Green Bonds: Demand, Drivers of Demand, and Impact Reporting

By

Hari Gopal Risal

Department of Accounting and Finance

University of Strathclyde,

199 Cathedral Street, Glasgow, Scotland G4 0QU, United Kingdom

2025

A thesis submitted for the award of Doctor of Philosophy

Under the supervision of

Professor Chandra Thapa

chandra.thapa@strath.ac.uk

Professor Andrew Marshall

a.marshall@strath.ac.uk

Department of Accounting and Finance,

University of Strathclyde

199 Cathedral Street, Glasgow, Scotland G4 0QU, United Kingdom

Declaration of authenticity and author's rights

This thesis is the result of the author's original research. It has been composed by the author and has not been previously submitted for an examination, which has led to the award of a degree.

Signed: Hari Gopal Risal

Date: 25 June 2025

Abstract

This thesis uniquely contributes to understanding greenness demand, the driving forces behind higher demand, and green bond (GB) issuers' motivations for voluntary impact reporting. The novelty of this research lies in its potential to provide valuable insights for green bond issuers, helping them make informed decisions and improve their practices.

In our first empirical investigation, I present novel findings on the unique greenness characteristics of GB issuance and their role in explaining the cross-sectional variations of corporate bond demand. Leveraging unique information on the orderbook size of green and non-green bonds issued globally from 2013 to 2022, I find that, on average, the demand for corporate GB is about 35 to 44% higher than comparable non-GB.

In the second empirical investigation, I show that ex-ante better environmental performance (lower CO_2 and higher investments in green innovations) and lower environmental, social and governance (ESG) risk incidents explain the variations in the demand for GB at the firm level. These findings provide valuable insights and also serve as a practical guide for existing and future GB issuers, helping them make informed decisions and improve their practices as required. By understanding the factors that drive demand for GB, issuers can better tailor their offerings to meet market needs and contribute to environmental sustainability.

In the third empirical investigation, I use hand-collected worldwide data to assess GB's impact reporting practices and issuers' motivation to publicly release impact reports (IR). GB's impact reporting is a voluntary decision, and it is a costly signal that firms with better environmental performance and higher ecological risk have a higher propensity to publish to showcase their environmental credibility.

This study aims to significantly enrich the existing literature by providing a comprehensive understanding of the multifaceted role of GBs IR in signalling environmental commitment and legitimacy gain. It explains the rationale of voluntary disclosure, signalling,

and legitimacy as the firms' primary motivation for impact reporting and external validation, ensuring concerned stakeholders are well-informed.

JEL classifications: D82, G14, G18, G32, M14, Q56

Keywords: *Green Bonds, Green Characteristics of Green Bonds, Signaling Theory, Green Innovations, ESG Risk Incidents, Impact Reporting, Voluntary Disclosure, Legitimacy, External Validation.*

Dedicated to my late parents, Mr. Ram Prasad Risal and Mrs. Laxmi Risal.

Acknowledgement

Pursuing a Ph.D. has been a long journey filled with learning, inspiration, challenges, and perseverance. I am genuinely grateful to my supervisors, Professor Chandra Thapa and Professor Andrew Marshall, for motivating, guiding, and supporting me on this journey. They ensured I had the required skills, knowledge, and resources to complete this study. They exceeded my expectations to ensure I became an independent researcher, leaving no stone unturned to sharpen my skills.

My late parents, Mr Ram Prasad Risal and Mrs Laxmi Risal, deserve all the credit for their unconditional love and support. My father was in his eighties, but he encouraged and motivated me to travel from Nepal to the United Kingdom while applying for my Doctor of Philosophy (Ph.D.). Unfortunately, I missed the opportunity to share my happiness about my selection to the Ph.D. program with a scholarship as he had already left us. My mother was in her seventies, and my dad had already left us, but she advised me to go onwards and grasp this opportunity and make an enormous impact through my research and wisdom post-Ph.D.. They supported my dream of pursuing higher studies, even though I had decided to venture into a new country. My lovely wife, Ms. Subhechha Panta, who also left behind her lucrative academic career, and our daughter, Aadrika, who accepted a challenge to make new friends in a new environment and missed her school friends, deserve all the praise for cheering, motivating, and making this journey enjoyable. I dedicate this thesis to you all.

I also appreciate all the support and advice the Accounting and Finance department members provided. Dr. Biwesh Neupane has been an enormous source of encouragement as he ensured all the available resources and support to make this study possible. Thanks to my fellow Ph.D. colleagues, Pratik Gupta and Olakunle Olaboopo, for all the discussions and long-lasting friendship.

I also extend my heartfelt thanks to the discussants and participants at the various conferences. Your valuable comments, especially those from prominent scholars such as Darrel Duffie, Arthur Krebbers, and Sean Kidney, have significantly enriched this study. I am deeply respectful and grateful to Kathmandu University for their generous support in providing me with a study leave for about three years. Lastly, I thank the University of Strathclyde for funding my Ph.D. studies. Your support and encouragement have been invaluable.

Signed: Hari Gopal Risal

Date: 25 June 2025

Table of Contents

List of Tables

List of Figures

List of Appendices

1. Introduction

Green and sustainable financing is at the forefront of addressing environmental concerns (Pástor *et al.* 2022). One such initiative is issuing 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.

GB issuance requires a green financing framework and prospectus with full details on ecological project identification and expected impacts. The GB issuers also collect the second party's opinion on their framework and prospectus. Some of the GB issuers acquire the certification from the climate bonds initiative to signal the investor that the proceeds will be invested in identified green and sustainable projects. International Capital Market Association (2022) prescribes impact reporting to all GB issuers following the 'Harmonized Framework on Impact Reporting,' with precise details on the proceeds used and the expected and actual outcome in metrics such as capacity installed, greenhouse gas (GHG) reduction, and annual

[1] See this link.
[2] see this link.
[3] see this link.

energy savings.[4] Despite the International Capital Market Association (ICMA) recommendation, impact reporting remains voluntary, and not all firms choose to publish their Impact Reports (IR).

Given the importance of GB, I answer the following three questions in our empirical chapters. First, do the GB's unique greenness characteristics explain the variations in the demand for bond issuance? Second, what are the potential drivers of the variations in the demand for GB? Third, what drives the GB issuers firm to publish their IR post-GB issuance?

1.1 Demand for Greenness

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

[4] See the harmonised framework on impact reporting of green bonds: link.

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 signalling 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 are informed of the proceeds' specific use in climate and environment-friendly green projects.

Further, the ICMA's (2018) GB principles also state that the post-issuance should follow with regular reporting on the use of the GB proceeds and include a credible third-party verification of the project's greenness. 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 summarise, 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. I 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, I 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, I 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.

Given the aforementioned discussion of the signalling framework of IA, the unique greenness of GB should be positively associated with explaining the demand for bonds issued by corporations. Accordingly, I test the hypothesis that the greenness of GB should lead to higher demand for GB relative to non-GB when issued by matched firms.

I test the hypotheses using a new comprehensive investment grade corporate GB 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. I 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. In addition, for a firm that issues GB in a particular year, I identify a matched firm in the same country, industry, and year that has yet to issue GB. Our final sample comprises 451 GB and 1,641 non-GB from 2013 to 2022, issued by 419 firms, which, to the best of my knowledge, is the largest sample size in the literature on GB.[5]

My 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. My 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 labelled green and zero otherwise.

[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.

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

A battery of following robustness checks supports this finding. First, as an alternative matching strategy, I perform a bond-level matching whereby I 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, I use the natural logarithm of the orderbook amount and the residual subscription as an alternative measure of investor demand. My main results remain robust. Finally, I conducted a non-parametric test whereby I randomly selected 902 placebo non-GB (twice the number of GB in our sample) from the non-GB universe and ran our baseline regressions 10,000 times. I find that demand for GB is significantly higher than for placebo non-GB 99.9% of the time, supporting our baseline results.

This study adds to scant but nascent research investigating the primary market offering of GB (Bessembinder *et al.* 2022). I 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

[6] Furthermore, I 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.

dissecting its pricing and returns to examine its "greenium- a green premium,"[7] considered a reputation effect of GB (Flammer 2020; Climate Bonds Initiative 2021a; Flammer 2021; Pástor *et al.* 2022). However, to my knowledge, no study has examined GB's subscription levels in the primary market.

1.2 *Drivers of Demand*

My findings on GB's higher demand further develop intuition on what drives the higher demand and how corporations can attract much higher demand in the primary market. Regarding the drivers, I argue that any 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, I identify two key drivers of GBs' demand.

First, firms' ex-ante environmental 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.* (2023) 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 carbondioxide (CO_2) emission should drive higher demand for GB.[8] 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-

[7] Greenium is the yield difference between GB and non-GB, reflecting a premium for green assets. See Tang & Zhang (2020) and Pastor et al. (2022) for more details.
[8] CO_2 captures both the scopes one and two of carbon emissions.

imitate signal should attract *value-based* 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, GB issued by firms with lower CO_2 emissions and strategies of higher greening investments should attract higher demand from investors.

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.[9] 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 issuance. As a result, issuers with a history of lower ESG risk likely experience greater demand for GB issuance.

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, 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 my expectation, I find that GB issued by firms with lower CO_2 emissions (measured using CO_2 intensity), better greening strategies (measured using number of green patents), and lower ESG risks (measured using Reputation Risk Index (RRI)) is significantly higher compared to GB and non-GB issued by other firms. Economically, I 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

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

around 1.31 to 1.81 times, and a 10% increase in the number of green patents increases GB demand by 15% to 19%.

I 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. I document that the bond issuer's past environment performance, strategies to invest in green innovations, and reputation-based ESG risk drive the demand for GB in the primary debt market. I explain how the signalling theory helps lower information asymmetry on GB issuance and factors that explain the heterogeneous demand within GB issuers.

My 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 (i.e., reduce CO_2 emissions and initiate greening strategies) and reduce the ESG risk to attract higher demand for issuing their GBs.

1.3 Motivation for Impact Reporting

The Climate Bonds Initiative (2021b) underscores a unique aspect of this study: approximately 59% of GB issuers, particularly larger ones, publish their impact report (IR) after issuing GB. This unique financial instrument, GB, is issued to finance climate-friendly projects adhering to GB principles, making it a fascinating study area (Flammer 2021).[10] International Capital Market Association (2022) prescribes impact reporting to all GB issuers following the 'Harmonized Framework on Impact Reporting,' with precise details on the use of GB proceeds, the expected and actual outcome related to environmental metrics such as the capacity of

[10] GB principles are voluntary process guidelines for GB issuance. They comprise four core components: use of proceeds, process for project evaluation and selection, management of proceeds, and reporting.

renewable energy installed, greenhouse gas (GHG) reduced or avoided, water use, water loss, and water waste reduced or avoided.[11]

For instance, Apple Inc. produced an "Annual Green Bond Impact Report" in 2022, reporting that it allocated $3.2 billion out of $4.7 billion issued in GB into environmental activities. 32% of the allocated GB proceeds were used to finance 59 environmental projects (related to low-carbon product designs, energy efficiency, renewable energy, carbon mitigation, and carbon sequestration) that help mitigate around 13.5 million metric tons of carbon emissions and install 707 Megawatt of renewable energy.[12] Despite the ICMA recommendation, it is important to note that impact reporting remains voluntary, and not all firms choose to publish it. This voluntary nature of reporting is a key motivator for the study, as I seek to understand the characteristics of these impact reporting firms and what drives them to publish IR.

I apply two theoretical lenses: the signalling theory and the legitimacy theory. The signalling theory emphasises reducing information asymmetry (IA) between two parties (Grossman 1981; Spence 2002; Connelly *et al.* 2011). Applying the signalling theory, I argue that the vocal green firms that have lower CO_2 emissions and belong to less polluting industries publish their IR or GB's proceeds use reports as a costly signal that competitors cannot mimic due to their poor environmental performance (i.e., higher CO_2).[13] The classical signalling theory developed by Spence (1973, 1974) notes that when one party possesses a relatively superior level of information relative to the receiving party, conveys a signal to the other party, for whom the relevant information is unobservable but valuable, it reduces the perceived level of IA.

[11] See the harmonised framework on impact reporting of green bonds: link
[12] See Apple's update on impact reports of 2022: link
[13] Signaling theory is about information asymmetry between two transacting parties (See Arrow 1963; Akerlof 1970; Ross 1973; Spence 1973; Rothschild & Stiglitz 1976; Holmström 1979; Stiglitz & Weiss 1981; Stiglitz 2002).

Drawing on these arguments from signalling theory, Flammer (2021) and Tang and Zhang (2020) argue that the GB offers a credible signal to potential investors about a firm's environmental commitments. This study says the GB's IR provides much more granular and accurate signals.

Second, I apply the legitimacy theory, which is heavily used in social and environmental reporting literature, to explain corporate social and environmental disclosure (Deegan 2002; Deegan *et al.* 2002). Legitimacy theory assumes managers adopt disclosure strategies about their environmental actions (Deegan 2002). Such disclosure and IR enhance the transparency and reliability of GB's proceed-to-use and impact, strengthening the firm's ESG reputation.

Although IR publication is a crucial post-GB issuance, studies have yet to explore this area (Bhutta *et al.* 2022). Any available literature focuses only on the GB's impact on a firm's stock market liquidity and investors' attention to the GB issuance (Dinh *et al.* 2023). I am motivated to fill the gap in the literature by offering GB issuers' motivation to impact reporting. Bansal and Clelland (2004) suggest that firms can conquer adverse environmental market risks by communicating their commitment to the natural environment. This novel argument aligns with the legitimacy theory that environmental reporting enhances firms' credibility (Deegan 2002; Milne & Patten 2002; Cho & Patten 2007). Based on this theory, I am motivated to assess the environmental risk facing firms' propensity to GB impact reporting.[14]

My key outcome is the motivating factors behind the GB issuer firms' IR publication post-GB issuance. First, I find that the low CO_2 emitters are motivated to publish their IR as a credible signal that other high emitters cannot mimic. The coefficient for the firm's CO_2

[14] I define the environmental risk facing firms as the firms that have higher number of negative risk incidents captured by media and counted by the RepRisk database.

intensity (*F_CO2Int)* is positive and statistically significant at a 1% significance level in all three models, which implies that a decrease in CO_2 intensity increases the probability of publishing IR. This finding has significant implications for understanding the motivations behind GB impact reporting, keeping the reader engaged and interested in the study's findings.

Second, firms that face environmental risk *(Env_Risk)* incidents, including potential greenwashing-related incidents, are inclined to publish their IR as a legitimacy-gaining strategy. The coefficient for Env_Risk is negative and statistically significant at a 1% significance level in all three models, implying that an increase in Env_Risk increases the probability of publishing GB IR (please refer to the third empirical chapter in section four for details). Third, I also report that the firms from polluting industries such as mining and manufacturing are publishing their IR as they face more scrutiny from the stakeholders (Becker & Henderson 2000). I further confirm the primary findings using alternative measures of IR, such as IR with an independent external review (ER) attached and IR_Regular (i.e., GB issuers publish more than one IR post GB issuance) and find consistent evidence. Additionally, I perform the battery of robustness tests by replacing the environmental risk (*Env_Risk)* with environmental incidents (*Env_Inc*) and potential greenwashing risk (*Env_Grw1*), consistently reporting similar results.

This study contributes to two strands of literature: First, it contributes to the literature related to non-financial voluntary disclosure as a ‘signalling’ through GB’s impact reporting. Existing studies that examine the GB primarily focus on pricing, valuation, cost of capital, and "greenium," a reputation effect of GB over a non-GB (Climate Bonds Initiative 2021a; Flammer 2021; Pástor *et al.* 2022). I explain the firm’s motivation for voluntarily reporting GB’s impact as a costly signal that competitors cannot easily imitate.

Second, it contributes to legitimacy theory while understanding the GB’s impact reporting practices. While there is sparse evidence on the examination of GB’s impact, to the

best of my knowledge, there is no literature discussing the GB issuer firms' motivation for impact reporting. For instance, Wang and Taghizadeh-Hesary (2023) note that the GB issuance increases wind and hydro-power consumption in the OECD countries. Similarly, Xu and Li (2023) note the CO_2 reduction in China but do not discuss the impact reporting post-GB issuance and issuers' motivation. Going further and deeper, I use the global sample to investigate the GB's impact reporting as a firm's legitimacy gain motive.

This study relies on signalling, voluntary disclosure, and legitimacy theories and explains the GB issuer firms' motivation for IR publication. Therefore, my study has practical implications for the issuer and investors and offers hands-on guidance to policymakers in strengthening the GB's impact reporting practices.

The remaining part of this thesis is organised as follows: Chapter Two offers empirical evidence on greenness demand. Chapter Three explains the drivers of greenness demand. Chapter Four provides empirical evidence on GB issuers' motivation for impact reporting. Finally, chapter five offers the summaries and conclusions from all empirical evidence, the implications, limitations, and future scopes.

2. First Empirical Chapter

I draw on information economics' signalling equilibrium framework to argue that GB's unique greenness characteristics should attract a much broader category of investors relative to non-GB issuance. These investors include *value-based* investors, *values-based* investors and those who fall in between. Starks (2023) classifies ESG investors into a wide 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 labour and poverty, etc. Pecuniary preference implies incorporating ESG factors solely to manage the risk-return profile of the investments. I use the signalling 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 Theoretical Framework on Hypothesis Development

2.1.1 Signalling Theory and Green Bonds

Signalling 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.[15]

Viewing through the lens of signalling theory, I 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. This assists in addressing the concerns of adverse selection and moral hazard. 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, reduced waste, etc. 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

[15] Literature notes various signalling 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 2017).

'*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 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.

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

Within the framework of the signalling theory discussed above, I 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 non-GB investors. I first demonstrate the attractiveness of *values-based* investors, followed by the attractiveness of *value-based* investors to GB.

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).[16] 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).[17]

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 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 criticised 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

[16] The PRI is working for a sustainable financial system through responsible investment. For details
[17] 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).

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, Chang *et al.* (2022) find 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, I 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.

At the other end of the spectrum, *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 favourable 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.

Specific to the literature on GB, and as noted earlier, ample evidence corroborates the relatively lower risks of adverse selection and the moral hazard of GB relative to non-GB. Empirical evidence suggests that GB issuance offers a new market and financially attractive signals. For example, current evidence documents that equity investors exhibit a positive market reaction to the announcement of GB issuance (Tang & Zhang 2020; Daubanes *et al.*

2021; Flammer 2021). For example, an 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). 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 bond investors with a more incredible safety net, lowering the default potential.

Further evidence suggests that GB's yield spread over non-GB is materially lower (Zerbib 2019). Thus, the lack of 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, I propose to test the following hypothesis.

$H_{2.1}$: The unique greenness characteristics of GB should lead to higher issuance demand than similar non-GB issues.

2.2 Sample, Variables, and Identification Strategy

2.2.1 Sample and Data Sources

I compile data from several sources. I 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 labelled as GB, which I denote as the universe of GB. Columns (1) and (2) of Table 2.1 show the year-wise distribution of the universe of GB, where I observe a sharp increase in the number of GB and issuance size over the years. In Appendix A, I report the distribution of the universe of GB issued worldwide, where I 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 United States.

Following the existing literature on GB, for instance Larcker and Watts (2020), I investigate investment-grade corporate GB with a fixed coupon. After removing non-fixed coupon bonds, I arrive at 1,337 investment-grade fixed coupon corporate GBs, representing 17.08% (1,337/7,826) of all the GBs issued from 2013 to 2022.[18] Columns (3) and (4) of Table 2.1 show the year-wise distribution of this sample GB, which again shows a sharp increase in the GB's number and the issuance size.

[Insert Table 2.1 about here]

[18] 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.

Appendix 2-A and Figure 2.1 further report the geographical distribution of this sample GB, highlighting variations in the number and size of issuances across 48 countries. The highest number was in the United States of America, followed by the Netherlands, France, and Germany.

[Insert Figure 2.1 about here]

Next, I 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 details on orderbook size that they collect based on daily surveys of bank underwriters. I extract all the bonds' characteristics and related information from IGM. Out of the 1,337 investment-grade fixed coupon GB from LSEG (formerly Refinitiv), I 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 literature.[19] Hereafter, I denote the sample of investment-grade fixed coupon corporate GB with complete information as a GB sample.

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

[19] 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.

Economic Cooperation and Development (OECD), the World Bank, and the International Monetary Fund (IMF).

2.2.2 Variables

2.2.2.1 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.

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 labelled green and zero otherwise. Thus, $D(Green)$ is the dummy variable reflecting the unique greenness features of the GB relative to non-GB.

2.2.2.2 Firm-level Covariates for PSM

Following the existing literature, I 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 2.4) (See Flammer 2021; Dutordoir *et al.* 2023). First, I use the natural logarithm of total assets (*F_Size*) as a proxy of firm size. Next, I use firms' operating performance, proxied by return on assets (*F_ROA*). Third, I use firm leverage, captured by the ratio of total debt to total assets (*F_Lev*). Fourth, I use the firm's sales

growth *(F_Rev_Gr)*. These variables are included to ensure that differences in firm characteristics do not drive GB issuance.

2.2.2.3 Bond Characteristics

Although PSM may control firm-level characteristics, I also need to control for bond features in our empirical set-up. I 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, I control for the bond issue size (*B_Size*) calculated as the natural log of the 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, I control for the bond's coupon rate (*B_Coupon*) and the bond rating (*B_Rating*), a numerical value assigned to the S&P credit rating with the highest value, 17, rated for AAA, and so on. Furthermore, I 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). I also posit that the complex nature of GB issuance may require more bookrunners; thus, I control for their number using the natural log of the number of bookrunners (*B_BR*).

In addition to using the above-mentioned B_Ch as control variables, I also incorporate the bond's issue currency (*B_Currency*) and the bond's maturity as fixed effects. I 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 and 10 years; three if it is between 10 and 30 years bonds; and four if maturity is above 30 years (Barbiero *et al.* 2024; Couaillier *et al.* 2024).

2.2.2.4 Country Characteristics

I 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 (All the variables are defined in Appendix 2-B). 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, I capture these country-level differences in GB issuance and demand by controlling the GDP growth rates *(C_GDPGR).*

2.3 Summary Statistics

Table 2.2 presents comprehensive details of all the variables, their summary statistics, and the number of observations. Panel A summarises all the investment grade fixed coupon corporate bonds for which I have complete information. They are winsorized at a 1% level to eliminate the impact of outliers. On average, a bond is subscribed to 3.33 times its issue size, whereas the median subscription is 2.67 times.[20] 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 (median) *F_ROA* is 4.17% (2.92%), and *F_Rev_Gr* is 5.15% (2.40%). These values resemble 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%).

Panel B of Table 2.2 presents 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% significance level.

[Insert Table 2.2 about here]

[20] The new bonds are often oversubscribed, which is consistent with the existing literature (Nikolova *et al.* 2020).

Using the Kernel density plot, I further visualise the GB and non-GB B_Subs. Figure 2.2 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, I find a significant demand for the greenness of a bond.

[Insert Figure 2.2 about here]

2.4 Identification Strategy

Panel C of Table 2.2 comprehensively summarises the firm and bond characteristics. I observe significant differences in GB and non-GB issuers' firm characteristics and bond features. The GB issuers, for instance, are significantly larger (based on *F_Size*) but poorer in operating performance (captured by *F_ROA*) than non-GB issuers. Similarly, 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). It also has a lower bond rating (*B_Rating*) but more bookrunners (*B_BR*). These findings provide a deeper understanding of the market dynamics and can guide future investment decisions.

As noted above, the GB issuers differ significantly from the non-GB issuers. To address this, I apply the PSM, a robust method that balances covariates to generate near-random and statistically similar treated and control groups. This approach is identical to the one used by Flammer (2020, 2021), which instils confidence in the comparability of our results. Our treated group comprises firms that issued GB, while the control group comprises firms that issued non-GB during the sample period. I match firms from the control group operating in the

same industry and country and issued in the same year. This matching process uses the covariates *F_Size*, *F_ROA*, *F_Lev*, and *F_Rev_Gr* measured a year before GB issuance. I first estimate probit regression before and after matching using Equation (2.1) below.

$$Treat_{jt} = \alpha + \boldsymbol{\beta_1}.\left(F\_Covariates_{jt-1}\right) + Year\ FE + Industry\ FE + Country\ FE + \varepsilon_{jt} \quad (2.1)$$

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.[21] $F\_Covariates_{jt-1}$ refer to the covariates *F_Size*, *F_ROA*, *F_Lev*, and *F_Rev_Gr*. I 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 2-B.

Model (1) of Table 2.3 presents the probit model results of Equation (2.1) based on 4,473 firm-year observations before matching. The results show that the specification captures significant variation in the dependent variable, as indicated by a *pseudo-*R^2 of 22.7%. I use the propensity scores from Model (1) to perform one-to-one nearest-neighbour matching from the same country, industry, and year with a calliper 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' 451 GB and 1,641 non-GB, respectively. These results demonstrate the effectiveness of the matching process in creating comparable groups.

I perform two diagnostics tests to ensure no observable statistical average differences between the matched treated and control firms. First, I re-run probit regression using Equation (2.1) 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

[21] Our dataset, with its unique pooled-cross-sectional nature, provides a comprehensive view as the same firm may issue GB/non-GB over two or more periods, even within the same year. This characteristic of our dataset is crucial for understanding the dynamics of environmental factors in investment decisions.

statistical differences in the firm characteristics between GB issuing firms and non-GB issuing firms. Likewise, I also observe a considerable drop in the pseudo-R^2 from 22.7% before the matching to 0.4% after the matching.

[Insert Table 2.3 about here]

Second, I conduct a univariate analysis of matching covariates between the treated and control groups and report their corresponding *t*-statistics in Table 2.4, 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 2.4 about here]

In Panel B of Table 2.4, I also report the mean *B_Ch* of the matched treated and control firms. I find that non-GB issues are significantly larger than GB and are managed by fewer bookrunners in the matched sample (similar to Panel C of Table 2.2). While comparing *B_Coupon*, consistent with existing literature that shows GB trade at greenium, I 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), I 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.

2.5 Empirical Analysis

2.5.1 Demand for Greenness ($H_{2.1}$)

I begin our analyses by investigating the distribution of the *B_Subs* of GB and non-GB, followed by univariate and multivariate analyses. I present the kernel density of *B_Subs* in Fig. 2.3, which provides insights into the frequency distribution of investor demand. Fig. 2.3 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 Figure 2.3 about here]

In Fig. 2.4, I 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, I 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 significant events of the Paris Agreement in 2015 and 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), I observe statistically higher *B_Subs* after 2015, indicating a gradual increase in demand for GB's greenness. This trend suggests that investors increasingly prefer green financing tools (such as GB), which could have significant implications for the future of bond markets and environmental finance.

[Insert Figure 2.4 about here]

Next, I conduct a univariate analysis of the demand for greenness. In Panel A of Table 2.5, the mean (median) difference in the *B_Subs* for GB, relative to non-GB, is 0.69 (0.60), 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 strong support to our *H2.1*. Since these differences are observed without controlling the relevant firm and bond characteristics, I proceed with multivariate analysis to confirm our hypothesis using the following regression model:

$$B\_Subs_{ijkt} = \beta . D\left(Green_{ijkt}\right) + \boldsymbol{\alpha} . F\_Covariates_{jkt-1} + \boldsymbol{\gamma} . B\_Ch_{ijkt} + \boldsymbol{\delta} . C\_Ch_{kt-1} + FE + \varepsilon_{ijkt} \quad (2.2)$$

where *i, j,k,* and *t* are indexed as bond, issuer firm, country, and time (year), respectively. *B_Ch* is a bond characteristic, and *C_Ch* is a country characteristic. All other variables are discussed in section 2.2 and defined in Appendix 2-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 2.5 presents the results of Equation (2.2). I compare 451 GB and 1,641 matched non-GB identified using firm-level PSM. Models (1) and (2) use several 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 a 1% significance level in Model (1) and at a 5% significance level in Model (2), which shows 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 *H2.1*. This is consistent with the signalling

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, I 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. I 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%. Considering investment-grade corporate bonds, the positive coefficient of *C_FTS* suggests that investors demonstrate yield-seeking behaviour due to historically lower government yield during our sample period and perceive the sample bonds as relatively safe alternatives to government debt.

[Insert Table 2.5 about here]

Interestingly, 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: I 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, and I find higher demand 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 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 investors' reaction to GB issuance by firms in financial sectors is insignificant. In contrast, GB issuance by firms in corporate sectors is positive and statistically significant.

However, Fatica *et al.* (2021) conclude that the financial sector shifts its lending away from polluting activities after the GB issuance, suggesting that banks provide a credible signal to the market that they are becoming greener after GB issuance. Hence, I 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 2.6.

[Insert Table 2.6 about here]

Panel A of Table 2.6 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 analysing investor demand in different sectors. I re-run Equation (2.2) for the financial and non-financial firms separately. I report the results in Panel B of Table 2.6. I find that the demand for GB issued by financial and non-financial firms is consistently higher than for non-GB. Panel C of Table 2.6 shows that the demand for GB issued by financial firms (non-financial firms) is about 45% to 52% (32% to 43%) higher than comparable non-GB. The results suggest that *values-based* and *value-based* investors consider the GB issued by financial and non-financial firms to be a credible signal of their environmental commitment.

2.6 Robustness Tests

2.6.1 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, I 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 issuer with the same maturity, currency, rating, bond structure, seniority, collateral, and coupon type. Similarly, for each GB, I 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. I further match conventional non-GB, 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. I get a match of 237 GB with 295 non-GB. These bonds are similar except for using proceeds in green or other projects, i.e., their greenness.

I re-run Equation (2.2) using this matched GB and non-GB sample and present the results in Panel A of Table 2.7. The coefficient of the primary variable $D(Green)$ is consistent with our main results in both models, which 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.

Matching within the same firm significantly reduces the sample size (Helwege *et al.* 2014), I 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. I identified 524 GB that matches 706 non-GB. I re-run Equation (2.2) using alternate matched GB and non-GB samples and present results in Panel B of Table 2.7. The coefficient of the primary variable of concern, $D(Green)$, again is consistent with our main results in all models that use different combinations of fixed

effects. It also 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 2.7 about 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, I perform another robustness test using a non-parametric approach and confirm that our result is not dependent on the matching strategy. First, I identify 451 GB issued from 2013 to 2022, for which I have complete information. Then, I identify 7,026 non-GB issued after 2010, for which I have complete information.

Next, I 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. I re-run Equation (2.2) in Model 1 of Table 2.5 for 10,000 times. Figure 2.5 plots 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 2.5. I 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. I also confirm that 90% of the estimated coefficients lie within the 95% confidence interval of the leading coefficient estimated in Model (1) of Table 2.5. Our baseline results are consistent in alternative bond-level and non-parametric matching approaches.

[Insert Figure 2.5 about here]

2.6.2 Alternative Proxies of Demand

Additionally, I 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, I 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 2.8.

In Panel A, the primary dependent variable is the natural log of the orderbook amount. The results are consistent with our main results and *H2.1*. The GB orderbook amount is about 9 to 12% higher than the orderbook demand of a comparable non-GB. Similarly, in Panel B, I report the results using residual subscription as the proxy for demand. The GB residual demand is 35% to 44% higher than for a comparable non-GB. Overall, all our robustness test results are comparable to our main result.

[Insert Table 2.8 about here]

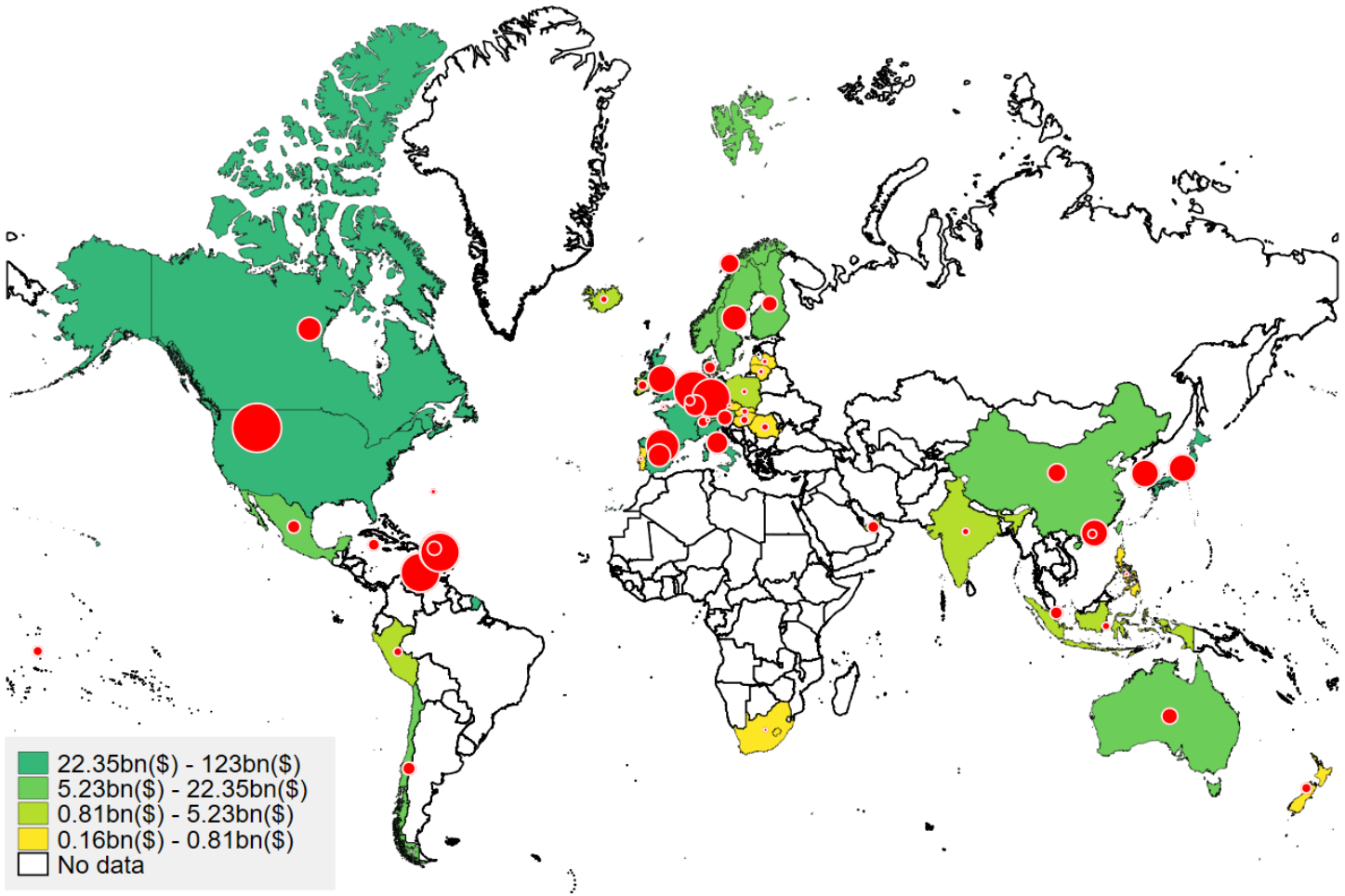


Figure 2. 1: Geographical Representation of GB Across the Globe

This figure portrays the size of investment-grade, fixed coupon GB representation globally. Dark green indicates the larger size of the GB issued ($bn), and the index explains the colour and the size of GB in each country. The red-circled bullet denotes the country of GB issues, and their size is proportionate to the number of GB issued in the country.

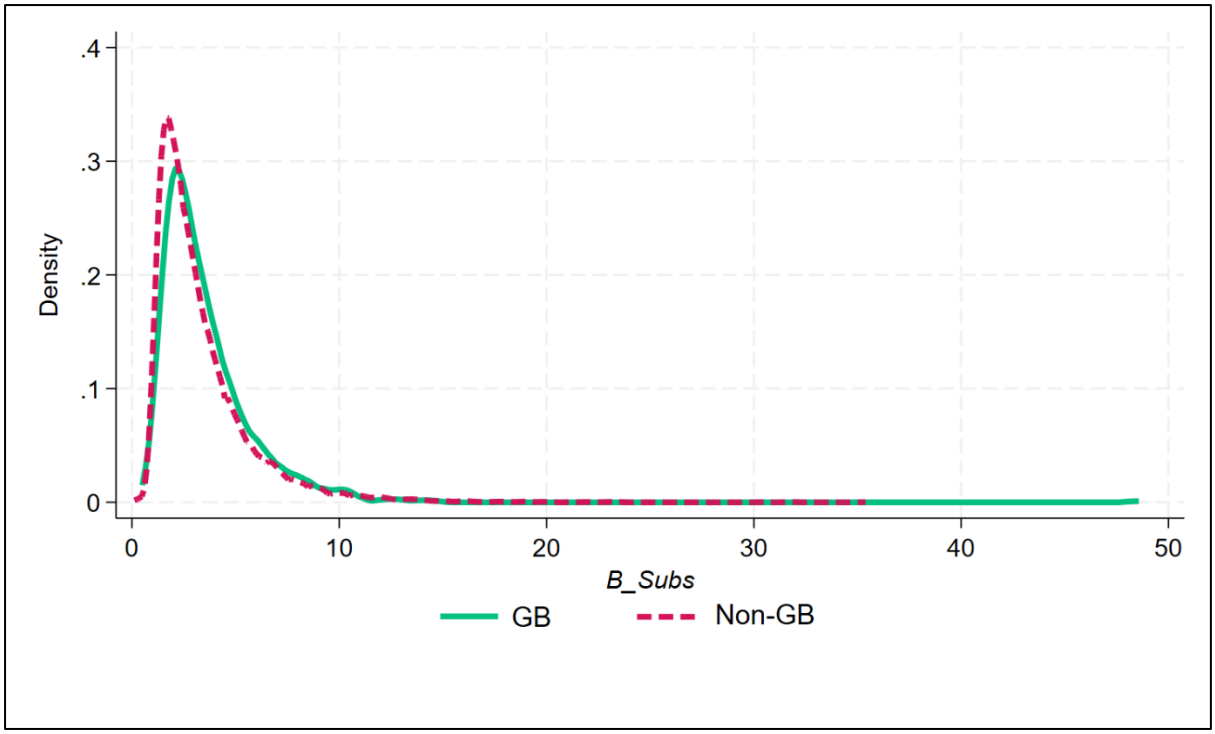


Figure 2. 2: Kernel Density Estimates of Bond Demand (Full Sample)

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

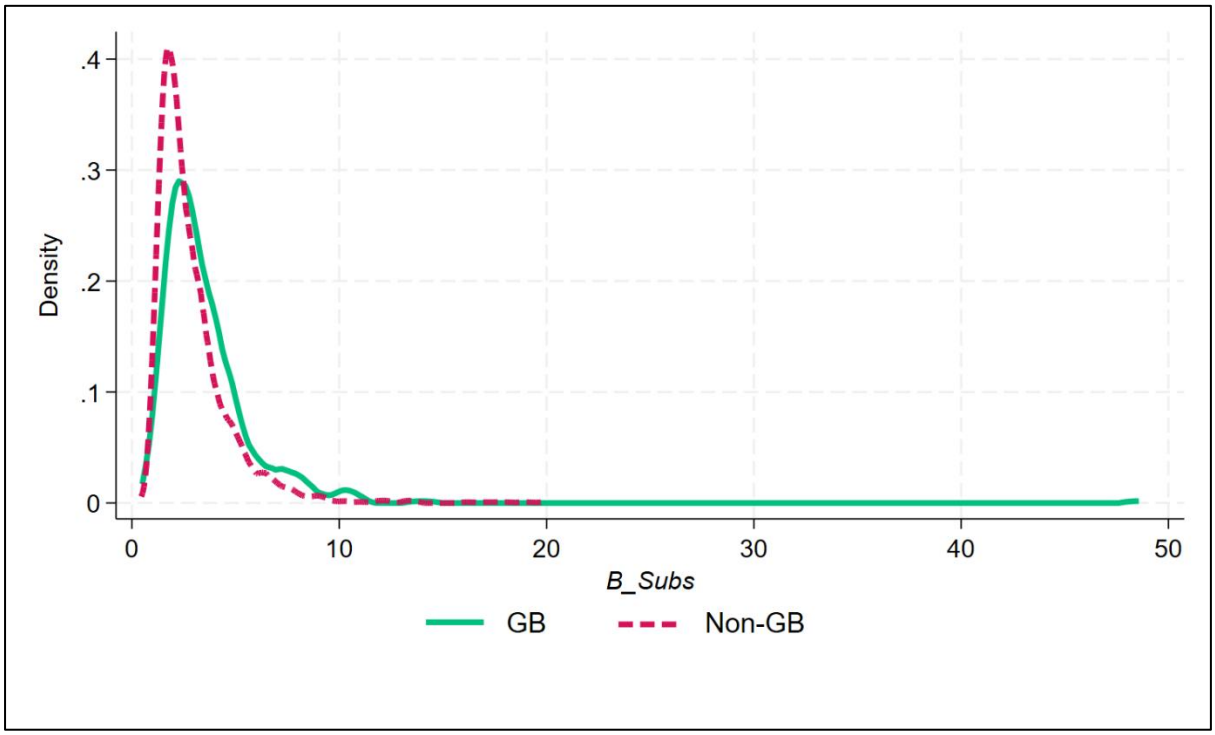
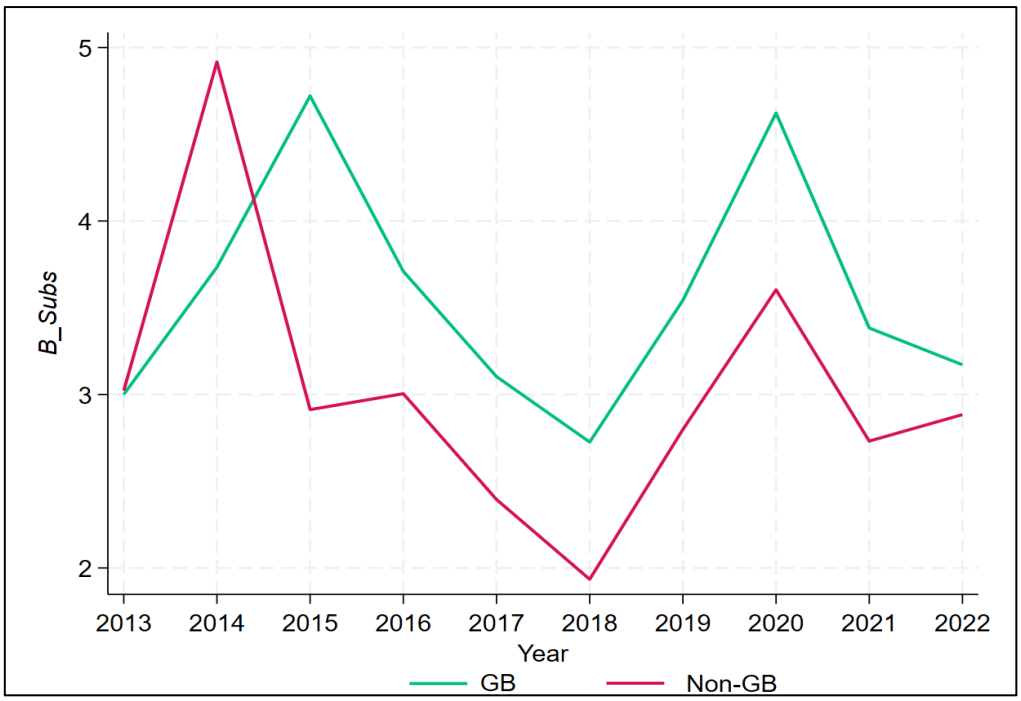
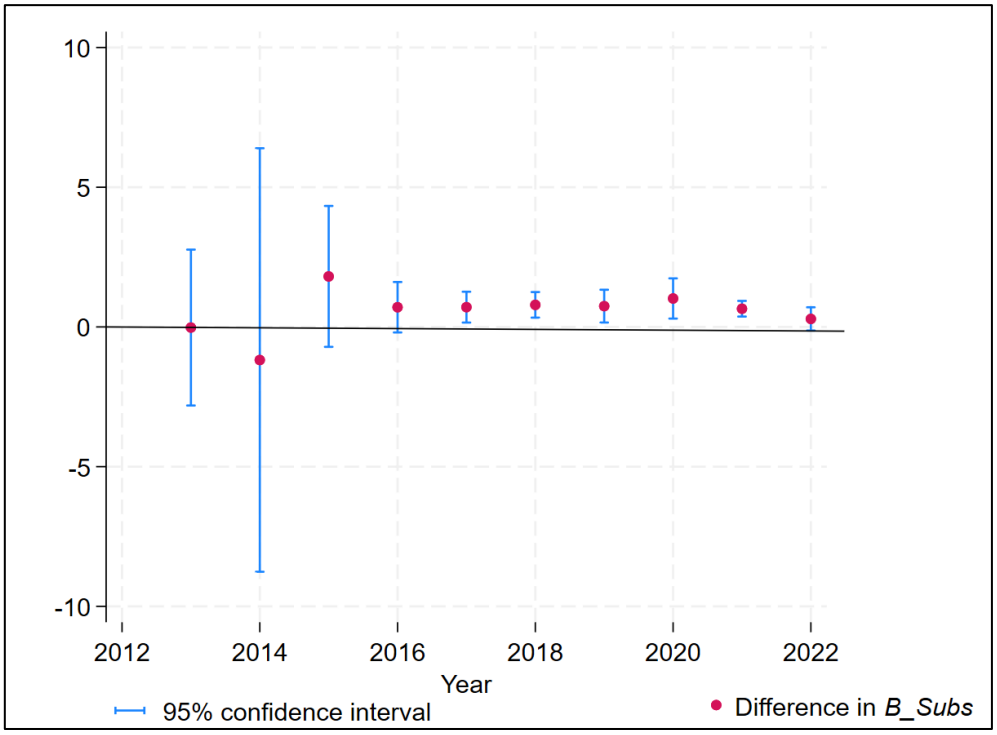


Figure 2. 3: Kernel Density Estimates of Bond Demand (Matched Sample)

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

Figure 2. 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).

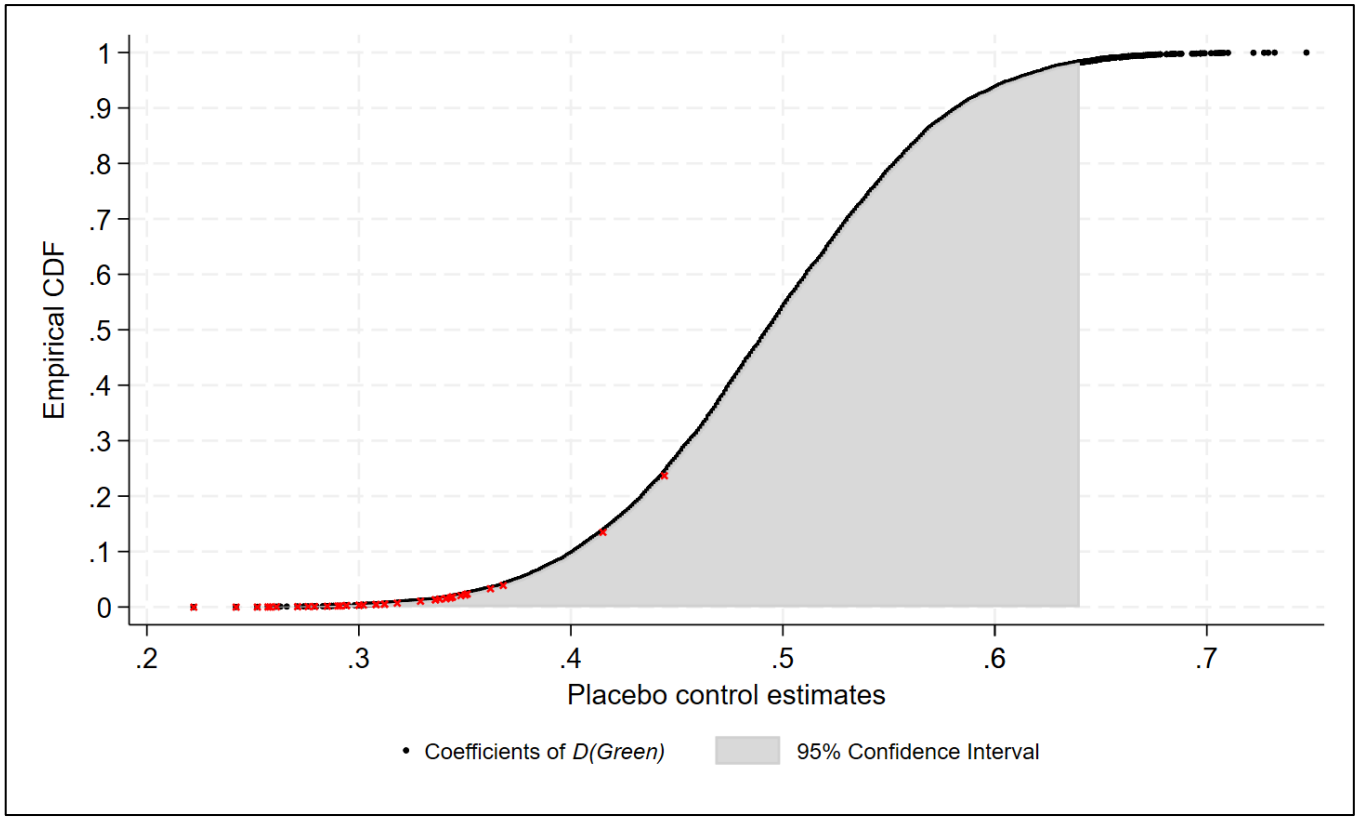


Figure 2. 5: Non-Parametric Test

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 2.5. The shaded area represents the 95% confidence interval of the leading coefficient of D(Green) in Model 1 of Table 2.5. The red X-marks estimate represents the D(Green) coefficient with a *p*-value greater than 0.10.

Table 2. 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 (in millions of US dollars) since its debut from 2007 to 2022. It also documents the universe of total corporate GB offering fixed coupon 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. 2: Summary Statistics of Sample data Before Matching

Panel A summarises the green and non-GB universe (investment grade and fixed-coupon corporate bonds). Panel B summarises the mean and median difference and statistics between the oversubscription GB and non-GB. Panel C summarises 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 2-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 2. 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.
$Treat_{jt} = \alpha + \boldsymbol{\beta_1}.(F\_Covariates_{t-1}) + FE_{year} + FE_{industry} + FE_{country} + \varepsilon_{jt}$

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	Post-match
	(1)	(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 2. 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)	Green (2)	Nongreen (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

Table 2. 5: Baseline Regression Results

In this table, I 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 2. 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, I report each industry's number of bonds, issue amount, share for treated, control, and total firm-year observation post-matching. In panel B, I offer the results based on bivariate analysis. In panel C, I 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 Subs	2.53	3.10	2.40	0.70**	5.01
Median Subs	2.00	2.60	2.00	0.60***	6.26
Observations	1034	188	846		
B.2. Non-financial firms					
Mean Subs	3.56	3.95	3.43	0.52**	2.33
Median 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 2. 7: Alternate Matching Strategies

I report the robustness of demand for greenness using alternative matching strategies. In panel A, I 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, I 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 2. 8: Alternate Definition of Investor Demand

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

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

where *i, j,k,* and *t* are indexed as the bond, issuer firm, country, and time (year), respectively. $Alt\ B\_Subs_{ijkt}$ is $Ln\left(B\_Orderbook_{ijkt}\right)$ 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)
$D\left(Green_{ijkt}\right)$	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

3. Second Empirical Chapter

3.1 Drivers of Greenness Demand

I argue that information about green bond (GB) 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 environmental, social and governance (ESG) performance and risk implications, I identify possible factors that could explain the within and cross-sectional variations in the demand for GB relative to non-GB issues. I follow Caramichael and Rapp (2024), Klausmann *et al.* (2024) and Dutordoir *et al.* (2023) in developing the novel hypothesis on drivers of greenness demand.

3.2 Theoretical Framework on Hypothesis Development

3.2.1 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) [22], better bond ratings (Apergis *et al.* (2022), higher bond return (Wei *et al.* (2022), better alignment of financial and environmental goals

[22] 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.

(Hartzmark & Sussman 2019; Edmans & Kacperczyk 2022)[23], and higher institutional ownership (Pedersen *et al.* 2021)[24].

In addition to GB's unique signalling 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). For 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).

Drawing on the above-discussed evidence, I 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, the demand for GB issued by firms with superior *ex-ante* ESG performance should be higher. This serves as an additional signal to investors regarding the credibility of proceeds 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, I propose the following hypothesis.

[23] 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).

[24] For example, investors are more attracted to invest in firms with lower CO_2 emissions (Azar *et al.* 2021).

$H_{3.1}$: 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.

3.2.2 Potential ESG Risk

In this section, I argue that a firm's potential ESG-related risk could also explain the variation in the demand for GB issuances. I 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, which leads to more transparent and reliable information. This 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 better ESG reputations as they are less likely to engage in risky or unethical behaviour 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, I propose the following hypothesis:

$H_{3.2}$: 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.

3.3 Data and Variables

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

I employ three different proxies to explain 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 tons) scaled by the firm's sales revenue. I rescale carbon intensity for a tractable interpretation of the regression estimates, whereby a higher value denotes lower carbon intensity.[25]

The second past ESG performance proxy is F_GRS, which denotes a firm's greening strategies and is 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 (USTPO), the European Patent Office (EPO), the Japan Patent Office (JPO), and World

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

Intellectual Property Organization (WIPO).[26] 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 page 20, Haščič and Migotto (2015)). I then identify green patents following the OECD's definition and classification (Haščič & Migotto 2015). Thapa *et al.* (2023) present a detailed classification mapping with the environmental policy goals. I count the number of patents classified as green for each firm annually.

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 (Ziolo 2021). RepRisk is an ESG data science company specialising 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 problems include human rights abuses, impact on communities, local participation issues, social discrimination, forced labour, child labour, discrimination on employment, and poor employment conditions. The governance-related problems include corruption, compensation issues, misleading communication (including greenwashing), fraud, tax evasion, and anti-competitive practices. Problems that relate to multiple categories of ESG are referred to as cross-cutting issues, such as controversial

[26] Following Luong *et al.* (2017) and Boubakri *et al.* (2021), for all approved patents, I 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).

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 categorised based on 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 organisations, local government bodies, and social media), medium (such as national and international media, international non-government organisations, 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 customised risk metrics to calculate F_RRI.[27] I rescale the F_RRI where a higher score denotes lower ESG-related reputational risk.[28] All the variables are defined in Appendix 2-B.

3.4 The Model

In this section, I test the hypothesis related to drivers of demand for GB ($H_{3.1}$ and $H_{3.2}$) using the following regression Equation (3.1).

$$B\_Subs_{ijkt} = \beta . D\left(Green_{ijkt}\right) \times \left(Drivers_{jkt-1}\right) + \boldsymbol{\alpha} . F\_Covariates_{jkt-1} + \boldsymbol{\gamma} . B\_Ch_{ijkt} + \boldsymbol{\delta} . C\_Ch_{kt-1} + FE + \varepsilon_{ijkt} \quad (3.1)$$

[27] See https://www.reprisk.com/lab/reprisk_index_for_companies_math.html
[28] I rescale the *F_RRI* by subtracting the maximum value of *F_RRI* in our sample.

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 and are available in Appendix 2-B.

3.4.1 Firm's ESG Performance and GB Demand ($H_{3.1}$)

I test $H_{3.1}$ employing two proxies. First, I use the inverted measure of carbon intensity to represent the firm's environmental performance, where a high value means better carbon performance. I argue that the demand for greenness is driven by *values-based* and *value-based* investors' desire to invest in firms with lower CO_2 emissions. 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 a *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. Wei *et al.* (2022) 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, I argue that GB issued by firms with lower CO_2 emissions is more attractive to investors than GB issued by firms with higher CO_2 emissions and other non-GB.

To test this conjecture, I use a variation of Equation (3.1) using firm-level CO_2 emissions (*F_CO₂)* as a driver for greenness. The results are presented in Table 3.1. 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 × 0.059 = 2 and 33.46 × 0.074 = 2.5). Thus, I 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 3.1 about here]

Second, I 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 favourable 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).

Given the above discussion, 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). I 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).

To test this hypothesis, I 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 firm's greening strategy proxy. The results are reported in Models (3) and (4) of Table 3.1. I 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, I confirm $H_{3.1}$ 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.

3.4.2 Firm's ESG Risk and GB Demand ($H_{3.2}$)

In this section, I investigate $H_{3.2}$ using a variation of Equation (3), where I 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 3.2. In Models (1) and (2), I find the coefficient of the interaction term to be positive and significant, suggesting that the demand for GB is higher for firms with lower *F_RRI*. Economically, the GB demand increases by 1.31 to 1.81 times for one standard deviation (i.e., 16.42) increase in *F_RRI*. Our finding extends Dutordoir *et al.* (2023), as they find that a better reputation drives GB issuance, whereas I find that a lower ESG risk drives demand for a bond's greenness.

[Insert Table 3.2 about here]

Table 3. 1: Carbon Emissions, Greening Strategies, and GB Demand

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

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

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)
$D\left(Green_{ijkt}\right) \times \left(F\_CO2_{jkt-1}\right)$	0.074**	0.059*		
	(2.27)	(2.02)		
$D\left(Green_{ijkt}\right) \times \left(F\_GRS_{jkt-1}\right)$			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 3. 2: ESG risk and GB Demand

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

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

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 *** 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)
$D\left(Green_{ijkt}\right) \times \left(F\_RRI_{jkt-1}\right)$	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

4. Third Empirical Chapter

This study draws upon two fundamental theories, signalling and legitimacy theories, to develop the hypotheses regarding the green bonds (GB) issuers' motivations for impact reporting. Studying these two theories together is crucial as Hummel and Schlick (2016) argue that they are not mutually exclusive but two sides of the same coin. Studying them together helps uncover insights into the underlying drivers of such reporting practices.

4.1 Theoretical Framework on Hypothesis Development

According to the signalling theory, good environmental performers signal their type through direct voluntary disclosures that poor environmental performers cannot easily mimic (Spence 1974; Clarkson *et al.* 2008). Transparent voluntary environmental disclosures increase the firm's value if investors perceive it as credible and convey incremental information about its environmental performance (Verrecchia 1983). Furthermore, such disclosures help lower the firm’s cost of capital by reducing information asymmetry about environmental performance (Clarkson *et al.* 2013). GB’s impact reporters follow the GB principles (Tang & Zhang 2020; Flammer 2021) and adhere to stringent disclosure and reporting standards to verify the environmental impact of their projects, including regular reporting on the use of proceeds and the ecological benefits achieved (Daubanes *et al.* 2021; Jankovic *et al.* 2022).

The main difference between the GB issuers that produce impact reorts (IR) and those that do not produce IR is the transparency of disclosure of the use of proceeds in environment-friendly projects (Larcker & Watts 2020). Reporting is a core component of the GB Principles. GB issuers are advised to report annually on the use of GB proceeds and the environmental impacts following the harmonised framework (International Capital Market Association

2022).[29] One of the key distinguishing features of GBs is the rigorous external verification process they undergo. This process involves independent third-party verification of the environmental impact and the use of proceeds, ensuring GBs' credibility and transparency, instilling confidence in their environmental impact and reinforcing the importance of trust in the GB market.

Legitimacy theory offers an alternative theoretical explanation for the voluntary disclosure of non-financial information. Suchman (1995, p.574) defines legitimacy as *''a generalised perception or assumption that the actions of an entity are desirable, proper, or appropriate within some socially constructed system of norms, values, beliefs, and definitions".* Legitimacy theory suggests that poorly performing companies use sustainability disclosure as a legitimation tactic to influence public perceptions regarding their sustainability performance (Deegan 2002).

Controversies on a firm's sustainability performance can seriously threaten its legitimacy. Kölbel *et al.* (2017) provide empirical evidence by showing that environmental controversies negatively translate into financial risk and argue that firms should have a strategy to avoid such controversies. In this case, firms may issue GB's IR to change the stakeholders' perception to positivity about the firm as they credibly signal the firm's environmental actions (Tang & Zhang 2020; Flammer 2021). This signal comes through the lower information asymmetry (IA) about using GB proceeds in preidentified socially responsible and green projects (Spence 2002; Connelly *et al.* 2011). If firms face criticism about their ESG handling, the GB's IR may signal positive environmental commitments.

[29] As noted earlier, most green bond issuers publish a report on proceeds allocation and impact about a year after issuance. Any material changes are also further updated. For details see Section 2.3. of ICMA (2024). Firms like Apple, ABN AMRO, and ANZ follow ICMA guidelines for regular reporting. See Apple's 2023 report, ABN AMRO's ESG bonds page, and ANZ's Sustainability bond's page.

However, this strategy to issue GB's IR may not always be a genuine commitment to sustainability but rather a part of the cheap talk intending to retain its legitimacy. 'Cheap talk' refers to insincere communication that is not backed by actions. Bingler *et al.* (2024) examine the relationship between cheap talk and emissions and environmental controversies, where they find a positive relationship. Recent literature by ElBannan and Löffler (2024) finds no measurable ecological benefits to issuer firms via GB issuance. These findings raise important questions about the true impact of GBs and the potential risks and challenges they may pose, such as greenwashing and the misuse of GB proceeds. It is crucial to note that these risks and challenges are not inherent to GBs but can arise due to the actions of individual issuers, underscoring the need for further scrutiny and regulation in the GB market.

The prevalence of greenwashing has skyrocketed in recent years; several firms have been combining poor environmental performance with positive communication about environmental performance (Delmas & Burbano 2011). Greenwashing is an overstatement and marketing of a firm's environmentally friendly activities by hiding the actual picture (Kim & Lyon 2015; Marquis *et al.* 2016). Issuing GB for a green project and using proceeds for a general purpose of the business may also be an example of greenwashing (KPMG 2015). One example of a potential greenwash is using GB $4 billion to build an airport runway in Hong Kong.[30] Greenwashing can profoundly affect consumer and investor confidence in green products and environmentally responsible firms, making these stakeholders reluctant to reward companies for environmentally friendly performance. This, in turn, increases the incentives for firms to engage in environmentally detrimental behaviour, which has been shown to create negative externalities and thus negatively affect social welfare. These risks underscore the need for scrutiny and regulation in the GB market.

[30] See the full details at this link and also in the following link.

On a more positive note, Zhang (2023) finds that green finance, primarily through green investment, can effectively eliminate a firm's greenwashing strategy. In a country-level study, evidence indicates that countries' environmental qualities improve significantly after the GB issuance. This suggests that, when used appropriately, GBs can be a powerful tool for promoting environmental sustainability (Chang *et al.* 2022). Alharbi *et al.* (2023) also report GB's positive contribution to renewable energy production in 44 countries. Flammer (2021) and Bhutta *et al.* (2022) also note that the firm's environmental performance increases post-GB issuance; hence, greenwashing should not be via GB. However, the Climate Bonds Initiative (2021b) notes that only about 41% of GB issuers (mostly smaller issuers) do not publish their impact report post-issuance, which may potentially cause environmental controversies.

Kölbel *et al.* (2017) suspect firms might respond to ESG controversies by increasing their ESG disclosure. Meanwhile, Hummel and Schlick (2016) find that ESG controversies lead to a subsequent increase in ESG disclosure in annual reports. Furthermore, their empirical analysis reveals that firms with higher ESG disclosure are better protected against adverse market reactions after an ESG controversy.

I refer to the following figure in a matrix form that explains the relationship between environmental performance and communication (Delmas & Burbano 2011).

[Insert Figure 4.1 about here]

Quadrant I represent all firms that issue GB IR to attract positive media attention and increase their legitimacy. In contrast, quadrant II represents firms that issue GB and use the proceeds in promised environmentally friendly projects communicated via IR and external validation. Similarly, quadrant III represents all firms that issue GB, are environmentally poor

performers, and do not publish IR or signal anything. Finally, the firms in Quadrant IV issue GB and invest the proceeds in promised green projects but do not publish the IR.

Emphasising quadrant II, GB issuance is a credible promise verified by external through the IR issued by firms. Hence, by promoting greater transparency and expanding the scope of emissions reporting, stakeholders can better assess the credibility of companies' climate commitments and determine whether they are truly addressing the pressing problem of climate change or merely paying lip service (Bingler *et al.* 2024). Companies with superior environmental performance have incentives to inform investors and other stakeholders of their strategy by voluntarily disclosing environmental information (Clarkson *et al.* 2008), hence publishing their GB IR. In our context, I claim that the firms that use GB proceeds wisely communicate this through GB IR following a prescribed format (International Capital Market Association 2022). They seek to reveal their performance type, something not directly observable to investors and other stakeholders, through direct voluntary IR that poor environmental performers cannot easily mimic. Doing so increases firm valuation since knowledgeable investors will infer that exposures and latent environmental liabilities are lower for good than poor environmental performers.

Thus, voluntary disclosure theory helps predict a positive association between the firm's environmental performance and GB's IR. From this conjecture, GB's IR is a credible signal (opposite to cheap talk) that GB issuers offer, complementing Bingler *et al.* (2024) findings that cheap talk increases environmental incidences. Firms that are proactive in consistent impact reporting and substantiate with external validation such as second-party opinion (SPO), third-party verification, auditors' statements, and GB certification are conscious enough to avoid environmental controversies and ESG risk.

Since organisations are involved in various prosocial activities, including environmental protection (Galaskiewicz 1997), Bansal and Clelland (2004) suggest that firms

can conquer adverse environmental market risks by communicating their commitment to the natural environment. Some strategies to reduce the risk of ESG reputation can be corporate social responsibility (CSR) programs and reporting environmental and social performance transparently and proactively (Kölbel *et al.* 2017). I introduce GB's impact reporting as a firm's positive environmental commitment that conquers negative news about its ESG and confirms it through external validation. GB's impact reporting is crucial to firms and investors as the ICMA requires that GB proceeds be invested in environment-friendly projects (Baker *et al.* 2022). Evidence about post-GB carbon emissions (CO_2) reduction and environmental performance improvement (Flammer 2021; Xu & Li 2023) supports our argument about the positive signal of impact reporting as a motivation for GB issuers.

Previous research has not established a relationship between GB's voluntary impact reporting and the firm's motivation. These two theories offer two predictions on the GB issuer firms' motivation for IR publication and external validation. I set the first hypothesis as follows:

$H_{4.1}$: Vocal green firms (having lower CO_2) have a higher propensity to publish GB IR as a credible signal.

On the other hand, legitimacy theory suggests that organisations may report and communicate when they underperform (i.e., firms belonging to quadrant I) as a strategy to maintain legitimacy (Suchman 1995). Thus, companies that perform poorly on a specific performance indicator offer superficial, incomplete, or ambiguous information to obscure their poor actual state while maintaining legitimacy and creating a proper sustainability image (Hummel & Schlick 2016).

Delmas and Burbano (2011) define greenwashing as the intersection of two firm behaviours: poor environmental performance and positive communication about environmental performance. The poor environmental performance may need improvement as it may be unappealing to stakeholders. Given the consequences of ESG-related reputation risks, literature on reputation management suggests that firms seek alternative ways to cope with them (McDonnell & King 2013).

The BlackRock CEO Laurence Fink advised that integrating a firm's ESG reputation risks into business strategies portrays long-term financial performance and value creation (Krueger *et al.* 2020; Risk 2020). Since ESG risk management positively links with firms' future value (Asante-Appiah & Lambert 2022), a firm's standing concerning ESG factors is a significant consideration for sustainable success. Kölbel *et al.* (2017) examine the effect of negative news on financial risk and show that negative media articles regarding ESG issues increase a firm's credit risk. They also provide a detailed analysis of the impact of an article's reach and severity, i.e., the total number of readers exposed to it and how harshly it criticises the firm. As the GB impact reporting is voluntary (International Capital Market Association 2018, 2021), environmental risk-facing firms may publish IR with the motive of legitimacy gain. Hence, my second hypothesis is:

$H_{4.2}$: Firms facing higher environmental risk (including greenwashing) are likelier to publish GB's IR to gain legitimacy.

4.2 Sample and Empirical Design

4.2.1 Sample data

I use the list of GB issuer firms from the Environment Finance (EF) database and the London Stock Exchange Group's (LSEG) DataStream database and visit every firm's website. I

manually download all the reports related to GB (i.e., Green financing framework, second-party opinion, third-party verification, certification, Impact reports, and use of proceeds reports) from their websites. Once downloaded, I read the reports and manually enter the date of issuance, impact reports publication, third-party verification, and independent auditor's signature.

I download the firm-level data from the LSEG DataStream. The GB issuer's identification is from the Refinitiv data, whereas the GB issuer firms are extracted from EF. Other relevant data are extracted from the World Bank through Stata. I obtain information on environmental reputation risk from RepRisk, a research and business intelligence provider specialising in ESG and business risk.[31] RepRisk screens over 100,000 media, stakeholder, and third-party sources daily in 15 languages, and its core research scope includes 28 ESG issues (Kölbel *et al.* 2017). As of April 2020, the dataset included more than 140,000 companies associated with risk incidents (Zhou & Wang 2020).

[Insert Table 4.1 about here]

Table 4.1 illustrates the complete status of GB issuers and impact reporter firms from the first corporate GB issuance in 2013 until the end of 2022. I consider only the corporations that have issued GBs. Among 1,127 GB issuers, 248 firms publicly avail their IR. Among the 248 impact reporting firms, only 111 have externally validated reports (ER). Similarly, 141 firms regularly (at least two consecutive reports in my sample) publish their IR.

I drop the firms without ISINs and use ISINs to match the data to firm-level databases. My final sample comprises 597 unique GB issuer firms across 54 countries. I summarise the environmental risk incidents faced by the firms and their characteristics in Table 4.2 below.

[31] RepRisk data are widely used by scholars, for instance, Kölbel *et al.* (2017); Zhou and Wang (2020); Asante-Appiah and Lambert (2022); Liu *et al.* (2022). Also, see the Appendix A for more details.

4.2.2 Variables

4.2.2.1 Dependent and Independent Variables

The dependent variable is GB's impact reporting by firm *j* at time *t* ($IR_{j,t}$). It takes a value of one if GB issuer firms publish their IR after GB issuance; otherwise, it takes a zero value. Furthermore, the IR may be substantiated with external validation through an independent accountant's verification and signed reports (see Appendix 4- B for a sample from Apple Corporation). In such cases, the dependent variable is $ER_{j,t}$, which takes a value of one; otherwise, it is zero. Similarly, I use *IR_Regular* if a firm publishes its GB IR regularly. The *IR_Regular* takes a value of one if a firm publishes its GB IR for at least two consecutive years; otherwise, it is zero.

As per the hypotheses, I have two independent variables. The first independent variable is the firm's carbon intensity ratio lagged by one year (F_CO2Int_{t-1}). It is the annual total CO_2 in billion tons divided by the billions of the United States (US) dollars of revenue. The second independent variable is the firm's environmental risk *(Env_Risk)* invidents including greenwashing incidents ex-ante IR publication (defined in Appendix 4- A; the calculation procedure is explained below).

To capture an accurate picture of environmental incidents related to risk reduction post-GB issuance and impact reporting, I keep only those firms that have faced at least one environmental incident during our study period. I sum the incidents each year under each category, such as climate change, GHG emissions, local pollution, overuse and wasting resources, and misleading communication. Furthermore, I deep dive into their novelty, reach, and severity and capture the intensity of each environmental incident. Finally, I construct the unique environmental index capturing the incidents, novelty (*Env_Nov)*, reach (*Env_Reach)*, and severity (*Env_Sev)* following Bingler et al. (2024).

I also use alternative definitions and consider the following two variables as alternatives to *Env_Risk*. First, I use the total number of annual environmental incidents (*Env_Inc). Second*, I use *Env_Grw1*, which captures only the greenwashing risk that occurs through misleading environmental communication.

4.2.2.2 Control Variables

Following the existing literature, I control the prominent firm characteristics (F_Ch) that may simultaneously affect the firms environmental performance (*F_CO2Int),* environmental risk (*Env_Risk)* and their impact reporting decisions (See Flammer 2021; Dutordoir *et al.* 2023). First, I use the natural logarithm of total assets (*F_Size*) as a proxy of firm size. Next, I use firms' operating performance, proxied by return on assets (*F_ROA*). Third, I use firm leverage, captured by the ratio of total debt to total assets (*F_Lev*). Fourth, I use the firm's sales growth *(F_Rev_Gr).* These variables are included to ensure that differences in firm characteristics do not drive GB's impact reporting behaviour.

4.3 Summary Statistics

Table 4.2 presents comprehensive details of all the variables, their summary statistics, and the number of observations. It summarises all the corporate GB issuers firms for which I have an International Securities Identification Number (ISIN). They are winsorized at a 2% level to eliminate the impact of outliers. The average *Env_Risk* firm face is 5.84. Similarly, the average *Env_Grw1* is 1.46, *Env_GHG* is 3.06, *Env_Inc* is 0.04, *Env_Nov* is 2.77, *Env_Reach* is 2.81, and *Env_Sev* is 2.59, respectively.

The average *F_Size* is 129 bn US$, *F_Lev* of 33.75%, *F_ROA* is 3.77% and *F_Rev_Gr* is 2.79% . Similarly, the average *F_CO2* is 5,608 billion tons, and the *F_CO2Int* is 466 times. These values are similar to Flammer (2021), and Tang and Zhang (2020).

[Insert Table 4.2 about here]

Table 4.3 presents initial evidence of significantly higher *Env_Risk* in firms that report their environmental impact through IR post GB issuance. The average *Env_Risk* for GB's impact reporter firms is 10.17, whereas for non-reporter firms, it is 3.52. The mean difference of 6.64 is statistically significant at the 1% significance level. Similarly, all other ESG risk incident parameters (i.e., *Env_Grw1, Env_GHG, Env_Inc*), including the novelty (*Env_Nov*), reach (*Env_Reach*), and severity (*Env_Sev*) of the incidents are significantly higher in GB's IR publishing firms than in non-publishing firms.

Conversely, the average *F_CO2Int* is 305.60 for GB's IR publishing firms, whereas, for non-publishing firms, it is 592.66. The mean difference of 287.06 is statistically significant at a 1% significance level. This evidence develops two intuitions. First, do the firms that have lower CO_2 have the motivation to publish their IR? Second, are the firms that face higher environmental risks, including greenwashing incidents, motivated to publish their IR?

The characteristics of the GB's IR publishing and non-publishing firms also differ significantly. The GB's IR publishing firms are significantly larger in size, *F_Size* (i.e., mean difference 1.49 is significant at 1% significance level), have lower financial risk, *F_Lev* (i.e., mean difference 3.29 is significant at 1% significance level), and have poor operating performance *F_ROA* (i.e., mean difference 0.36 is significant at 1% significance level), lower revenue growth *F_Rev_Gr* (i.e., mean difference 2.27 is significant at 1% significance level), and lower *F_CO2* (i.e., mean difference 1,178.63 is significant at 5% significance level).

[Insert Table 4.3 about here]

4.4 Empirical Analysis

I apply the probit regression to estimate the propensity of GB issuer firms' impact reporting using the Equation below:

$$IR_{jt} = \alpha + \boldsymbol{\beta_1}.CO2Int_{j,t-1} + \boldsymbol{\beta_2}.Env\_Risk_{j,t-1} + \boldsymbol{\beta_3}.\left(Covariates_{j,t-1}\right) + FE_{year} + FE_{industry} + \varepsilon_{jt} \quad (4.1)$$

where *j and t are indexed as GB's IR publishing firm* and time (year), respectively. The dependent variable IR_{jt} takes one if a firm publicly avails its IR post GB issuance; otherwise, it is zero. All other variables are discussed in section 4.2 and defined in Appendix 4-A. Our regression includes several fixed effects to rule out trends such as year and industry. The ε_{jt} is the error term clustered at firm and year levels.

Table 4.4 presents the results of the above Equation. Models (2) and (3) replace the IR in Model (1) with *ER* and *IR_Regular*, respectively. The coefficient of our first primary variable Env_Risk is negative and statistically significant at a 1% significance level in all three Models. The coefficient for *F_CO2Int* is -0.196, statistically significant at a 1% significance level in Model (1)**,** implying that a one-unit decrease in CO_2 intensity increases the probability of publishing IR by 19.6%. In our Model (2), our dependent variable is ER, meaning the IR is reviewed and signed by an independent external accountant where the result is consistent with that of Model (1). The coefficient for *F_CO2Int* is -0.126, statistically significant at a 1% significance level, which implies that a one-unit decrease in CO_2 intensity increases the probability of publishing ER by 12.6%.

The results are consistent in Model (3), where I use IR_Regular as the dependent variable. IR_Regular implies that the GB issuer firms publish at least two IR post-GB issuance in our sample. The coefficient for *F_CO2Int* is -0.168, statistically significant at the 1%

significance level. It implies that a one-unit decrease in CO_2 intensity increases the probability of publishing IR regularly by 16.8%. These results show that environmentally better performing (i.e., firms with lower CO_2) are motivated to publish their IR, ER, and IR_Regular, supporting the $H_{4.1}$. This is consistent with the signalling argument that the actual impact creator firms credibly signal their commitment to the environment, lowering the information asymmetry about proceeds use and publicly avail IR post GB issuance.

Similarly, the coefficient of the second primary variable Env_Risk is positive and statistically significant at a 1% significance level in all three Models. The coefficient for *Env_Risk* is 0.0058, significant at a 1% significance level in Model (1)**,** indicating that a one-unit increase in environmental risk is associated with a 0.58% higher probability of the firm publicly availing its IR. In Model (2), the dependent variable is ER, meaning the IR is reviewed and signed by an independent external accountant where the result is consistent with that of Model (1). The coefficient for *Env_Risk* is 0.0139, statistically significant at a 1% significance level, which implies that a one-unit increase in *Env_Risk* increases the probability of publishing ER by 1.39%.

The results are consistent in Model (3), where I use IR_Regular as the dependent variable. IR_Regular implies that the GB issuer firms publish at least two IR post-GB issuance in our sample. The coefficient for *Env_Risk* is 0.0057, statistically significant at a 1% significance level, which implies that a one-unit increase in *Env_Risk* increases the probability of publishing IR regularly by 0.57%. These findings suggest that firms with more significant environmental risks are more likely to avail their GB IR publicly. These results show that the firms facing environmental risk are motivated to publish their IR, IR with external validation (ER), and in a granular manner (IR_Regular), supporting our $H_{4.2}$. This is consistent with the legitimacy theory, which states that risk-facing firms want to gain legitimacy through transparent impact reporting post GB issuance.

Regarding firm characteristics, *F_Size* exhibits a positive and statistically significant relationship with the likelihood of IR publication in all three models. This suggests that larger firms are more likely to report using IR post-GB issuance, consistent with the Climate Bonds Initiative (2021b). I further find that *F_Lev* has a positive and significant relationship with the likelihood of GB's impact reporting, indicating that firms with higher leverage are likely to practice IR publication. These findings suggest that the firm characteristics plays a positive and significant role in the decision to impact reporting post-GB issuance, voluntarily.

[Insert Table 4.4 about here]

Although I employ the industry fixed effects (FE) in the baseline results, the dynamics of firms belonging to the polluting and non-polluting industries may differ. For instance, polluting firms may face higher scrutiny (Becker & Henderson 2000) and be inclined to legitimatise through voluntary impact reporting post-GB issuance. Table 4.5 below presents the differences in the likelihood of firms' impact reporting post-GB issuance between non-polluting and polluting firms. For non-polluting firms, both the environmental risk (*Env_Risk)* and environmental performance (*F_CO2Int)* do not significantly influence impact reporting post-GB issuance. This result is intuitive and aligns with our argument about *Env_Risk* as they face lesser scrutiny (Becker & Henderson 2000) and either do not emit CO_2 or emit very smaller amount. The results also show that *F_Size* and *F_Lev* are significant predictors of IR publication. Specifically, larger firms are more likely to publish an IR, as indicated by the positive and highly significant coefficient for firm size (0.341). At the same time, higher leverage also increases the probability of publication (0.0252), with both coefficients significant at the 1% level.

For polluting firms, the picture is more intuitive. The GB issuer firms' *Env_Risk* plays a significant role, with firms facing higher *Env_Risk* are more likely to publish an IR post-GB issuance. The coefficient for *Env_Risk* (0.0079) implies that a one-unit increase in *Env_Risk* increases the likelihood of publishing IR by 0.79%, which reflects their responsiveness to environmental concerns. On the other hand, *F_CO2Int* has a significant negative relationship with IR publication (-0.196), implying that a one-unit decrease in *F_CO2Int* increases the probability of publishing IR by 19.6%, suggesting that firms with lower emissions are more likely to disclose their environmental impact post GB issuance. Like non-polluting firms, larger firms are more likely to publish an IR (0.148), indicating that firm size (*F_Size)* is a consistent determinant across both groups. These findings highlight that the polluting firms that may face regulatory scrutiny (Becker & Henderson 2000) are more likely to face *Env_Risk* and be motivated to GB's impact reporting than the non-polluting firms.

[Insert Table 4.5 about here]

4.5 Robustness Tests

I perform robustness tests to ensure the initial findings are consistent and generalisable. In the primary model in Table 4.4, I use the *Env_Risk* as a driving factor for firms' impact reporting post-GB issuance. The *Env_Risk* is an index capturing all environmental incidents a GB issuer firm faces in a year. As there is literature (see Hoepner *et al.* (2024)) that uses the total number of incidents (*Env_Inc)* a firm faces for robustness, I use the same in Table 4.6 below. The robustness test reaffirms the initial interpretation that environmental risk incidents (*Env_Inc)* significantly influences the likelihood of impact reporting post GB issuance. The positive and statistically significant coefficient for *Env_Inc* (0.0216) suggests that the firms facing higher environmental risk incidents are more inclined to report on their GB's impact.

In addition, the robustness test confirms the negative relationship between GB issuer firms' environmental performance (*F_CO2Int)* and GB's impact reporting (-0.199), highlighting that lower emitter GB issuers are more likely to disclose their environmental impact. As in the baseline, firm size (*F_Size)* is a strong predictor for GB's impact reporting, larger firms show a higher probability (0.215), indicating that transparency tends to correlate with firm size.

[Insert Table 4.6 about here]

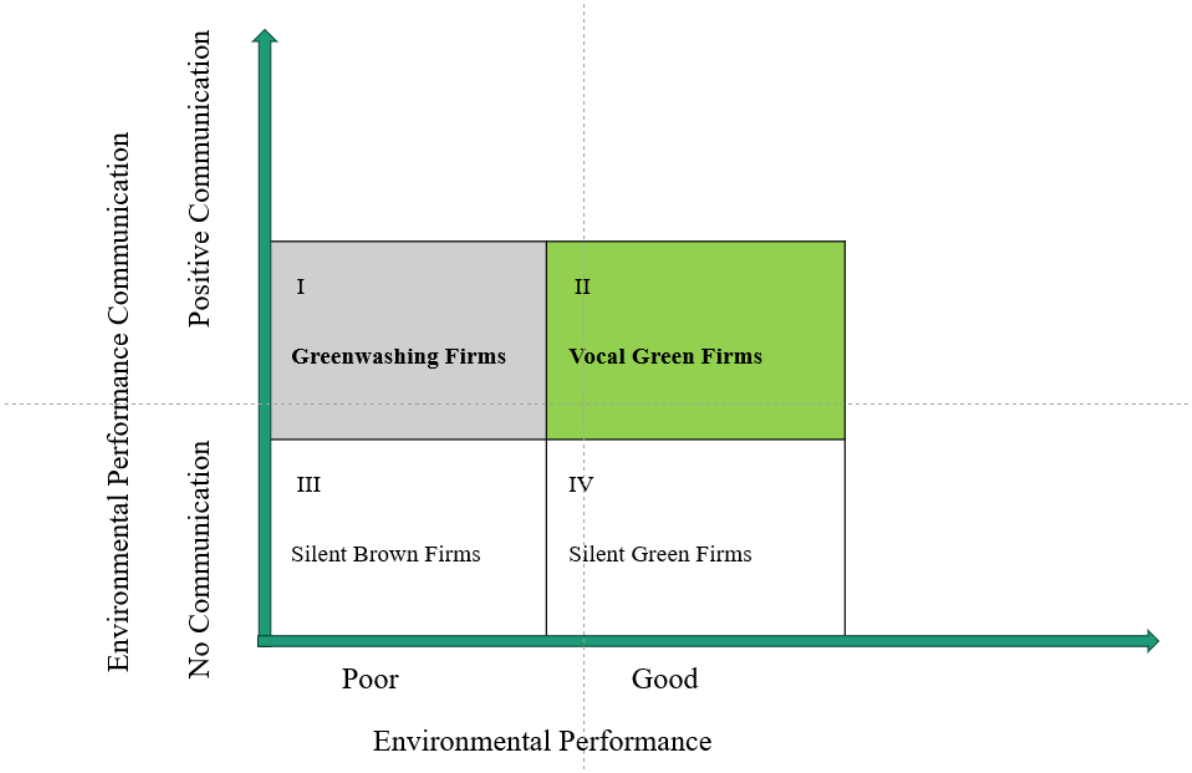
Misleading communication is also known as greenwashing.[32] Here, I consider only the environmental incidents that occurred through misleading communication (*Env_Grw1*) for robustness tests. Table 4.7 below in Model (1) predicts the likelihood of an *Env_Grw1* firm publishing its IR post-GB issuance, Model (2) examines the ER, and Model (3) focuses on regular IR publication. In Model (1), the *Env_Grw1* coefficient is positive (0.0069) and statistically significant at the 10% level, indicating that firms facing more greenwashing-related incidents are marginally more likely to publish an IR, suggesting that environmental incidents may trigger transparency through reporting. Conversely, the coefficient for *F_CO2Int* remains negative and highly significant (-0.189), confirming that firms with higher CO_2 emissions are less likely to disclose their environmental impact, even when they issue GB. This identifies the need to assess a relationship between firms' environmental performance and transparency, particularly for high-emitting firms.

[32] The RepRisk data captures the misleading communication and potential greenwashing firms. For details: https://www.reprisk.com/research-insights/news-and-media-coverage/reprisk-data-shows-increase-in-greenwashing-with-one-in-three-greenwashing-public-companies-also-linked-to-social-washing

In Model (2), which focuses on ER, *Env_Grw1* remains highly significant with a coefficient of 0.0247, statistically significant at a 1% significance level, reinforcing the finding that greenwashing-related incidents positively correlate with IR publication with ER. The negative and statistically significant coefficient for *F_CO2Int* (-0.101), statistically significant at a 1% significance level, is consistent, aligning with the idea that firms with higher emitters are less likely to report their environmental impact. Lastly, in Model (3), which considers regular IR publication (IR_regular), the results confirm that *F_Size* is still a strong determinant of IR publication, with a coefficient of 0.169, statistically significant at a 1% significance level, consistent with previous findings. However, the coefficient for *F_CO2Int* remains negative (-0.159), statistically significant at a 1% significance level, confirming that higher emissions discourage transparency, even in the case of regular reporting.

Overall, the robustness test results further reinforce the initial interpretations from Table 4.4. *Env_Risk* measured by *Env_Grw1* and *F_Size* significantly drives the likelihood of publishing an IR. Similarly, *F_CO2Int* consistently presents a negative relationship with transparency, indicating that high-emitting firms are less likely to avail their IR.

[Insert Table 4.7 about here]



Source: Delmas & Burbano, 2011, p. 67

Figure 4. 1 Environmental Performance and Communication Matrix

The horizontal axis of the figure shows the environmental performance of the GB issuer firms, whereas the vertical axis shows the communication of performance through impact reports post-GB issuance.

Table 4. 1: Green Bonds (GB) Impact Reporting over Time

This Table reports the number of corporate green bonds (GB) issuers from 2013 to 2022 from worldwide. The 'IR' represents number of GB issuers that published at least one impact report (IR) in a particular year, the 'ER' represents the number of GB issuers that have published their IR with independent reviewer's external review (ER) and 'IR_regular' represents the regular publication of IR, at least two IR publication in my sample.

Year	Total Corporate GB universe and impact reporting over the years			
	IR	ER	IR_regular	GB issuers
2013	0	0	0	3
2014	0	0	0	10
2015	2	1	2	20
2016	3	3	3	30
2017	22	16	20	64
2018	29	20	26	86
2019	39	20	28	161
2020	56	17	29	202
2021	59	20	15	331
2022	38	14	18	220
Total	248	111	141	1,127

Table 4. 2: Summary Statistics of Sample Data

This Table summarises the statistics [Number of observations (Observation), Mean, Median, Standard Deviation (Std. Dev.), Minimum and Maximum] of green bonds (GB) issuer firm's environmental risk incident counts (Env_Risk, Env_Grw1, Env_GHG, Env_Inc, Env_Nov, Env_Reach and Env_Sev) and firm-level characteristics (F_Size, F_ROA, F_Lev, F_Rev_Gr, F_CO2 (bil ton) and F_CO2Int). It also reports the number of observations available for each variable with the international securities identification number (ISIN) in all panels. All the variables are defined in Appendix 4- A.

Summary statistics of the GB issuers and impact reporters, including their ESG incidents						
	Observation	Mean	Median	Std. Dev.	Minimum	Maximum
Env incidents						
Env_Risk	5,970	5.84	0	14.90	0	75.00
Env_Grw1	5,970	1.46	0	4.48	0	23.00
Env_GHG	5,970	3.06	0	8.46	0	43.00
Env_Inc	5,970	1.84	0	4.77	0	24.00
Env_Nov	5,970	2.77	0	6.86	0	34.00
Env_Reach	5,970	2.81	0	7.37	0	37.00
Env_Sev	5,970	2.59	0	6.74	0	34.00
Firm Characteristics						
F_Size ($ bil)	5,585	129.00	141.00	354.00	0.15	1,980
F_Lev (%)	5,515	33.75	33.51	17.11	2.14	73.53
F_ROA (%)	5,397	3.77	3.07	3.90	-4.97	16.31
F_Rev_Gr (%)	4,977	2.79	3.23	17.65	-47.89	47.06
F_CO2 (bil ton)	3,237	5,607.94	273.92	14,300	710	74,800
F_CO2Int	3,237	466.02	39.71	1146.46	0.26	5,914.59

Table 4. 3: Summary Statistics of GB's Impact Reporter and and Non-Reporter Firms

This is a summary of statistics of GB's Impact reporter (GBIR) and non-reporter (NonIR) firms. It also summarises the mean differences between Environmental incident counts (Env_Risk, Env_Grw1, Env_GHG, Env_Inc, Env_Nov, Env_Reach and Env_Sev) and firm-level characteristics (F_Size, F_ROA, F_Lev, F_Rev_Gr, F_CO2 (bil ton) and F_CO2Int), and t-statistics between GBIR and NonIR. All the variables are defined in Appendix 4- A.

	All Mean (a)	NonIR Mean (b)	GBIR Mean (c)	Difference (c-b)	t-stat
Env incidents					
Env_Risk	5.84	3.52	10.17	-6.64***	-14.27
Env_Grw1	1.46	0.82	2.66	-1.85***	-13.02
Env_GHG	3.06	1.68	5.62	-3.94***	-14.80
Env_Inc	1.84	1.11	3.21	-2.10***	-14.11
Env_Nov	2.77	1.66	4.83	-3.16***	-14.75
Env_Reach	2.81	1.71	4.88	-3.17***	-13.76
Env_Sev	2.59	1.56	4.54	-2.98***	-14.11
Firm Characteristics					
F_Size ($ bil)	16.59	16.05	17.55	-1.49***	-26.20
F_Lev (%)	33.75	34.93	31.64	3.29***	6.96
F_ROA (%)	3.77	3.90	3.54	0.36***	3.29
F_Rev_Gr (%)	2.79	3.60	1.33	-2.27***	-4.54
F_CO2 (bil ton)	5,607.94	6,127.89	4,949.26	1,178.63**	2.34
F_CO2Int	466.02	592.66	305.60	287.06***	7.43
Observations	5,970	3,890	2,080		

Table 4. 4: Baseline Results

This Table reports the firms' propensity to impact reporting using the following model.

$$IR_{jt} = \alpha + \boldsymbol{\beta_1}.CO2Int_{t-1} + \boldsymbol{\beta_2}.Env\_Risk_{t-1} + \boldsymbol{\beta_3}.(F\_Ch_{t-1}) + FE_{year} + FE_{industry} + \varepsilon_{jt}$$

The dependent variable (IR_{jt}) is one if a firm *j* publicly avails their GB's impact reports (IR) in a year *t* and zero otherwise. In models (2) and (3), it replaces the IR used in the model (1) and uses the ER and IR_regular, respectively. The 'IR' represents number of GB issuers that published at least one impact report (IR) in a particular year, the 'ER' represents the number of GB issuers that have published their IR with independent reviewer's external review (ER) and 'IR_regular' represents the regular publication of IR, at least two IR publication in my sample. All other variables are defined in Appendix 4-A. FE denotes fixed effects in terms of year and industry. Model (1) predicts the likelihood of a firm publishing its IR post-GB issuance. Standard errors are clustered at the industry and year level, *t*-statistics are presented in parentheses, and *, **, and *** denote statistical significance at the 10%, 5%, and 1% significance levels.

	IR (1)	ER (2)	IR_regular (3)
F_CO2Int	-0.196***	-0.126***	-0.168***
	(-12.86)	(-9.52)	(-6.64)
Env_Risk	0.0058***	0.0139***	0.0057***
	(5.67)	(7.99)	(4.49)
F_Size	0.222***	0.0767***	0.143***
	(11.40)	(3.95)	(8.44)
F_Lev	0.0083***	0.0026	0.0077***
	(3.63)	(1.43)	(3.60)
F_ROA	0.0084	-0.0029	0.0105*
	(1.23)	(-0.29)	(1.85)
F_Rev_Gr	-0.0009	-0.0027	-0.0020
	(-0.39)	(-1.10)	(-0.90)
Industry FE	Yes	Yes	Yes
Time FE	Yes	Yes	Yes
Number of obs	2,939	2,939	2,939
Pseudo R^2	0.125	0.0908	0.0780

Table 4. 5: Baseline Results with Polluting and Non-polluting Firms

This table reports the firms' propensity to impact reporting using the following model.

$$IR_{jt} = \alpha + \boldsymbol{\beta_1}.CO2Int_{t-1} + \boldsymbol{\beta_2}.Env\_Risk_{t-1} + \boldsymbol{\beta_3}.(F\_Ch_{t-1}) + FE_{year} + FE_{industry} + \varepsilon_{jt}$$

The dependent variable (IR_{jt}) is one if a firm *j* in the publicly avails their GB's impact reports (IR) in a year *t* and zero otherwise. Models (1) and (2) report the results of non-polluting and polluting firms, respectively. Model (1) predicts the likelihood of a non-polluting firm publishing its IR post-GB issuance, whereas Model (2) predicts the likelihood of a polluting firm publishing its IR post-GB issuance. All the variables are defined in Appendix 4- A. Standard errors are clustered at the industry and year level, *t*-statistics are presented in parentheses, and *, **, and *** denote statistical significance at the 10%, 5%, and 1% significance levels.

IR	Non-polluters (1)	Polluters (2)
F_CO2Int	0.0966	-0.196***
	(0.30)	(-12.42)
Env_Risk	0.0025	0.0079***
	(1.13)	(6.46)
F_Size	0.341***	0.148***
	(12.03)	(5.51)
F_Lev	0.0252***	-0.0021
	(12.23)	(-0.95)
F_ROA	0.0244	0.0039
	(1.61)	(0.59)
F_Rev_Gr	0.0021	-0.0028
	(0.62)	(-0.94)
Industry FE	Yes	Yes
Time FE	Yes	Yes
Number of obs	1,265	1,658
Pseudo R^2	0.193	0.0790

Table 4. 6: Robustness Tests with Alternative Definitions: Environmental Incidents

This table uses the following model to report the environmental incidents facing firms' propensity to impact reporting.

$$IR_{jt} = \alpha + \boldsymbol{\beta_1}.CO2Int_{t-1} + \boldsymbol{\beta_2}.Env\_Inc_{t-1} + \boldsymbol{\beta_3}.(F\_Ch_{t-1}) + FE_{year} + FE_{industry} + \varepsilon_{jt}$$

The dependent variable (IR_{jt}) is one if a firm *j* in the publicly avails their GB's IR in a year *t* and zero otherwise. In models (2) and (3), it replaces the IR used in the model (1) and uses the ER and IR_regular, respectively. The 'IR' represents number of GB issuers that published at least one impact report (IR) in a particular year, the 'ER' represents the number of GB issuers that have published their IR with independent reviewer's external review (ER) and 'IR_regular' represents the regular publication of IR, at least two IR publication in my sample. All other variables are defined in Appendix 4-A. FE denotes fixed effects in terms of year and industry. Model (1) predicts the likelihood of environmental incidents facing a firm publishing its IR post-GB issuance. Standard errors are clustered at the industry and year level, *t*-statistics are presented in parentheses, and *, **, and *** denote statistical significance at the 10%, 5%, and 1% significance levels.

	IR (1)	ER (2)	IR_regular (3)
F_CO2Int	-0.199***	-0.134***	-0.172***
	(-12.68)	(-8.64)	(-6.62)
Env_Inc	0.0216***	0.0469***	0.0213***
	(6.55)	(7.98)	(4.77)
F_Size	0.215***	0.0691***	0.135***
	(10.88)	(3.43)	(8.05)
F_Lev	0.0084***	0.0029	0.0079***
	(3.69)	(1.51)	(3.67)
F_ROA	0.0082	-0.0032	0.0103*
	(1.19)	(-0.33)	(1.81)
F_Rev_Gr	-0.0009	-0.0029	-0.0020
	(-0.39)	(-1.17)	(-0.91)
Industry FE	Yes	Yes	Yes
Time FE	Yes	Yes	Yes
Number of obs	2,939	2,939	2,939
Pseudo R^2	0.126	0.0956	0.0797

Table 4. 7: Robustness Tests with Alternative Definitions: Greenwashing

This table uses the following model to report the greenwashing incidents facing firms' propensity to impact reporting.

$$IR_{jt} = \alpha + \boldsymbol{\beta_1}.CO2Int_{t-1} + \boldsymbol{\beta_2}.Grw1_{t-1} + \boldsymbol{\beta_3}.(F\_Ch_{t-1}) + FE_{year} + FE_{industry} + \varepsilon_{jt}$$

The dependent variable (IR_{jt}) is one if a firm *j* in the publicly avails their GB's IR in a year *t* and zero otherwise. In models (2) and (3), it replaces the IR used in the model (1) and uses the ER and IR_regular, respectively. The 'IR' represents number of GB issuers that published at least one impact report (IR) in a particular year, the 'ER' represents the number of GB issuers that have published their IR with independent reviewer's external review (ER) and 'IR_regular' represents the regular publication of IR, at least two IR publication in my sample. All other variables are defined in Appendix 4-A. FE denotes fixed effects in terms of year and industry. Model (1) predicts the likelihood of environmental incidents facing a firm publishing its IR post-GB issuance. Standard errors are clustered at the industry and year level, *t*-statistics are presented in parentheses, and *, **, and *** denote statistical significance at the 10%, 5%, and 1% significance levels.

	IR (1)	ER (2)	IR_regular (3)
F_CO2Int	-0.189***	-0.101***	-0.159***
	(-12.91)	(-9.66)	(-6.56)
$Grw1$	0.0069*	0.0247***	0.0090***
	(1.91)	(4.56)	(2.67)
F_Size	0.248***	0.135***	0.169***
	(12.13)	(6.20)	(8.40)
F_Lev	0.0081***	0.0019	0.0074***
	(3.47)	(1.13)	(3.40)
F_ROA	0.0090	-0.0016	0.0110*
	(1.34)	(-0.17)	(1.93)
F_Rev_Gr	-0.0011	-0.0030	-0.0022
	(-0.48)	(-1.19)	(-0.98)
Industry FE	Yes	Yes	Yes
Time FE	Yes	Yes	Yes
Number of obs	2,939	2,939	2,939
Pseudo R^2	0.122	0.0757	0.0755

5. Summary, Conclusion and Future Scope

5.1 Summary of Findings

This study offers three meaningful insights, one at each empirical chapter. First, 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 Green Bonds (GB) issued worldwide, I investigate if the demand for GB is higher compared to matched non-GB.

I investigate the investor's demand for greenness using a robust matching strategy. I perform a Propensity Score Matching (PSM) using matching covariates (i.e., the firm size, financial risk captured by the leverage, their operating profit and the sales growth) to eliminate any fundamental differences between GB and non-GB issuers. Thus, I 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. A battery of further robustness checks supports the above-noted results. As an alternative matching strategy, I perform a bond-level matching whereby I 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).

I also use the natural logarithm of the orderbook amount and the residual subscription as an alternative measure of investor demand. Finally, I proceed with a non-parametric test by randomly selecting 902 placebo (twice the number of GB in my sample) from the non-GB universe and run the baseline regressions 10,000 times. I find that demand for GB is significantly higher than for placebo non-GB 99.9% of the time, supporting the baseline results.

Second, I test two novel hypotheses *($H_{3.1}$ and $H_{3.2}$)* to identify the drivers of greenness demand using GB as a financial product that captures greenness. I find that investors consider the firm's environment-related credibility before they buy the GB. In this regard, I find that the

investors consider GB issuer firms' environmental performance (captured through the ex-ante GB issuance greenhouse gas emission abbreviated as CO_2) that enhances the green credibility of firms. Investors' attraction to GB issued by firms with lower CO_2 is higher than the higher emitter and non-GB issuers. Furthermore, firms that have invested in green innovation (captured through the number of green patent registration) also serve as the credible green signal, leading to a heterogeneous demand for GB across firms. Next, this study finds that the GB issuer firms' environmental social and governance (ESG) risks are another parameter investors consider. I find the higher demand for GB issued by firms that face a lesser number of ESG-related risks.

Third, this study examines the factors driving firms' decisions to publish impact reports (IR) post-GB issuance, focusing on two central hypotheses grounded in signalling theory and legitimacy theory. By utilising robust analytical frameworks and alternative definitions of environmental performance and risk, this research provides an in-depth understanding of how firms strategically disclose their environmental performance and commitment to stakeholders. The findings accentuate the pivotal roles of environmental performance and environmental risk as key determinants of reporting behaviour, offering significant contributions to the growing literature on green financing, corporate transparency, and environmental accountability.

Consistent with signalling theory**,** the results affirm that low-emitting firms are more inclined to publish their impact reports (IR) post-GB issuance as a credible signal of their superior environmental performance. Being resource-intensive and transparent, IR publication is a costly signal that higher-emitting competitors cannot replicate. Across all models, the negative and highly significant coefficients for firm's carbon emission intensity (*F_CO2Int*) demonstrate that firms with lower carbon intensities are more likely to disclose their GB-related impacts, aligning with my first hypothesis ($H_{4.1}$). This finding corroborates prior research, such as Spence (1973), who emphasised that credible signals are costly and difficult to imitate to

distinguish firms with genuine advantages. For low-emitting firms, disclosing an IR is an investment in reinforcing their commitment to sustainability and differentiating themselves in an increasingly environmentally conscious marketplace.

Furthermore, the robustness tests, which involve testing the consistency of the results under different conditions or assumptions, reveal an intriguing paradox. The signalling theory predicts that vocal green firms (firms that have lower *F_CO2Int* and communicate their environmental performance) have more substantial incentives to publish IRs. Similarly, the results show that polluting firms are also significantly motivated to disclose. This suggests that while vocal green firms signal superior environmental performance, polluting firms may use IRs to signal incremental improvements or overcome regulatory scrutiny (Becker & Henderson 2000) which non-polluting does not face. This dynamic signalling illuminates our understanding of firms' varying environmental footprints and leverages transparency to navigate competitive pressures and stakeholder expectations.

Additionally, I use legitimacy theory to interpret the influence of environmental risk including the potential greenwash (*Env_Risk)* on reporting behaviour. As firms face increasing scrutiny over their environmental impacts, the pressure to demonstrate accountability and align with societal norms intensifies. The *Env_Risk*'s statistically significant coefficients across all models support my second hypothesis that the firms facing higher environmental risk (including greenwashing) are likelier to publish IR post-GB issuance to gain legitimacy ($H_{4.2}$) and rebuild trust. This finding aligns with the arguments of Suchman (1995), who posits that organisations seek legitimacy by aligning their actions with socially constructed norms and values. The IR publication is a proactive strategy for polluting firms, often at the forefront of public and regulatory scrutiny, to mitigate reputational risks, enhance stakeholder confidence, and signal their commitment to improving environmental performance.

The results also reveal interesting variations in the relationship between the GB issuer firms characteristics (*F_Ch)* and IR publication. Firm size emerges as a consistent predictor across all models, with larger firms significantly more likely to disclose their environmental impacts. These findings echo prior studies, such as those by Deegan (2002) and Hoepner *et al.* (2024), suggesting that larger firms face greater stakeholder scrutiny and transparency initiatives. The alternative definitions of *Env_Risk* in the robustness tests further enrich the analysis. By replacing *Env_Risk* with environmental risk related to potential greenwashing related (*Env_Grw1)* incidents, the study uncovers additional layers of complexity in firms' reporting behaviour.

The positive and significant coefficients for *Env_Grw1* indicate that firms experiencing more greenwashing-related incidents are motivated to publish IRs as a defensive strategy to counteract negative perceptions and restore credibility. This finding is consistent with Lyon and Maxwell (2011) argument that firms use disclosure to manage reputational risks and prevent regulatory interventions. Moreover, the robustness tests reveal that regular reporting behaviour (IR_Regular), which refers to the consistent and timely publication of IR, is influenced by similar factors, reinforcing the notion that transparency is a strategic response to external pressures and internal motivations.

5.2 Conclusions from Empirical Chapters

In the first empirical chapter, I conclude that investor demand for GB is consistently higher than the matched non-GB in the primary market worldwide. I further report that the demand for GB is higher across industries, whether it is a GB issued by financial or non-financial firms.[33] Our findings are consistent with the signalling theory and socially responsible investment principles. The GB issuance provides signals to investors about the firm's

[33] The financial firms issue GB to finance the environmental friendly projects of their loan customers whereas the non-financial firms issue GB to finance their own green projects.

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 the extremes (i.e., *value-based* and *values-based)* of investors and all other that lies between them, signalling 'higher future firm value' and 'environmental contribution, also known as the socially responsible investing (SRI)'.

In the second empirical chapter, I conclude that the GB issuers' profile, including ex-ante ESG performance (proxied by their lower carbon emissions and higher green innovation) and the firm's ESG risks (captured by their negative environmental incidents including potential greenwashing), explain the heterogeneous demand for GB in the primary market. These Novel findings benefit the GB issuers as they can improve the relevant parameters and attract investors as required. This is also important for investors' decision making before they buy the GB issued in the primary markets.

In the third empirical chapter, I conclude that low-emitting firms are more inclined to publish IR post GB issuance as a credible signal of their superior environmental performance, consistent with signalling theory. Being resource-intensive and transparent, IR publication is a costly signal that higher-emitting competitors cannot replicate. Similarly, the results show that polluting firms are also motivated to disclose the incremental achievenment through the GB proceeds use. This suggests that while vocal green firms signal superior environmental performance, polluting firms may use IRs to signal incremental improvements or overcome regulatory scrutiny (Becker & Henderson 2000) which non-polluting does not face.

On the other hand, legitimacy theory offers a lens through which to interpret the influence of environmental risk on reporting behaviour. As firms face increasing scrutiny over their environmental impacts, the pressure to demonstrate accountability and align with societal norms intensifies. Hence, I conclude that ecological risk-facing firms have the motivation for GB's impact reporting as a legitimatising strategy. This finding raises important questions

about the role of green finance in driving meaningful environmental accountability. While GB is intended to channel investments toward sustainable projects, the need for more transparency among high-emitting and environmental risk facing issuers undermines their credibility and effectiveness.

Overall, I conclude that the green characteristics of GB are a powerful signal that attracts investors to the primary market. This stringent requirement and rigorous process of GB issuance makes it a more credible candidate than a matched non-GB, leading to a substantially higher demand for GB. This greenness of GB inherently appeals to *values-based* investors, it also attracts *value-based* investors due to its lower information asymmetry on proceeds use, lower coupons, and better credibility. Furthermore, investors consider the GB issuer firms' ex-ante GB issuance environmental performance, their green initiatives, and ESG-related risks. These ex-ante better performance and lower risks explain the heterogeneity in greenness demand between the GB and non-GB issuers.

Despite the international capital markets association's GB principles prescription on GB's impact reporting, not all issuers publicly release their impact reports after GB issuance. Our results conclude that vocal green firms and environmental risk-facing firms are motivated to publish their IR for credible signals and legitimacy gains, respectively. Furthermore, GB issuers from polluting industries are more sensitive to IR publication and legitimacy gains.

5.3 Implication

This study offers practical implications to multiple stakeholders. Corporations should 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. I recommend that regulators devise a supportive mechanism that

enhances countries' environmental commitment and boosts global GB demand. Governments can incentivise corporations to encourage the issuance of GB, offer clear guidelines, establish green infrastructure, develop green technology, and enhance green energy production.

From a policy perspective, these findings have several implications. First, regulators and standard-setting bodies should consider incorporating mandatory disclosure requirements for GB issuers to ensure consistency and comparability in reporting. As demonstrated by the European Union's GB Standard (EU-GBS), a harmonised framework for IR can enhance market confidence and prevent greenwashing. Second, stakeholders, including investors, civil society organisations, and rating agencies, should demand greater accountability from high-emission firms to bridge the gap between environmental performance and transparency. Third, firms can benefit from adopting a more proactive approach to reporting, as transparency mitigates risks, attracts impact investors, and enhances their reputation.

5.4 Future Direction

Through GB issuance alongside policymakers' support, the country's environmental commitment, and firms' responsible investment initiatives, we can attract a large investment pool to support the global net zero target and the United Nation (UN) Sustainable Development Goals (SDGs). Further research should explore the possibility of greenwashing through GB issuance and intervention needs to maintain the green credibility of GBs. Similarly, researcher may examine whether GB contributes to green innovation, and investigate the factors influencing the demand for GB in the secondary market.

My studies do not capture the outcome of GB's actual impact on the environment and society. Hence, future research may exploit this opportunity and offer the role of GB and issuer firms in impact creation. Furthermore, I report the issuers' motivations for impact reporting but not the outcome post impact reporting. It opens up a possibility of exploring studies to measure the outcome in firms post impact reporting and offer guidelines for harmonised practices.

References

Akerlof, G.A., 1970. The market for “lemons”: Quality uncertainty and the market mechanism. The Quarterly Journal of Economics 84, 488-500

Alessi, L., Ossola, E., Panzica, R., 2021. What greenium matters in the stock market? The role of greenhouse gas emissions and environmental disclosures. Journal of Financial Stability 54, 100869

Alharbi, S.S., Al Mamun, M., Boubaker, S., Rizvi, S.K.A., 2023. Green finance and renewable energy: A worldwide evidence. Energy Economics, 106499

Allen, F., 1991. Asymmetric Information and the Role of Intermediaries in Financial Markets. Review of Economic Studies 58, 529-547

Ambec, S., Lanoie, P., 2008. Does it pay to be green? A systematic overview. The Academy of Management Perspectives, 45-62

Amiraslani, H., Lins, K.V., Servaes, H., Tamayo, A., 2023. Trust, social capital, and the bond market benefits of ESG performance. Review of Accounting Studies 28, 421-462

Andriosopoulos, D., Czarnowski, P., Marshall, A.P., 2022. Does green innovation increase shareholder wealth? In: Available at SSRN 4012633

Apergis, N., Poufinas, T., Antonopoulos, A., 2022. ESG scores and cost of debt. Energy Economics 112, 106186

Arrow, K.J., 1963. Uncertainty and the Welfare Economics of Medical Care. The American Economic Review 53, 941-973

Asante-Appiah, B., Lambert, T.A., 2022. The role of the external auditor in managing environmental, social, and governance (ESG) reputation risk. Review of Accounting Studies, 1-53

Azar, J., Duro, M., Kadach, I., Ormazabal, G., 2021. The big three and corporate carbon emissions around the world. Journal of Financial Economics 142, 674-696

Baker, M., Bergstresser, D., Serafeim, G., Wurgler, J., 2022. The pricing and ownership of US green bonds. Annual Review of Financial Economics 14, 415-437

Bansal, P., Clelland, I., 2004. Talking trash: Legitimacy, impression management, and unsystematic risk in the context of the natural environment. Academy of Management Journal 47, 93-103

Barbiero, F., Schepens, G., Sigaux, J.d., 2024. Liquidation value and loan pricing. The Journal of Finance 79, 95-128

Beber, A., Brandt, M.W., Kavajecz, K.A., 2009. Flight-to-quality or flight-to-liquidity? Evidence from the euro-area bond market. The Review of Financial Studies 22, 925-957

Becker, R., Henderson, V., 2000. Effects of air quality regulations on polluting industries. Journal of Political Economy 108, 379-421

Bessembinder, H., Jacobsen, S., Maxwell, W., Venkataraman, K., 2022. Overallocation and secondary market outcomes in corporate bond offerings. Journal of Financial Economics 146, 444-474

Bhutta, U.S., Tariq, A., Farrukh, M., Raza, A., Iqbal, M.K., 2022. Green bonds for sustainable development: Review of literature on development and impact of green bonds. Technological Forecasting and Social Change 175, 121378

Bingler, J.A., Kraus, M., Leippold, M., Webersinke, N., 2024. How cheap talk in climate disclosures relates to climate initiatives, corporate emissions, and reputation risk. Journal of Banking & Finance, 107191

Blouin, M.R., 2003. Equilibrium in a decentralized market with adverse selection. Economic Theory 22, 245-262

Bolton, P., Kacperczyk, M., 2021. Do investors care about carbon risk? Journal of Financial Economics 142, 517-549
Boubakri, N., Chkir, I., Saadi, S., Zhu, H., 2021. Does national culture affect corporate innovation? International evidence. Journal of Corporate Finance 66, 101847
Branco, M.C., Rodrigues, L.L., 2006. Corporate social responsibility and resource-based perspectives. Journal of Business Ethics 69, 111-132
Brugler, J., Comerton-Forde, C., Martin, J.S., 2022. Secondary market transparency and corporate bond issuing costs. Review of Finance 26, 43-77
Caramichael, J., Rapp, A.C., 2024. The green corporate bond issuance premium. Journal of Banking & Finance 162, 107126
Carter, R., Manaster, S., 1990. Initial public offerings and underwriter reputation. Journal of Finance 45, 1045-1067
Ceccarelli, M., Ramelli, S., Wagner, A.F., 2024. Low carbon mutual funds. Review of Finance 28, 45-74
Chang, L., Taghizadeh-Hesary, F., Chen, H., Mohsin, M., 2022. Do green bonds have environmental benefits? Energy Economics 115, 106356
Cho, C.H., Patten, D.M., 2007. The role of environmental disclosures as tools of legitimacy: A research note. Accounting, Organizations and Society 32, 639-647
Clarkson, P.M., Fang, X., Li, Y., Richardson, G., 2013. The relevance of environmental disclosures: Are such disclosures incrementally informative? Journal of Accounting and Public Policy 32, 410-431
Clarkson, P.M., Li, Y., Richardson, G.D., Vasvari, F.P., 2008. Revisiting the relation between environmental performance and environmental disclosure: An empirical analysis. Accounting, Organizations and Society 33, 303-327
Climate Bonds Initiative, 2019. Climate Bonds Standard. pp. 1-34
Climate Bonds Initiative, 2021a. Green Bond Pricing in the Primary Market. pp. 1-30
Climate Bonds Initiative, 2021b. Post-issuance Reporting in the Green Bond Market. p. 58
Cohen, B.D., Dean, T.J., 2005. Information asymmetry and investor valuation of IPOs: Top management team legitimacy as a capital market signal. Strategic Management Journal 26, 683-690
Connelly, B.L., Certo, S.T., Ireland, R.D., Reutzel, C.R., 2011. Signaling theory: A review and assessment. Journal of Management 37, 39-67
Costantini, M., Sousa, R.M., 2022. What uncertainty does to euro area sovereign bond markets: Flight to safety and flight to quality. Journal of International Money and Finance 122, 102574
Couaillier, C., LO DUCA, M., Reghezza, A., RODRIGUEZ D'ACRI, C., 2024. Caution: Do Not Cross! Distance to Regulatory Capital Buffers and Corporate Lending in a Downturn. Journal of Money, Credit and Banking
Dass, N., Nanda, V., Xiao, S.C., 2017. Truncation bias corrections in patent data: Implications for recent research on innovation. Journal of Corporate Finance 44, 353-374
Daubanes, J.X., Mitali, S.F., Rochet, J.-C., 2021. Why Do Firms Issue Green Bonds? Swiss Finance Institute Research Paper
Deegan, C., 2002. Introduction: The legitimising effect of social and environmental disclosures–a theoretical foundation. Accounting, Auditing & Accountability Journal 15, 282-311
Deegan, C., Rankin, M., Tobin, J., 2002. An examination of the corporate social and environmental disclosures of BHP from 1983-1997: A test of legitimacy theory. Accounting, Auditing & Accountability Journal 15, 312-343

Degryse, H., Goncharenko, R., Theunisz, C., Vadasz, T., 2023. When green meets green. Journal of Corporate Finance, 102355
Delis, M., De Greiff, K., Ongena, S., 2018. Being stranded on the carbon bubble? Climate policy risk and the pricing of bank loans. SFI Research Paper
Delmas, M.A., Burbano, V.C., 2011. The drivers of greenwashing. California Management Review 54, 64-87
Derrien, F., Krueger, P., Landier, A., Yao, T., 2021. ESG news, future cash flows, and firm value. Swiss Finance Institute Research Paper
Diamond, D.W., Verrecchia, R.E., 1991. Disclosure, liquidity, and the cost of capital. The Journal of Finance 46, 1325-1359
Dierkens, N., 1991. Information asymmetry and equity issues. Journal of Financial and Quantitative Analysis 26, 181-199
Dinh, T., Eugster, F., Husmann, A., 2023. Corporate Green Bonds: The Role of External Reviews for Investment Greenness and Disclosure Quality. Available at SSRN 4419454
Dutordoir, M., Li, S., Neto, J.Q.F., 2023. Issuer Motivations for Corporate Green Bond Offerings. British Journal of Management
Dyck, A., Lins, K.V., Roth, L., Wagner, H.F., 2019. Do institutional investors drive corporate social responsibility? International evidence. Journal of Financial Economics 131, 693-714
Eckbo, B.E., 1986. Valuation effects of corporate debt offerings. Journal of Financial Economics 15, 119-151
Edmans, A., Kacperczyk, M., 2022. Sustainable finance. Review of Finance 26, 1309-1313
Edmans, A., Levit, D., Schneemeier, J., 2022. Socially responsible divestment. European Corporate Governance Institute–Finance Working Paper
El Ghoul, S., Guedhami, O., Kwok, C.C., Mishra, D.R., 2011. Does corporate social responsibility affect the cost of capital? Journal of Banking & Finance 35, 2388-2406
ElBannan, M.A., Löffler, G., 2024. How effectively do green bonds help the environment? Journal of Banking & Finance 158, 107051
Fatica, S., Panzica, R., Rancan, M., 2021. The pricing of green bonds: are financial institutions special? Journal of Financial Stability 54, 100873
Flammer, C., 2020. Green bonds: effectiveness and implications for public policy. Environmental and Energy Policy and the Economy 1, 95-128
Flammer, C., 2021. Corporate green bonds. Journal of Financial Economics 142, 499-516
Galaskiewicz, J., 1997. An urban grants economy revisited: Corporate charitable contributions in the Twin Cities, 1979-81, 1987-89. Administrative Science Quarterly, 445-471
Gomulya, D., Mishina, Y., 2017. Signaler credibility, signal susceptibility, and relative reliance on signals: How stakeholders change their evaluative processes after violation of expectations and rehabilitative efforts. Academy of Management Journal 60, 554-583
Grossman, S.J., 1981. The informational role of warranties and private disclosure about product quality. The Journal of Law and Economics 24, 461-483
Hart, S.L., 1995. A natural-resource-based view of the firm. Academy of Management Review 20, 986-1014
Hartzmark, S.M., Sussman, A.B., 2019. Do investors value sustainability? A natural experiment examining ranking and fund flows. The Journal of Finance 74, 2789-2837
Haščič, I., Migotto, M., 2015. Measuring environmental innovation using patent data.
He, Y., Kahraman, B., Lowry, M., 2021. ES risks and shareholder voice. European Corporate Governance Institute–Finance Working Paper

He, Y.E., Kahraman, B., Lowry, M., 2023. ES risks and shareholder voice. The Review of Financial Studies 36, 4824-4863
Hegde, D., Ljungqvist, A., Raj, M., 2022. Quick or broad patents? Evidence from US startups. The Review of Financial Studies 35, 2705-2742
Heinkel, R., Kraus, A., Zechner, J., 2001. The effect of green investment on corporate behavior. Journal of Financial and Quantitative Analysis 36, 431-449
Helwege, J., Huang, J.-Z., Wang, Y., 2014. Liquidity effects in corporate bond spreads. Journal of Banking & Finance 45, 105-116
Hoepner, A.G., Oikonomou, I., Sautner, Z., Starks, L.T., Zhou, X., 2023. ESG shareholder engagement and downside risk. Review of Finance 28, 483-510
Hoepner, A.G., Oikonomou, I., Sautner, Z., Starks, L.T., Zhou, X.Y., 2024. ESG shareholder engagement and downside risk. Review of Finance 28, 483-510
Holmström, B., 1979. Moral Hazard and Observability. The Bell Journal of Economics 10, 74-91
Hughes, J.S., Liu, J., Liu, J., 2007. Information asymmetry, diversification, and cost of capital. The Accounting Review 82, 705-729
Hummel, K., Schlick, C., 2016. The relationship between sustainability performance and sustainability disclosure–Reconciling voluntary disclosure theory and legitimacy theory. Journal of Accounting and Public Policy 35, 455-476
ICMA, 2024. Guidance Handbook. pp. 1-48. ICMA
Ilhan, E., Sautner, Z., Vilkov, G., 2021. Carbon tail risk. The Review of Financial Studies 34, 1540-1571
International Capital Market Association, 2018. Green Bond Principles. pp. 1-8
International Capital Market Association, 2021. Green Bond Principles. pp. 1-10
International Capital Market Association, 2022. Handbook: Harmonized Framework for Impact Reporting. p. 75
Ioannou, I., Serafeim, G., 2015. The impact of corporate social responsibility on investment recommendations: Analysts' perceptions and shifting institutional logics. Strategic Management Journal 36, 1053-1081
Jankovic, I., Vasic, V., Kovacevic, V., 2022. Does transparency matter? Evidence from panel analysis of the EU government green bonds. Energy Economics 114, 106325
Kapraun, J., Latino, C., Scheins, C., Schlag, C., 2021. (In)-credibly green: which bonds trade at a green bond premium? In: Proceedings of Paris December 2019 Finance Meeting EUROFIDAI-ESSEC
Karpavičius, S., 2014. Dividends: Relevance, rigidity, and signaling. Journal of Corporate Finance 25, 289-312
Khang, K., King, T.H.D., 2006. Does dividend policy relate to cross-sectional variation in information asymmetry? Evidence from returns to insider trades. Financial Management 35, 71-94
Kim, E.-H., Lyon, T.P., 2015. Greenwash vs. brownwash: Exaggeration and undue modesty in corporate sustainability disclosure. Organization Science 26, 705-723
King, A.A., Lenox, M.J., Terlaak, A., 2005. The strategic use of decentralized institutions: Exploring certification with the ISO 14001 management standard. Academy of Management Journal 48, 1091-1106
Klassen, R.D., McLaughlin, C.P., 1996. The impact of environmental management on firm performance. Management Science 42, 1199-1214
Klausmann, J., Krueger, P., Matos, P., 2024. The green transition: evidence from corporate green revenues. Available at SSRN 4850449
Kleimeier, S., Viehs, M., 2018. Carbon disclosure, emission levels, and the cost of debt. In: Available at SSRN

Kogan, L., Papanikolaou, D., Seru, A., Stoffman, N., 2017. Technological innovation, resource allocation, and growth. The Quarterly Journal of Economics 132, 665-712
Kölbel, J.F., Busch, T., Jancso, L.M., 2017. How media coverage of corporate social irresponsibility increases financial risk. Strategic Management Journal 38, 2266-2284
KPMG, 2015. Gearing up for green bonds. p. 16
Krebbers, A., Marshall, A., McColgan, P., Neupane, B., 2021. Bookrunner syndicate geography and the quality of service: The benefits of a local team. Journal of International Money and Finance 119, 102500
Krebbers, A., Marshall, A., McColgan, P., Neupane, B., 2023. Orderbook demand for corporate bonds. European Financial Management 29, 247-287
Krueger, P., Sautner, Z., Starks, L.T., 2020. The importance of climate risks for institutional investors. The Review of Financial Studies 33, 1067-1111
Lambert, R.A., Leuz, C., Verrecchia, R.E., 2012. Information asymmetry, information precision, and the cost of capital. Review of Finance 16, 1-29
Larcker, D.F., Watts, E.M., 2020. Where's the greenium? Journal of Accounting and Economics 69, 101312
Leland, H.E., Pyle, D.H., 1977. Informational asymmetries, financial structure, and financial intermediation. The Journal of Finance 32, 371-387
Liu, C., Wang, S.L., Li, D., 2022. Hidden in a group? Market reactions to multi-violator corporate social irresponsibility disclosures. Strategic Management Journal 43, 160-179
Longstaff, F.A., 2004. The Flight-to-Liquidity Premium in U.S. Treasury Bond Prices. The Journal of Business 77, 511-526
Luong, H., Moshirian, F., Nguyen, L., Tian, X., Zhang, B., 2017. How do foreign institutional investors enhance firm innovation? Journal of Financial and Quantitative Analysis 52, 1449-1490
Lyon, T.P., Maxwell, J.W., 2011. Greenwash: Corporate environmental disclosure under threat of audit. Journal of Economics & Management Strategy 20, 3-41
Marquis, C., Toffel, M.W., Zhou, Y., 2016. Scrutiny, norms, and selective disclosure: A global study of greenwashing. Organization Science 27, 483-504
Matos, P., 2020. ESG and responsible institutional investing around the world: A critical review. CFA Institute Research Foundation Literature Reviews.
Mazzacurati, J., Paris, W., Tsiotras, A., 2021. Environmental Impact and Liquidity of Green Bonds. ESMA Report on Trends, Risks and Vulnerabilities. No. 2. 2021. pp. 95-105
McCahery, J.A., Sautner, Z., Starks, L.T., 2016. Behind the scenes: The corporate governance preferences of institutional investors. The Journal of Finance 71, 2905-2932
McDonnell, M.-H., King, B., 2013. Keeping up appearances: Reputational threat and impression management after social movement boycotts. Administrative Science Quarterly 58, 387-419
Mikkelson, W.H., Partch, M.M., 1986. Valuation effects of security offerings and the issuance process. Journal of Financial Economics 15, 31-60
Milne, M.J., Patten, D.M., 2002. Securing organizational legitimacy: An experimental decision case examining the impact of environmental disclosures. Accounting, Auditing & Accountability Journal 15, 372-405
Minton, B.A., Schrand, C., 1999. The impact of cash flow volatility on discretionary investment and the costs of debt and equity financing. Journal of Financial Economics 54, 423-460

Montiel, I., Husted, B.W., Christmann, P., 2012. Using private management standard certification to reduce information asymmetries in corrupt environments. Strategic Management Journal 33, 1103-1113
Musteen, M., Datta, D.K., Kemmerer, B., 2010. Corporate reputation: Do board characteristics matter? British Journal of Management 21, 498-510
Ng, A.C., Rezaee, Z., 2015. Business sustainability performance and cost of equity capital. Journal of Corporate Finance 34, 128-149
Nikolova, S., Wang, L., Wu, J.J., 2020. Institutional allocations in the primary market for corporate bonds. Journal of Financial Economics 137, 470-490
Park, H.D., Patel, P.C., 2015. How does ambiguity influence IPO underpricing? The role of the signalling environment. Journal of Management Studies 52, 796-818
Pástor, Ľ., Stambaugh, R.F., Taylor, L.A., 2022. Dissecting green returns. Journal of Financial Economics 146, 403-424
Pedersen, L.H., Fitzgibbons, S., Pomorski, L., 2021. Responsible investing: The ESG-efficient frontier. Journal of Financial Economics 142, 572-597
Piñeiro-Chousa, J., López-Cabarcos, M.Á., Caby, J., Šević, A., 2021. The influence of investor sentiment on the green bond market. Technological Forecasting and Social Change 162, 120351
Pope, P.F., Wang, Y., Xu, H., 2023. Actions Speak Louder than Words: The Effects of Green Commitment in the Corporate Bond Market. In: Available at SSRN
Principles for Responsible Investment, 2021-22. Annual Report. pp. 1-49
Raghunandan, A., Rajgopal, S., 2022. Do ESG funds make stakeholder-friendly investments? Review of Accounting Studies 27, 822-863
Ramelli, S., Ossola, E., Rancan, M., 2021. Stock price effects of climate activism: Evidence from the first Global Climate Strike. Journal of Corporate Finance 69, 102018
Riedl, A., Smeets, P., 2017. Why do investors hold socially responsible mutual funds? The Journal of Finance 72, 2505-2550
Risk, C.R.I.I., 2020. A fundamental reshaping of finance.
Ross, S.A., 1973. The Economic Theory of Agency: The Principal's Problem. The American Economic Review 63, 134-139
Ross, S.A., 1977. The determination of financial structure: the incentive-signalling approach. The Bell Journal of Economics, 23-40
Rothschild, M., Stiglitz, J., 1976. Equilibrium in Competitive Insurance Markets: An Essay on the Economics of Imperfect Information*. The Quarterly Journal of Economics 90, 629-649
Schnatterly, K., Johnson, S.G., 2014. Independent boards and the institutional investors that prefer them: Drivers of institutional investor heterogeneity in governance preferences. Strategic Management Journal 35, 1552-1563
Sharfman, M.P., Fernando, C.S., 2008. Environmental risk management and the cost of capital. Strategic Management Journal 29, 569-592
Shishlov, I., Morel, R., Cochran, I., 2016. Beyond transparency: unlocking the full potential of green bonds. Institute for Climate Economics 2016, 1-28
Spence, M., 1973. Job Market Signalling. The Quarterly Journal of Economics 87, 629-649
Spence, M., 1974. Market Signaling. Harvard University Press, Cambridge, MA
Spence, M., 2002. Signaling in retrospect and the informational structure of markets. American Economic Review 92, 434-459
Starks, L.T., 2023. Presidential Address: Sustainable Finance and ESG Issues—Value versus Values. The Journal of Finance
Stiglitz, J.E., 2002. Information and the Change in the Paradigm in Economics. American Economic Review 92, 460–501

Stiglitz, J.E., Weiss, A., 1981. Credit Rationing in Markets with Imperfect Information. The American Economic Review 71, 393-410
Suchman, M.C., 1995. Managing legitimacy: Strategic and institutional approaches. Academy of Management Review 20, 571-610
Tang, D.Y., Zhang, Y., 2020. Do shareholders benefit from green bonds? Journal of Corporate Finance 61, 101427
Tang, Y., 2021. The Effects of Green and Social Finance on Firms, Markets and the Economy. In: Asian Development Outlook
Thapa, C., Chetteeraphat, A., Paudyal, K., 2023. Do Green Innovations Attract Institutional Investors? Available at SSRN 4594648
Verrecchia, R.E., 1983. Discretionary disclosure. Journal of Accounting and Economics 5, 179-194
Wang, L., Wu, J., 2023. Deciphering greenium: the role of investor demand. SSRN
Wang, Y., Taghizadeh-Hesary, F., 2023. Green bonds markets and renewable energy development: Policy integration for achieving carbon neutrality. Energy Economics 123, 106725
Wei, P., Qi, Y., Ren, X., Duan, K., 2022. Does Economic Policy Uncertainty Affect Green Bond Markets? Evidence from Wavelet-Based Quantile Analysis. Emerging Markets Finance and Trade 58, 4375-4388
Welker, M., 1995. Disclosure policy, information asymmetry, and liquidity in equity markets. Contemporary Accounting Research 11, 801-827
Xu, X., Li, J., 2023. Can green bonds reduce the carbon emissions of cities in China? Economics Letters 226, 111099
Zerbib, O.D., 2019. The effect of pro-environmental preferences on bond prices: Evidence from green bonds. Journal of Banking & Finance 98, 39-60
Zhang, D., 2023. Does green finance really inhibit extreme hypocritical ESG risk? A greenwashing perspective exploration. Energy Economics 121, 106688
Zhang, M., Zhang, S., Lee, C.-C., Zhou, D., 2021. Effects of trade openness on renewable energy consumption in OECD countries: New insights from panel smooth transition regression modelling. Energy economics 104, 105649
Zhou, N., Wang, H., 2020. Foreign subsidiary CSR as a buffer against parent firm reputation risk. Journal of International Business Studies 51, 1256-1282
Ziolo, M., 2021. Finance and sustainable development : designing sustainable financial systems. Routledge, Abingdon, Oxon ; New York, NY.

Appendix 2- A: Geographical Distribution of Green Bonds (GB)

This table reports the entire GB issued worldwide from its debut in 2007 to 2022 and corporate GB that offer fixed coupons, which 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 million dollars, and the share of each country's issue size.

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 2- B: Definitions 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 is divided by the amount of bond issued.	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 the 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. I 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

Appendix 4- A: Definition of Variables

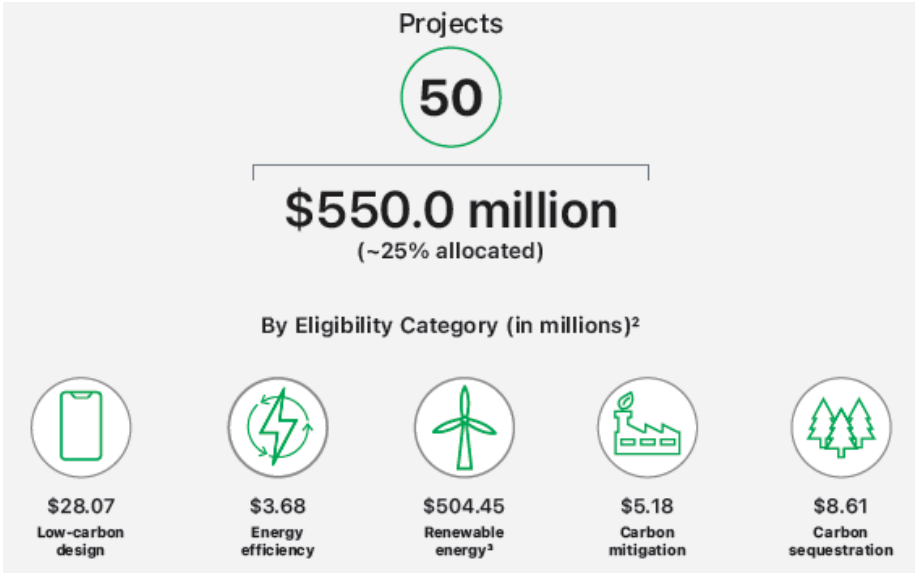
This Table reports all the variables used in the study, along with their definition and data sources.

Variable Names	Definition	Data Source
Independent Variables		
F_CO2Int	The firm's carbon (CO_2) and carbon equivalent (CO_2e) intensity are captured in tonnes per billion US dollar sales revenue. A lower value shows lower emission intensity.	Refinitiv
Env_Risk	A GB issuer firm's ESG-related risk incident index. This index captures each incident's intensity using RepRisk's weights. I compute the yearly sum of product of novelty, reach, and severity weights of environmental incidents firms face. I construct it using the RepRisk data following Bingler *et al.* (2024)	RepRisk and Author calculation
Env_Inc	This is the yearly sum of environmental incidents firms face (Hoepner *et al.* 2024).	RepRisk and Author calculation
Env_GHG	This is the yearly sum of environmental incidents index related to climate change, greenhouse gas emissions (GHG), and global pollution firms face.	RepRisk and Author calculation
Env_Grw1	This is the yearly sum of misleading communication incidents index firms face but specific to environmental issues.	RepRisk and Author calculation
Env_Risk_Nov	This is the yearly sum of novel environmental incidents firms face (Hoepner *et al.* 2024)	RepRisk and Author calculation
Env_Risk_Reach	This is the yearly sum of the reaches of environmental incidents firms face.	RepRisk and Author calculation
Env_Risk_Sev	This is the yearly sum of the severity of environmental incidents firms face.	RepRisk and Author calculation
Dependent Variables		
IR	The dummy variable takes a value of 1 if the firm 'j' has published at least one GB impact report post-GB issuance or 0 otherwise.	Manually checked and noted
ER	The dummy variable takes a value of 1 if the firm 'j' has published at least one GB impact report post-GB issuance, which is examined by an independent auditor and signed at a time 't,' or zero otherwise.	Manually checked and noted

IR_Regular	The dummy variable takes a value of 1 if the firm 'j' has published a GB impact report each year post-GB issuance (our sample covers at least two reports published by GB issuers) at a time 't' or zero otherwise.	Manually checked and noted
SPO	The dummy variable takes a value of one if the firm has any external reviews, such as SPO, certification, or auditor reports about GB, and zero otherwise.	Manually checked and noted
Firm Characteristics (F_Ch_{t-1})		
F_Size	Natural logarithm of firms' Total assets in billions of US dollars.	Refinitiv
F_ROA	The book value of total assets scales operating income before depreciation.	Refinitiv
F_Lev	Total debt is divided by the total assets.	Refinitiv
F_Rev_Gr	This is the annual revenue growth rate.	Refinitiv

Appendix 4- B: Apple Corporation's impact reports (IR) Snapshot and Independent Auditor's Examination Report

Annual GB IR (Fiscal Year 2021 Update): 2019 GB Cumulative Allocation



Projected Environmental Benefits: The 50 projects Apple allocated 2019 GB funds since issuance is estimated to result in the following direct environmental benefits.

1,854,000 MWh Renewable energy generation (annual)	2,883,000 metric tons of CO_2e GHG emissions to be mitigated or offset.	699 MW Newly installed renewable energy capacity

EY Building a better working world

Ernst & Young LLP
303 Almaden Boulevard
San Jose, CA 95110

Tel: +1 408 947 5500
Fax: +1 408 947 5717
ey.com

Report of Independent Accountants

To the Management of Apple Inc.:

We have examined management's assertion, in Exhibit A, that $550.0 million of net proceeds from the 0.000% notes due 2025 and 0.500% notes due 2031 issued by Apple Inc. ("Apple") were allocated, during the period from September 29, 2019 to September 25, 2021 (the "Reporting Period"), to qualifying Eligible Projects that meet one or more of the Eligibility Criteria (each as defined in the "Use of Proceeds" section of the Prospectus Supplement dated November 7, 2019, to the Prospectus dated November 5, 2018, filed by Apple on November 8, 2019, with the Securities and Exchange Commission pursuant to Rule 424(b)(2) under the Securities Act of 1933, as amended). Apple's management is responsible for the assertion, having a reasonable basis for its assertion, selection of the Eligibility Criteria and the allocation, during the Reporting Period, of amounts to Eligible Projects that meet one or more of the Eligibility Criteria. Our responsibility is to express an opinion on the assertion based on our examination.

Our examination was conducted in accordance with attestation standards established by the American Institute of Certified Public Accountants. Those standards require that we plan and perform the examination to obtain reasonable assurance about whether management's assertion is fairly stated, in all material respects. An examination involves performing procedures to obtain evidence about management's assertion. The nature, timing, and extent of the procedures selected depend on our judgment, including an assessment of the risks of material misstatement of management's assertion, whether due to fraud or error. We believe that the evidence we obtained is sufficient and appropriate to provide a reasonable basis for our opinion.

Our examination was not conducted for the purpose of evaluating (i) whether funds in excess of the net proceeds were allocated to Eligible Projects during the Reporting Period, (ii) the amount allocated to each category of Eligible Projects during the Reporting Period, (iii) that any payments made pursuant to any power purchase agreements or virtual power purchase agreements to which amounts were allocated during the Reporting Period were in accordance with such agreements, (iv) the environmental benefits of the Eligible Projects, (v) conformance of any Eligible Projects with any third-party published principles, standards or frameworks, such as the Green Bond Principles, dated June 2018, published by the International Capital Market Association or (vi) any information included in Apple's Annual Green Bond Impact Report, Fiscal Year 2021 Update, other than management's assertion. Accordingly, we do not express an opinion or any other form of assurance other than on management's assertion included in Exhibit A.

In our opinion, management's assertion, included in Exhibit A, that $550.0 million in net proceeds from the 0.000% notes due 2025 and 0.500% notes due 2031 issued by Apple were allocated during the Reporting Period to qualifying Eligible Projects that met one or more of the Eligibility Criteria is fairly stated, in all material respects.

Ernst & Young LLP

February 16, 2022
San Jose, California

Appendix 4- C: RepRisk Methodology

RepRisk adopts a multi-stage procedure to construct the current RepRisk Index (RRI). First, it has a proprietary search algorithm that traces worldwide media sources in 23 languages daily from news outlets, government and NGO websites, blogs, and social media. Second, it has trained analysts who select and classify significant events. The events are categorised based on the number of affected countries, company/companies involved in the issue, the severity of the crisis, and the reach/importance of the media that reported the problem. The severity of the situation is rated on a scale of 1 (low) to 3 (high).

The severity is determined via a rule-based method as a function of three dimensions, that is, (a) the consequence of the risk incident (e.g., concerning health and safety: no further consequences, injury, or death); (b) the extent of the risk incident (i.e., one person, a group of people, a large number of people); (c) whether the risk is caused by an accident, by negligence, or intent, or even in a systematic way. The reach of the media in which the crisis is reported is rated on a scale of 1 (low) to 3 (high). For instance, independent watchdog reports are classified as 1, whereas significant news outlets, such as the BBC and WSJ, are classified as 3. Third, selected and categorised data are verified by an independent senior analyst for accuracy.

RepRisk began in 2006, and now it screens above 246,000 firms using 100,000 public sources (including media, regulatory, and commercial documents) in 23 different languages daily for adverse ESG incidents. Across these sources, they search for 28 mutually exclusive ESG issues that were defined by essential international standards as set by, for example, the World Bank and OECD, plus three other categories, which are more loosely named “other environmental,” “other social,” and “other governance.” These issues are then classified into subcategories of environmental (e.g., climate change), social (e.g., poor employment conditions), and governance (e.g., misleading communication, executive compensation). I focus on the environmental incidents, their severity, novelty, and reach and cover the issues

related to "climate change, GHG emissions, and global pollution," local pollution, and "overuse and wasting of resources."[34] Additionally, I explore the "misleading communication including greenwashing" from governance subcategories related to environmental incidents.

He *et al.* (2023) highlight the following two remarkable points related to RepRisk data: first, for any event that multiple news outlets cover, RepRisk eliminates these duplicates and considers them the most reliable source. Second, for any event that relates to various issues, for example, "impacts on landscapes ecosystems and biodiversity" and "occupational health and safety issues," as in the case of the BP Deepwater Horizon oil spill, RepRisk records both underlying factors. To obtain a more comprehensive measure of ESG-related incidents, I take advantage of this level of detail in the data through the RepRisk database.

[34] A complete list of the 28 RepRisk issues and more detail on RepRisk is available here.