. Importantly, GB attracts both *value* investors and *values-based* (SRI) investors, signaling higher future firm value and environmental contribution.

Importantly, we identify the significant drivers of GB demand by testing two novel hypotheses. We find that investors consider the firm's environment-related credibility before they buy the GB. Hence, a heterogeneous demand for GB across firms exists depending upon their profile, including ESG performance (such as lower carbon emissions and higher green innovation) and the firm's ESG risks.

Our study offers practical implications. Corporations may want to consider the benefits of improving their ESG performance to attract higher demand for GB issues. Furthermore, firms are motivated to reduce their ESG-related reputation risk, lower CO_2 emissions, consider alternative energy, innovate on technology, or adopt new greener and more sustainable processes. We also recommend regulators devise a supportive mechanism that enhances countries' environmental commitment and boosts global GB demand. Governments can incentivize corporations to encourage the issuance of GB, offer clear guidelines, establish green infrastructure, develop green technology, and enhance green energy production.

Through GB issuance, policymakers' support, the country's environmental commitment, and firms' responsible investment initiatives can attract a large pool of investment to support the global net zero and the UN's SDGs. Further research should explore the possibility of greenwashing through GB, examine whether GB contributes to green innovation, and investigate the factors influencing the demand for GB in the secondary market.

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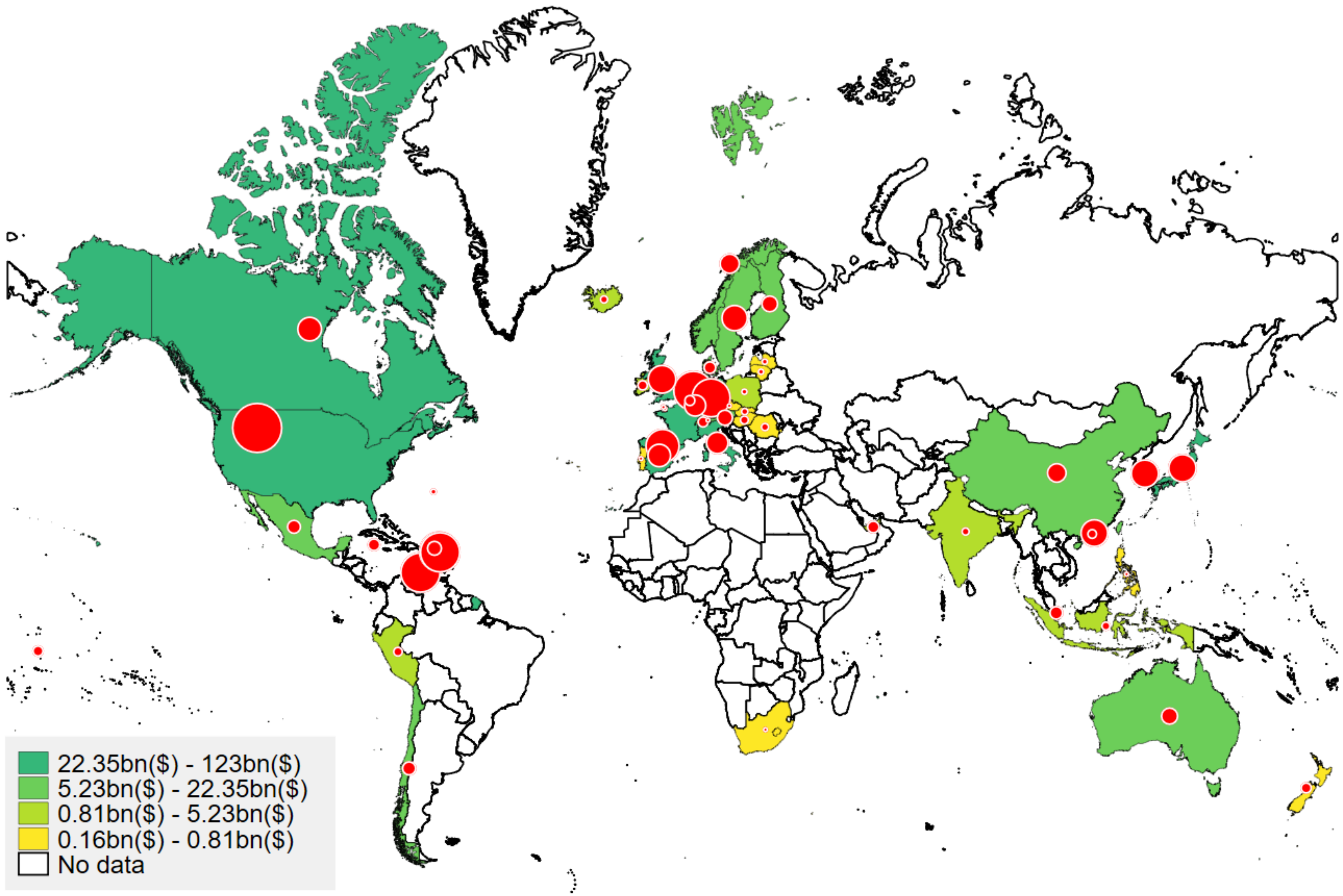


Fig. 1. Geographical representation of GB across the globe
This figure shows the size of investment-grade fixed coupon GB globally. The red-circled bullet denotes the country of GB issues, and their size is proportionate to the number of GB issued in the country.

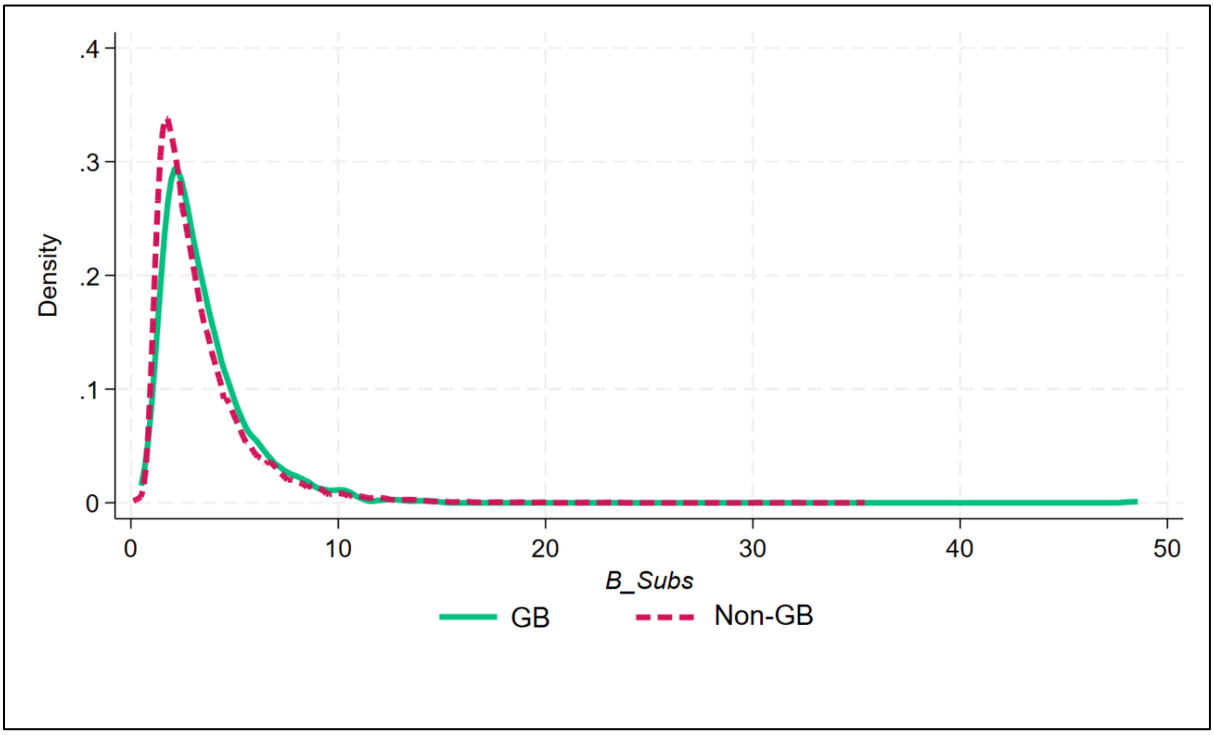


Fig. 2. Kernel density estimates of bond demand (full sample)

The figure presents a density plot of *B_Subs* of GB (green line) and non-GB (red dashed line) for the full sample. The plot uses a Gaussian kernel and the Silverman rule for bandwidth selection.

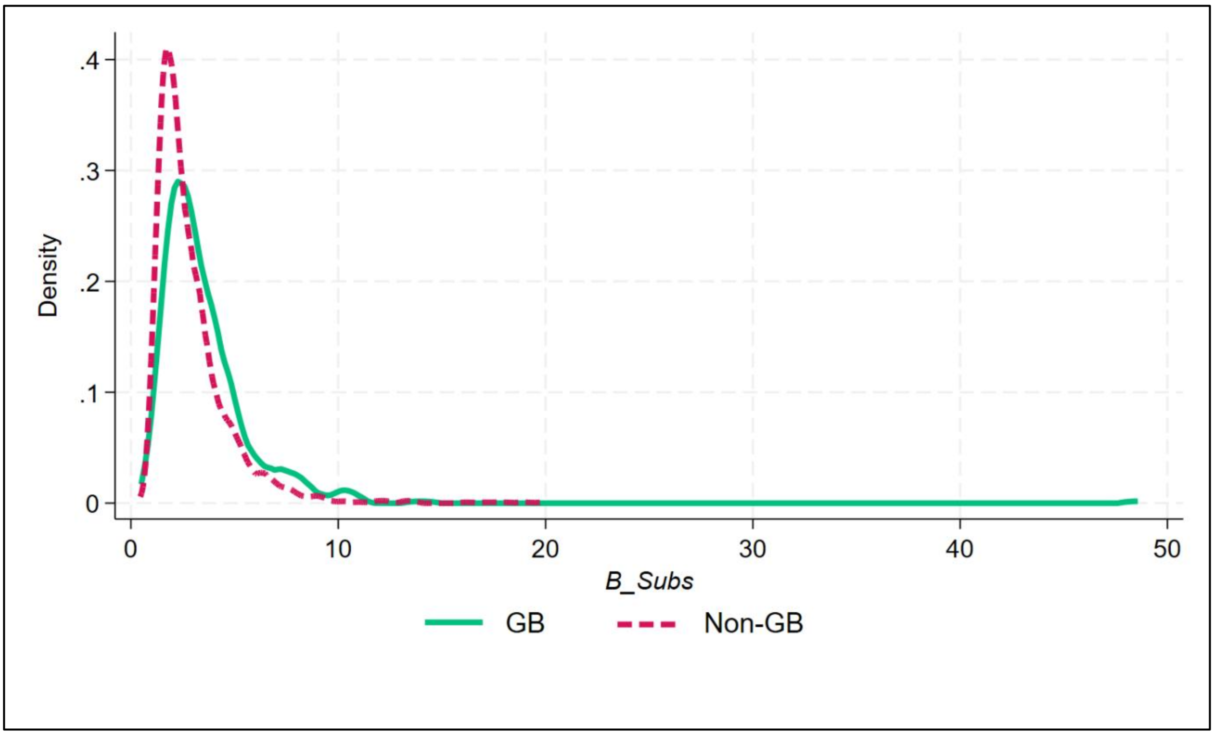
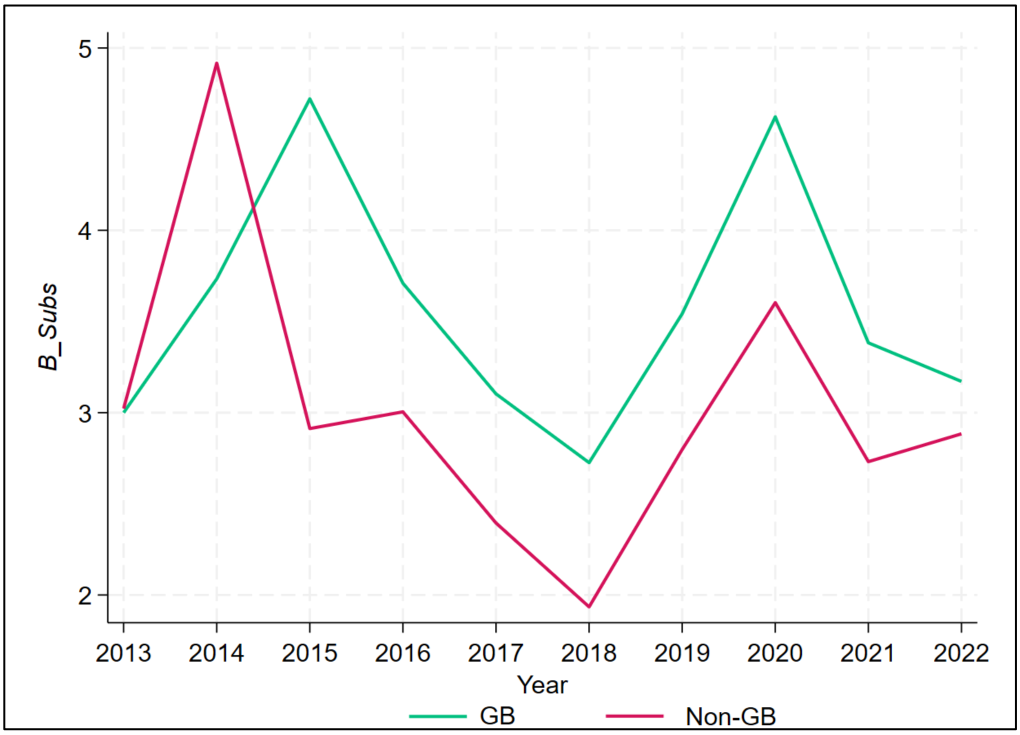
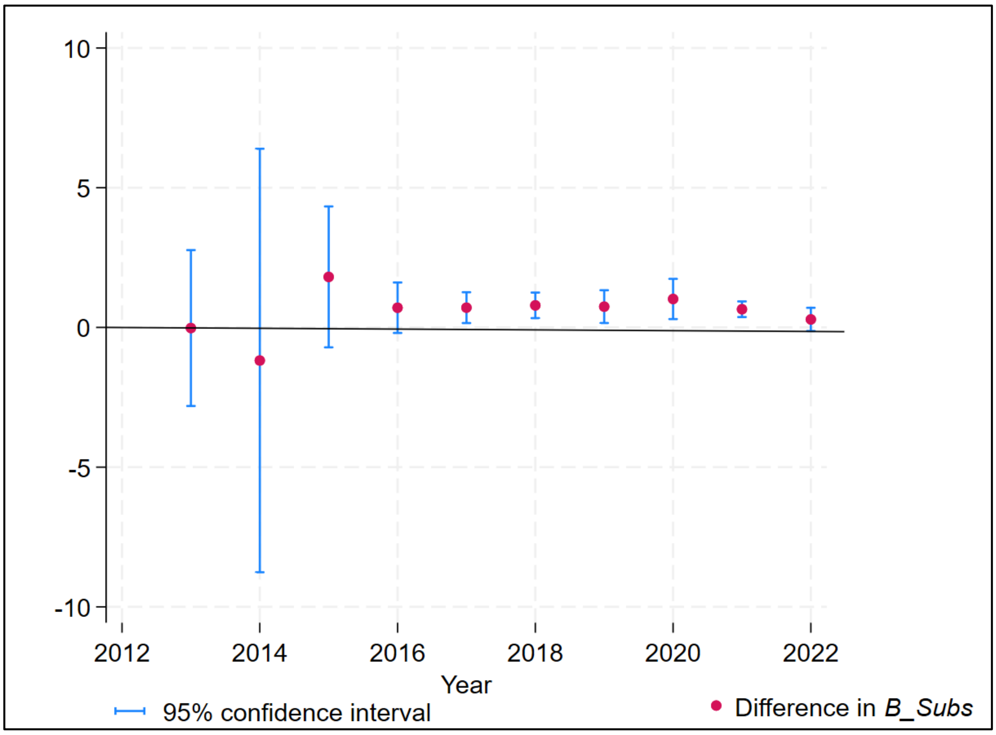


Fig. 3. Kernel density estimates of bond demand (matched sample)

The figure presents a density plot of the *B_Subs* (in the x-axis) of GB and non-GB for the matched sample. The plot uses a Gaussian kernel and the Silverman rule for bandwidth selection.



(a) Average *B_Subs* of GB and non-GB



(b) Difference in *B_Subs* between GB and non-GB

Fig. 4. Annual trend and mean difference

Panel (a) compares the *B_Subs* of GB (green line) and non-GB (red line) from 2013 to 2022. Panel (b) shows the mean difference in *B_Subs* between GB and non-GB with its confidence interval (blue).

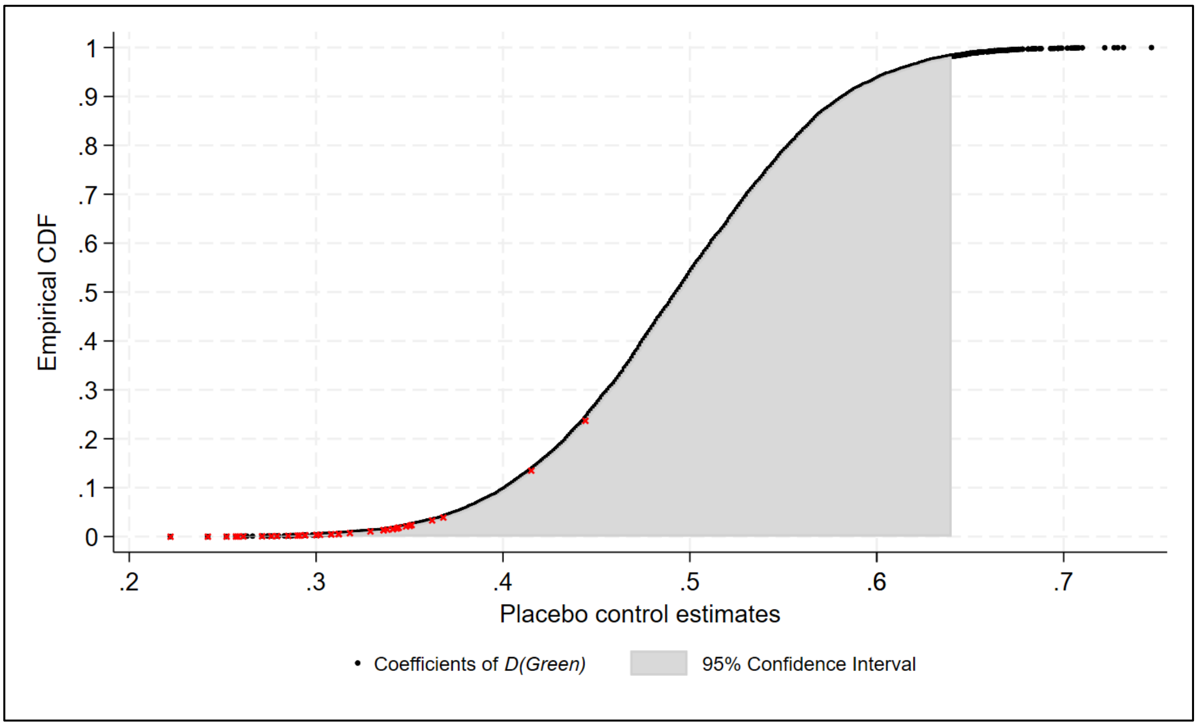


Fig. 5. Non-parametric test

The graph shows the cumulative distribution function (CDF) of 10,000 beta estimates of *D(Green).* It considers 902 random corporate non-GB from the universe of corporate non-GB, twice the number of corporate GB with complete information. It reports for 10,000 iterations of baseline Model (1) of Table 5. The shaded area represents the 95% confidence interval of the leading coefficient of *D(Green)* in Model (1) of Table 5. The red X-marks estimate represents *D(Green)* coefficient with a *p*-value greater than 0.10.

Table 1

GB over time: Comparative analysis of total GB, investment grade, fixed coupon corporate GB, and our data universe

This table reports the number of GB issued (#) and the issue amount (million US dollars) since its debut from 2007 to 2022. It also documents the universe of total corporate GB offering fixed coupons investment grade, followed by our sample GB with bond subscription information from their debut covering the period of 2013 to 2022 worldwide.

Year	Total GB universe		Investment grade fixed coupon corporate GB		Our sample GB	
	#	Issue Amount (m$)	#	Issue Amount (m$)	#	Issue Amount (m$)
2007	1	629.5				
2008	2	473.9				
2009	5	893.8				
2010	53	2,691.7				
2011	29	812.8				
2012	24	2,408.2				
2013	45	12,465.4	4	2,474.3	3	2,105.3
2014	140	30,584.7	10	5,246.2	3	2,130.1
2015	305	48,928.9	15	8,449.7	8	3,567.9
2016	258	98,941.2	42	26,487.6	26	16,572.4
2017	455	160,324.1	79	44,311.4	43	24,452.4
2018	545	157,389.6	74	41,547.1	42	28,536.1
2019	949	284,948.7	170	87,903.8	98	62,972.0
2020	1203	297,903.2	218	103,154.0	136	80,918.1
2021	2095	636,889.8	358	179,144.3	232	133,891.4
2022	1717	540,330.4	367	197,632.6	226	147,124.0
Total	7,826	2,276,615.9	1,337	696,350.8	817	502,269.7

Table 2
Summary statistics of sample data before matching

Panel A summarizes the green and non-GB universe (investment grade and fixed-coupon corporate bonds). Panel B summarizes the mean and median difference and statistics between the oversubscription GB and non-GB. Panel C summarizes the mean differences between firm-level covariates, bond characteristics, and t-statistics between GB and non-GB. The table also reports the number of observations available for each variable with subscription information in all panels. All the variables are defined in Appendix B.

Panel A: Summary statistics of the bond universe with subscription data						
	Observation	Mean	Median	Std. Dev.	Minimum	Maximum
Dependent variable						
B_Subs (times)	12593	3.33	2.67	2.17	1.00	12.20
PSM covariates						
F_Size (b$)	10540	281.70	64.33	478.88	0.26	1948.23
F_Lev (%)	10531	35.68	32.50	21.13	0.00	99.74
F_ROA (%)	10305	4.17	2.92	4.95	-8.29	24.32
F_Rev_Gr (%)	9913	5.15	2.40	27.75	-93.06	201.61
Bond characteristics						
B_Size (m$)	12593	822.74	674.84	526.50	6.70	7000.00
B_Coupon (%)	12593	2.34	2.13	1.61	0.00	11.50
B_Rating	12593	9.04	10	4.709	1.00	17.00
B_Maturity	12593	2.25	2.00	0.83	1.00	4.00
B_BR	12593	4.93	4.00	3.13	0.00	40.00
Country characteristics						
C_GDPGR (%)	12248	1.65	2.20	3.42	-9.30	8.10
C_FTS (%)	12221	0.65	0.47	0.86	-1.22	4.03
C_FTQ (%)	12221	0.13	-0.04	1.67	-2.51	4.79

Panel B: Univariate Analysis of B_Subs					
	All	GB (1)	Non-GB (2)	Diff (1-2)	stat
Mean B_Subs	3.33	3.56	3.32	0.24***	3.56
Median B_Subs	2.67	3.0	2.67	0.33***	5.273
Observations	12593	817	11776		

Panel C: Mean differences between the GB and non-GB				
	GB (1)	Non-GB (2)	Diff (1-2)	*t*-stat
Firm-level covariates				
F_Size (b$)	323.91	278.76	45.15**	2.02
F_ROA (%)	3.27	4.23	-0.96***	-6.37
F_Lev (%)	35.30	35.64	-0.34	-0.47
F_Rev_Gr(%)	5.43	5.13	0.30	0.28
Bond characteristics				
B_Size (m$)	633.43	835.87	-202.44***	-18.00
B_Coupon (%)	1.83	2.38	-0.55***	-10.53
B_Rating	8.22	9.10	-0.88***	-5.16
B_Maturity	2.22	2.25	-0.03	-1.04
B_BR	5.80	4.87	0.93***	6.60

Table 3

Diagnostic test for propensity score matching (PSM): Probit analysis

This table reports the parameter estimates from the probit model used to estimate propensity scores for firms in the treatment and control groups.

$$Treat_{jt} = \alpha + \boldsymbol{\beta_1}.\left(F\_Covariates_{jt-1}\right) + Year\ FE + \ Industry\ FE + Country\ FE + \varepsilon_{jt}$$

The dependent variable ($Treat_{jt}$) is one if a firm *j* in the treated group issues GB in a year *t* and zero otherwise. The treated group consists of firms that have issued GB, and the control group consists of firms that have not issued GB. The pre-match and post-match equations include year, industry, and country-fixed effects. Model (1) predicts the likelihood of being a treated firm from the entire sample of firms with no missing covariates. Model (2) predicts the probability of matched treated and control firms using PSM with no replacement. Standard errors are clustered at the country-industry level, *t*-statistics are presented in parentheses, and *, **, and *** denote statistical significance at the 10%, 5%, and 1% significance levels.

	Dummy= 'one' if it belongs to treated (i.e., firm issuing the GB); 'zero' otherwise.	
	Pre-match (1)	Post-match (2)
F_Size	0.120***	0.031
	(3.16)	(0.81)
F_ROA	0.005	0.030
	(0.40)	(1.44)
F_Lev	0.000	0.003
	(0.07)	(0.81)
F_Rev_Gr	-0.003**	0.001
	(-2.22)	(0.30)
Year fixed effects	Yes	Yes
Industry fixed effects	Yes	Yes
Country fixed effects	Yes	Yes
Pseudo R^2	0.227	0.004
No. of Obs. (firm-year)	4,473	702

Table 4
Summary statistics of propensity score matched sample

The table reports the mean values of all firms, treated and control firms, and differences between treated and control firms post-PSM. Panel A shows the mean values of PSM covariates for 706 firm-year observations. Panel B shows the mean values of bond characteristics for 2,099 GB and non-GB issued by matched treated and control firms. The *t*-statistics are presented in the final column, and *, **, and *** denote statistical significance at the 10%, 5%, and 1% significance levels, respectively.

Panel A: Mean values of PSM covariates for all matched, treated, and control firms					
	All (1)	Treated (2)	Control (3)	Diff. (2-3)	*t*-stat
F_Size (b$)	17.96	17.98	17.94	0.04	0.26
F_ROA (%)	3.04	3.20	2.88	0.32	1.19
F_Lev (%)	37.00	37.31	36.69	0.62	0.40
F_Rev_Gr (%)	1.82	2.22	1.42	0.81	0.67

Panel B: Mean values of bond characteristics post matching					
	All (1)	GB (2)	Non-GB (3)	Diff. (2-3)	*t*-stat
B_Size (m$)	786.47	627.10	830.27	-203.17***	-11.21
B_Coupon (%)	1.88	1.76	1.91	-0.15**	-1.97
B_Rating	9.27	9.12	9.31	-0.19	-0.85
B_Maturity	2.28	2.32	2.26	0.06	1.30
B_BR	4.84	5.39	4.68	0.71***	4.07
B_Size (m$)	786.47	627.10	830.27	-203.17***	-11.21

Table 5

Baseline regression results

In this table, we report the results of bivariate and multivariate analysis. Panel A shows the bivariate analysis results, and Panel B shows the multivariate analysis results of two models of the following regression equation:

$$B\_Subs_{ijkt} = \beta . D(Green_{ijkt}) + \boldsymbol{\alpha} . F\_Covariates_{jkt-1} + \boldsymbol{\gamma} . B\_Ch_{ijkt} + \boldsymbol{\delta} . C\_Ch_{kt-1} + FE + \varepsilon_{ijkt}$$

where *i, j,k,* and *t* are indexed as the bond, issuer firm, country, and time (year), respectively. All the variables are defined in Appendix B. FE denotes fixed effects at year, industry, country, currency, and maturity bucket, as denoted at the bottom of each model. The standard errors are clustered at firm and year, and t-stats are presented in parentheses.*, **, and *** denote statistical significance at the 10%, 5%, and 1% significance levels, respectively. The sample includes all firm-year observations of the treated and matched control firms worldwide from 2013–2022.

Panel A: Univariate Analysis of B_Subs					
	All	GB (1)	Non-GB (2)	Diff (1-2)	stat
Mean B_Subs	3.05	3.59	2.90	0.69***	4.85
Median B_Subs	2.5	3.0	2.4	0.60***	7.647
Observations	2092	451	1641		

Panel B: Multivariate Analysis		
	(1)	(2)
$D(Green_{ijkt})$	0.436***	0.346**
	(4.79)	(3.05)
F_Size	0.016	0.018
	(0.41)	(0.45)
F_ROA	-0.002	0.000
	(-0.05)	(0.01)
F_Lev	-0.002	-0.002
	(-0.71)	(-0.75)
F_Rev_Gr	-0.002	-0.002
	(-0.66)	(-0.95)
B_Size	-0.948***	-0.893***
	(-7.09)	(-4.92)
B_Coupon	0.330***	0.302***
	(3.71)	(3.80)
B_Rating	0.001	-0.008
	(0.08)	(-0.67)
B_BR	0.158**	0.075
	(2.79)	(1.35)
C_FTS	0.175**	0.516***
	(3.25)	(4.56)
C_FTQ	-0.004	0.192
	(-0.05)	(0.87)
C_GDPGR	0.010	0.040***
	(0.64)	(3.29)
Year fixed effects	Yes	Yes
Industry fixed effects	Yes	Yes
Country fixed effects		Yes
B_Currency fixed effects	Yes	Yes
B_Maturity fixed effects	Yes	Yes
Number of observations	1878	1877
Adjusted R^2	0.181	0.197

Table 6
Sample representation across industries and comparative analysis between financial (banks) and non-financial firms

This table reports the industry classification of treated and control groups and the demand comparison of non-financial and financial firms (banks). In panel A, we report each industry's number of bonds, issue amount, share for treated, control, and total firm-year observation post-matching. In panel B, we offer the results based on bivariate analysis. In panel C, we report the GB demand comparison between the non-financial and financial firms (banks) based on the results of the following regression equation:

$$B\_Subs_{ijkt} = \beta.D\left(Green_{ijkt}\right) + \boldsymbol{\alpha}.F\_Covariates_{jkt-1} + \boldsymbol{\gamma}.B\_Ch_{ijkt} + \boldsymbol{\delta}.C\_Ch_{kt-1} + FE + \varepsilon_{ijkt}$$

where *i*, *j*,*k*, and *t* are indexed as the bond, issuer firm, country, and time (year), respectively. All the variables are defined in Appendix B. FE denotes fixed effects at year, industry, country, currency, and maturity bucket as denoted at the bottom of each model. The standard errors are clustered at firm and year, and *t*-stats are presented in parentheses, and *, **, and *** denote statistical significance at the 10%, 5%, and 1% significance levels, respectively. # indicates the number. The sample includes all firm-year observations of the treated and matched control firms from 2013–2022 worldwide.

Panel A: Industry classification of firm-year observation post-PSM									
	GB issued			Non-GB issued			All firms		
Industry	#	Issue amount (b$)	%	#	Issue amount (b$)	%	#	Issue amount (b$)	%
Basic materials	9	5.3	1.9	15	8.84	0.6	24	14.14	0.9
Communication services	4	3.84	1.4	40	76.84	5.6	44	80.68	4.9
Consumer discretion	24	18.4	6.5	154	144.11	10.6	178	162.51	9.9
Consumer staples	4	3.85	1.4	18	15.38	1.1	22	19.23	1.2
Energy	7	3.67	1.3	12	10.74	0.8	19	14.41	0.9
Financials	188	115.81	40.9	846	761.62	55.9	1034	877.43	53.3
Health care	3	2.68	0.9	24	21.91	1.6	27	24.59	1.5
Industrials	22	12.78	4.5	41	31.59	2.3	63	44.37	2.7
Information technology	7	5.56	2.0	28	22.84	1.7	35	28.4	1.7
Real estate	73	41.76	14.8	145	91.74	6.7	218	133.5	8.1
Utilities	110	69.17	24.5	318	176.85	13.0	428	246.02	15.0
Total	451	282.82		1,641	1362.46		2,092	1645.28	

Panel B: Univariate Analysis of B_Subs					
	All	GB (1)	Non-GB (2)	Diff (1-2)	*t*-stat
B.1. Financial firms					
Mean B_Subs	2.53	3.10	2.40	0.70**	5.01
Median B_Subs	2.00	2.60	2.00	0.60***	6.26
Observations	1034	188	846		
B.2. Non-financial firms					
Mean B_Subs	3.56	3.95	3.43	0.52**	2.33
Median B_Subs	3.00	3.33	2.90	0.43***	3.50
Observations	1058	263	795		

Panel C: Regression results for non-financial and financial firms				
	Non-financial firms		Financial firms	
	(1)	(2)	(1)	(2)
$D(Green_{ijkt})$	0.428***	0.317**	0.518**	0.453**
	(4.48)	(2.49)	(3.38)	(2.93)
F_Size	-0.074	-0.034	0.001	-0.026
	(-1.10)	(-0.39)	(0.03)	(-0.76)
F_ROA	-0.020	-0.013	0.098***	0.104***
	(-0.46)	(-0.31)	(5.21)	(5.03)
F_Lev	0.005	0.010*	-0.004**	-0.005**
	(0.71)	(2.30)	(-3.07)	(-2.85)
F_Rev_Gr	-0.005	-0.007*	0.005	0.004
	(-1.29)	(-2.11)	(1.23)	(1.44)
B_Size	-1.163***	-1.042***	-0.763***	-0.694***
	(-6.04)	(-5.81)	(-7.19)	(-4.43)
B_Coupon	0.378***	0.369***	0.219	0.177
	(7.67)	(6.47)	(1.58)	(1.40)
B_Rating	0.023	0.013	-0.004	-0.011
	(0.56)	(0.35)	(-0.50)	(-1.11)
B_BR	0.467**	0.314	-0.060	-0.082
	(3.09)	(1.44)	(-0.84)	(-0.83)
C_FTS	0.050	0.578**	0.304***	0.503**
	(0.38)	(2.48)	(5.43)	(3.26)
C_FTQ	0.042	0.094	-0.053	0.333***
	(0.22)	(0.33)	(-1.49)	(3.76)
C_GDPGR	-0.007	-0.029	0.042*	0.068*
	(-0.14)	(-0.69)	(1.98)	(1.96)
Year fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Country fixed effects		Yes		Yes
B_Currency fixed effects	Yes	Yes	Yes	Yes
B_Maturity fixed effects	Yes	Yes	Yes	Yes
Number of observations	998	994	879	878
Adjusted R^2	0.103	0.113	0.251	0.281

Table 7
Alternate matching strategies

We report the robustness of demand for greenness using alternative matching strategies. In panel A, we report the OLS outcome of samples matched at the bond level (i.e., the treated and control bonds are issued by the same firm, have the same currency, have the same S&P rating, and issued in the same country, and have same maturity bucket, issued not earlier than two years and closest possible to issue size). Panel B reports that the OLS outcome of samples matched at the bond level but within the same industry and with the same matching criteria. In this table, we report the results of various models of the following regression equation:

$$B\_Subs_{ijkt} = \beta . D(Green_{ijkt}) + \boldsymbol{\alpha} . F\_Covariates_{jkt-1} + \boldsymbol{\gamma} . B\_Ch_{ijkt} + \boldsymbol{\delta} . C\_Ch_{kt-1} + FE + \varepsilon_{ijkt}$$

where *i*, *j*,*k*, and *t* are indexed as the bond, issuer firm, country, and time (year), respectively. All the variables are defined in Appendix B. FE denotes fixed effects at year, industry, country, currency, and maturity bucket as denoted at the bottom of each model. The standard errors are clustered at firm and year, and *t*-stats are presented in parentheses, and *, **, and *** denote statistical significance at the 10%, 5%, and 1% significance levels, respectively. The sample includes all firm-year observations of the treated and matched control firms from 2013–2022.

	Panel A: Same firm's GB and non-GB		Panel B: Same industry's GB and non-GB	
	(1)	(2)	(1)	(2)
$D(Green_{ijkt})$	0.600***	0.544***	0.524***	0.483***
	(5.82)	(5.32)	(4.20)	(4.64)
PSM covariates	Yes	Yes	Yes	Yes
B_Characteristics	Yes	Yes	Yes	Yes
C_Characteristics	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Country fixed effects		Yes		Yes
B_Currency fixed effects	Yes	Yes	Yes	Yes
B_Maturity fixed effects	Yes	Yes	Yes	Yes
Number of observations	285	278	620	616
Adjusted R^2	0.244	0.265	0.244	0.298

Table 8
Alternate definition of investor demand

We report the robustness test using two alternate definitions of investor demand. In this table, we report the results of the following equation:

$$Alt\ B\_Subs_{ijkt} = \beta.D(Green_{ijkt}) + \boldsymbol{\alpha}.F\_Covariates_{jkt-1} + \boldsymbol{\gamma}.B\_Ch_{ijkt} + \boldsymbol{\delta}.C\_Ch_{kt-1} + FE + \varepsilon_{ijkt}$$

where *i*, *j*,*k*, and *t* are indexed as the bond, issuer firm, country, and time (year), respectively. $Alt\ B\_Subs_{ijkt}$ is $Ln(B\_Orderbook_{ijkt})$ in Models (1) and (2) and $Resid\_B\_Subs_{ijkt}$ in Models (3) and (4). All the variables are defined in Appendix B. FE denotes fixed effects at year, industry, country, *B_Currency*, and *B_Maturity* as denoted at the bottom of each model. The standard errors are clustered at firm and year, and *t*-stats are presented in parentheses, and *, **, and *** denote statistical significance at the 10%, 5%, and 1% significance levels, respectively. The sample includes all firm-year observations of the treated and matched control firms from 2013–2022.

	Panel A: Natural log of orderbook amount		Panel B: Residual subscription	
	(1)	(2)	(3)	(4)
$D(Green_{ijkt})$	0.122***	0.094**	0.436***	0.350***
	(3.82)	(3.07)	(5.97)	(3.68)
F_Covariates	Included	Included	Included	Included
B_Ch	Included	Included	Included	Included
C_Ch	Included	Included	Included	Included
Year fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Country fixed effects		Yes		Yes
B_Currency fixed effects	Yes	Yes	Yes	Yes
B_Maturity fixed effects	Yes	Yes	Yes	Yes
Number of observations	1878	1877	1878	1877
Adjusted R^2	0.533	0.546	0.122	0.14253

Table 9
Carbon emissions, greening strategies, and GB demand

This table reports the firm's carbon emissions heterogeneity and GB demand. In this table, we report the results of various models of the following regression equation:

$$B\_Subs_{ijkt} = \beta.D(Green_{ijkt}) \times (Drivers_{jkt-1}) + \boldsymbol{\alpha}.F\_Covariates_{jkt-1} + \boldsymbol{\gamma}.B\_Ch_{ijkt} + \boldsymbol{\delta}.C\_Ch_{kt-1} + FE + \varepsilon_{ijkt}$$

where, $Drivers_{jkt-1}$ is proxied using F_CO2_{jkt-1} in Models (1) and (2), and F_GRS_{jkt-1}in Models (3) and (4). All the variables are defined in Appendix B. FE denotes fixed effects at year, industry, country, currency, and maturity bucket as denoted at the bottom of each model. The standard errors are clustered at firm and year, and *t*-stats are presented in parentheses, and *, **, and *** denote statistical significance at the 10%, 5%, and 1% significance levels, respectively. The sample includes all firm-year observations of the treated and matched control firms from 2013–2022.

	CO_2		Greening strategies	
	(1)	(2)	(3)	(4)
$D(Green_{ijkt}) \times (F\_CO2_{jkt-1})$	0.074**	0.059*		
	(2.27)	(2.02)		
$D(Green_{ijkt}) \times (F\_GRS_{jkt-1})$			0.186**	0.146**
			(3.24)	(2.81)
F_Size	-0.072	-0.053	-0.001	0.00248
	(-1.25)	(-0.34)	(-0.03)	(0.07)
F_ROA	-0.008	-0.009	0.011	0.0151
	(-0.15)	(-0.18)	(0.47)	(0.79)
F_Lev	0.002	0.008	-0.002	-0.00147
	(0.55)	(0.98)	(-0.71)	(-0.69)
F_Rev_Gr	0.002	0.001	0.000	0.000
	(0.24)	(0.22)	(0.27)	(0.15)
B_Size	-1.025***	-0.870***	-0.864***	-0.789***
	(-6.94)	(-3.58)	(-11.97)	(-9.06)
B_Coupon	0.402***	0.362***	0.321***	0.301***
	(4.30)	(4.08)	(4.30)	(4.47)
B_Rating	0.003	0.001	-0.003	-0.011
	(0.11)	(0.05)	(-0.28)	(-0.96)
B_BR	0.163	-0.027	0.158**	0.115*
	(1.23)	(-0.20)	(2.66)	(2.21)
C_FTS	0.120	0.672***	0.232***	0.418***
	(1.60)	(3.62)	(4.94)	(4.34)
C_FTQ	-0.069	0.147	-0.027	0.175
	(-0.76)	(0.63)	(-0.39)	(0.98)
C_GDPGR	-0.009	0.029	0.039**	0.052**
	(-0.24)	(0.97)	(2.42)	(2.64)
Year fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Country fixed effects		Yes		Yes
B_Currency fixed effects	Yes	Yes	Yes	Yes
B_Maturity fixed effects	Yes	Yes	Yes	Yes
Number of observations	1213	1211	1,878	1,877
Adjusted R^2	0.166	0.193	0.228	0.248

Table 10
ESG risk, greening strategies, and GB demand

This table reports the firm's ESG risks, greening strategies, and GB demand. In this table, we report the results of various models of the following regression equation:

$$B\_Subs_{ijkt} = \beta . D(Green_{ijkt}) \times (Drivers_{jkt-1}) + \boldsymbol{\alpha} . F\_Covariates_{jkt-1} + \boldsymbol{\gamma} . B\_Ch_{ijkt} + \boldsymbol{\delta} . C\_Ch_{kt-1} + FE + \varepsilon_{ijkt}$$

Where, $Drivers_{jkt-1}$ refers to F_RRI_{jkt-1} in Models (1) and (2). All the variables are defined in Appendix B. FE denotes fixed effects at year, industry, country, currency, and maturity bucket as denoted at the bottom of each model. The standard errors are clustered at firm and year, and *t*-stats are presented in parentheses, and *, **, and *** denote statistical significance at the 10%, 5%, and 1% significance levels, respectively. The sample includes all firm-year observations of the treated and matched control firms from 2013–2022.

	(1)	(2)
$D(Green_{ijkt}) \times (F\_RRI_{jkt-1})$	0.011***	0.008*
	(5.58)	(1.99)
F_Size	-0.001	-0.054
	(-0.01)	(-0.80)
F_ROA	-0.065	-0.073
	(-0.75)	(-0.77)
F_Lev	0.006	0.010
	(0.55)	(1.04)
F_Rev_Gr	-0.003	-0.003
	(-0.77)	(-1.65)
B_Size	-1.087***	-1.009***
	(-6.11)	(-5.96)
B_Coupon	0.646***	0.656***
	(9.01)	(6.22)
B_Rating	0.009	0.004
	(0.35)	(0.20)
B_BR	0.188*	-0.081
	(2.08)	(-0.39)
C_FTS	0.158***	0.554***
	(4.44)	(4.50)
C_FTQ	0.019	0.243*
	(0.25)	(1.95)
C_GDPGR	-0.017	0.034
	(-0.44)	(0.96)
Year fixed effects	Yes	Yes
Industry fixed effects	Yes	Yes
Country fixed effects		Yes
B_Currency fixed effects	Yes	Yes
B_Maturity fixed effects	Yes	Yes
Number of observations	1,000	997
Adjusted R^2	0.210	0.236

Appendix-A

Geographical distribution of GB

This table reports the entire GB issued over the globe from their debut in 2007 to 2022 and corporate GB that offer fixed coupons, and they do have investment grades from their debut in 2013 to 2022. In addition, it reports the number of bonds (#) issued by each country, the issue size in a million dollars, and the share of the issue size of each country.

Domicile	Total GB (#)			Investment-grade, fixed-coupon Corporate GB		
	#	Issue Amount (m$)	% Share	#	Issue Amount (m$)	% Share
United States	740	216,400	9.507%	210	123,000	17.674%
Netherlands	212	154,500	6.788%	133	93,800	13.478%
France	465	209,900	9.222%	95	68,900	9.900%
Germany	702	251,000	11.027%	126	62,000	8.909%
Spain	137	65,700	2.886%	43	28,900	4.153%
Japan	438	63,800	2.803%	64	28,300	4.066%
South Korea	317	60,300	2.649%	64	26,400	3.793%
United Kingdom	216	86,300	3.792%	66	24,000	3.449%
Italy	75	59,700	2.623%	39	23,700	3.405%
Canada	119	56,400	2.478%	48	22,900	3.291%
Hong Kong	149	54,700	2.403%	61	21,800	3.132%
Luxembourg	226	97,800	4.297%	38	20,000	2.874%
Norway	237	46,000	2.021%	31	18,000	2.586%
Mexico	36	20,140	0.885%	14	16,600	2.385%
Sweden	753	75,700	3.326%	55	16,100	2.313%
Finland	71	25,700	1.129%	21	11,500	1.652%
China (Mainland)	1,515	343,400	15.087%	29	11,400	1.638%
Austria	60	16,970	0.746%	19	8,330	1.197%
Cayman Islands	22	12,150	0.534%	11	7,830	1.125%
Chile	30	16,850	0.740%	14	7,600	1.092%
Australia	45	20,350	0.894%	22	6,750	0.970%
Denmark	62	38,490	1.691%	11	6,490	0.933%
British Virgin Islands	27	7,790	0.342%	16	5,710	0.820%
Singapore	43	18,240	0.801%	13	4,740	0.681%
United Arab Emirates	21	6,350	0.279%	11	4,580	0.658%
Belgium	31	62,560	2.749%	8	4,360	0.626%
Ireland	32	25,590	1.124%	7	3,490	0.501%
Indonesia	29	16,120	0.708%	5	2,520	0.362%
Peru	10	1,945	0.085%	6	1,840	0.264%
India	69	14,140	0.621%	4	1,540	0.221%
Macau	9	3,390	0.149%	6	1,540	0.221%
Iceland	9	1,923	0.084%	4	1,280	0.184%
Switzerland	70	16,470	0.724%	8	1,270	0.182%
Poland	12	6,020	0.264%	2	1,060	0.152%
Jersey	3	1,548	0.068%	1	1,060	0.152%
New Zealand	36	6,309	0.277%	8	809	0.116%
Portugal	12	6,028	0.265%	1	798	0.115%
Liechtenstein	3	855	0.038%	1	639	0.092%
Lithuania	4	733	0.032%	2	639	0.092%
Slovakia	7	1,337	0.059%	3	619	0.089%
Romania	4	607	0.027%	4	607	0.087%
Czech Republic	3	1,437	0.063%	1	532	0.076%
Guernsey	29	612	0.027%	1	426	0.061%
Hungary	24	6,033	0.265%	5	423	0.061%
Bermuda	7	2,500	0.110%	2	400	0.057%
Philippines	74	11,800	0.518%	1	300	0.043%
South Africa	22	1,269	0.056%	1	300	0.043%
Latvia	6	412	0.018%	2	160	0.023%
Mauritius	30	14,700	0.646%			
Brazil	63	6,430	0.282%			
Taiwan	89	6,360	0.279%			
Russia	8	3,400	0.149%			
Thailand	54	3,110	0.137%			
Ivory Coast	20	2,690	0.118%			
Greece	7	2,450	0.108%			
Argentina	26	2,150	0.094%			
Serbia	2	2,130	0.094%			

Turkey	9	2,090	0.092%			
Malaysia	224	1,740	0.076%			
Venezuela	5	1,660	0.073%			
Ukraine	2	1,650	0.072%			
Egypt	2	1,500	0.066%			
Georgia	4	1,500	0.066%			
Saudi Arabia	2	1,500	0.066%			
Honduras	6	1,020	0.045%			
Costa Rica	2	1,000	0.044%			
Israel	1	1,000	0.044%			
Colombia	10	772	0.034%			
Panama	14	614	0.027%			
Pakistan	1	500	0.022%			
Bangladesh	1	387	0.017%			
Vietnam	3	351	0.015%			
Cyprus	1	319	0.014%			
Nigeria	6	305	0.013%			
Laos	3	242	0.011%			
Belarus	1	81	0.004%			
Slovenia	1	80	0.004%			
Estonia	1	68	0.003%			
Fiji	2	45	0.002%			
Seychelles	1	15	0.001%			
Morocco	1	13	0.001%			
Namibia	1	4	0.000%			
Total	7,826	2,276,144	100%	1,337	695,942	100%

Appendix B

Definition of variables

This table reports all the variables used in the study, along with their definition and data sources. The subscripts *i, j, k,* and *t* denote the '*i*'th bond issued by firm '*j*' in country '*k*' at time '*t*.'

Variable Names	Definition	Data Source
Dependent Variables		
B_Subs_{ijkt}	Orderbook size divided by issue amount of bond.	Informa Global Markets (IGM)
$Ln(B\_Orderbook)_{ijkt}$	Natural logarithm of the size of the orderbook in amount ($).	IGM
$Resid\_B\_Subs_{ijkt}$	A Residuals subscription is obtained by regressing the subscription ratio on the log of the number of bonds issued before the concerned issuance and the industry average orderbook size.	IGM & Refinitiv Author's calculation
Independent Variables		
$D(Green_{ijkt})$	The dummy variable equals one if the bond tranche is Green and zero otherwise (comparable non-GB). GB is any debt instrument whose proceeds are used for environmentally friendly projects, such as water cleaning, waste management, and renewable energy (International Capital Market Association 2021).	IGM & Refinitiv
F_RRI_{jkt-1}	The firm's inverted reputation risk index at time *t-1*. The inverted reputation index ranges between one and 100, where a higher score exhibits a lower reputation risk.	Derived from RepRisk
F_GRS_{jkt-1}	The natural log number of green patent registrations by the GB issuers until time *t-1*. A higher number reflects the firm's higher degree of green innovation initiatives.	Derived from PATSTAT
F_CO2_{jkt-1}	The firm's inverted carbon (CO_2) and carbon equivalent (CO_2e) intensity are captured in tonnes per billion US dollar sales revenue. A higher value shows lower emission intensity.	Derived from Refinitiv
$F\_Covariates_{jkt-1}$	*Firm-level Covariates*	
F_Size	Natural logarithm of the firm's total assets.	Capital IQ & Refinitiv
F_ROA	The operating income before depreciation is divided by the book value of total assets.	Capital IQ & Refinitiv
F_Lev	Total debt is divided by the total assets.	Capital IQ & Refinitiv
F_Rev_Gr	This is the annual revenue growth rate.	Capital IQ & Refinitiv
B_Ch_{ijkt}	*Bond Characteristics*	
B_Size	Natural logarithm of the size of the bond issued.	Derived from IGM & Refinitiv
B_Coupon	Plain vanilla fixed coupon rates are offered for each bond.	IGM & Refinitiv
B_Rating	The S&P Credit Rating for each tranche is assigned a numerical value. The highest is 17 for AAA, 16 for AA+, and so on.	IGM & Refinitiv
B_BR	Natural log number of bookrunners for each lot of bond issuance.	IGM
B_Maturity	A numerical value is assigned based on the maturity bucket. It takes value of 'one' if a bond's maturity is less than or equal to five years; 'two' for maturity between five to ten years; 'three' for ten to thirty years bonds; and 'four' for all bonds maturing above thirty years.	Derived from Refinitiv
B_Currency	Currency in which the bonds are issued.	Refinitiv

C_Ch_{kt-1}	*Country Characteristics*	
C_FTS	The flight to safety (FTS) is the difference between the long-term government bond rate and the short-term rate of the bond issuer's country (Costantini & Sousa 2022).	OECD/World Bank/IMF
C_FTQ	The flight to quality (FTQ) is the difference between long-term (i.e., ten-year) government bond rates of bond-issued countries and the benchmark long-term government bond rates. We use the USA's long-term government bond rate as a benchmark for non-USA firms and Germany's long-term government bond rate as a benchmark for USA firms. The proxies for "safe-haven" (benchmark) can be the long-term interest rate of the USA, Japan, or Germany, depending upon the relevance of the studies (Costantini & Sousa 2022).	OECD/World Bank/IMF
C_GDPGR	The annual growth rate of each country's real gross domestic product (GDP).	IMF