Norwegian School of Economics
Bergen, Spring 2023

Green Bond Issuance Frequency and Corporate Cost of Capital

Elvin Gahramanov and Mesbah Uddin Suruj

Supervisor: Darya Yuferova

Master thesis, Economics and Business Administration

Major: Financial Economics

NORWEGIAN SCHOOL OF ECONOMICS

This thesis was written as a part of the Master of Science in Economics and Business Administration at NHH. Please note that neither the institution nor the examiners are responsible − through the approval of this thesis − for the theories and methods used, or results and conclusions drawn in this work

Acknowledgments

This master thesis marks the completion of our Master of Science in Economics and Business Administration at the Norwegian School of Economics (NHH).

The experience of coordinating and writing this thesis has certainly been challenging, but ultimately very rewarding. Our thesis has been inspired by the growing body of research on the role of firms and the investment community in contributing to a sustainable future. We saw the opportunity to further shed light on how repetitive green bond issuance can reduce corporate cost of capital and improve firms environmental, social and governance (ESG) score.

We express our deepest gratitude to our supervisor, Darya Yuferova, for her stimulating feedback and support over the course of writing this thesis. Your willingness to share ideas and suggestions has helped us to shape this thesis into a final product of which we can be proud. Also, we thank the library staff and the Finance department at NHH for providing us access to crucial data. Finally, we would like to thank our families and friends for the invaluable encouragement and support we received throughout our studies.

Norwegian School of Economics

Bergen, May 2023

Elvin Gahramanov

Mesbah Uddin Suruj

Abstract

This thesis examines the controversial cost-of-capital advantage of green bonds over conventional bonds in the green bond market. While anecdotal evidence suggested a cheaper cost of capital for green bonds, previous studies mostly focused on market reactions, coupon rates, and environmental scores, leaving a literature gap regarding the effect of green bond issuance on the corporate cost of capital.

To address this gap, the thesis investigates the impact of frequent green bond issuance on the corporate cost of capital, comparing it to companies issuing a single green bond or only conventional bonds. Employing the difference-in-difference (DiD) method, the study analyzes changes in the cost of capital components, debt, and equity following multiple green bond issuances. A sample of 1462 green bonds issued by 787 universe public corporations between January 2015 and January 2023 is utilized, alongside a benchmark group of conventional bond issuers without green bonds for comparison. The dataset includes both bond-level and firm-level data retrieved from the Thomson Reuters Eikon datastream.

This study contributes to the literature by uniquely focusing on the relationship between green bond issuance frequency and the issuer's cost of capital, shedding light on financial implications. The findings of the study suggest that repetitive green bond issuers experience a lower cost of equity compared to first-time issuers of both green and conventional bonds. However, there is no significant evidence supporting a lower overall cost of capital for firms with frequent green bond issuance, which aligns with previous research by Flammer (2020) that find no pricing differential for corporate green bonds. This contradicts the cost of capital argument, which suggests that companies would issue green bonds to benefit from a cheaper source of financing.

Content

List of Figures

List of Tables

List of Acronyms

$	Symbol of United States Dollar
%	Symbol of Percent
€	Symbol of Euro sign
bps	Basis point
CBI	Climate Bonds Initiative
CBS	Climate Bond Standard
CNY	Chinese Yuan Renminbi
COD	Cost of debt
COE	Cost of equity
CSR	Corporate Social responsibility
DID	Difference -in-Differences
ESG	Environmental, Social, and Governance
EU	European Union
EUR	European Union currency
GB	Green Bond
GBP	Green Bond Principles
GHG	Greenhouse gas
ICMA	International Capital Market Association
IFC	International Finance Corporation
LTD	Long-term cost of debt
Q3	Third Quartile
ROA	Return on assets
STD	Short-term cost of debt
TA	Total asset
TRBC	Thomson reuters business classification
UK	United Kingdom
USD	United States Dollar
WACC	Weighted average cost of capital
YTM	Yield to maturity

1. Introduction

The cost of capital advantage of green bonds over conventional bonds has been a matter of controversy since the inception of the green bond market. During the initial period of the market, anecdotal statements made by green bond issuers regarding the oversubscription of their bonds and the resultant pricing disparity compared to similar conventional bonds provided the basis for market participants to contend that green bonds confer a cheaper cost of capital (Harrison, 2017b). However, the existing evidence in this area is limited since previous studies on green bonds have primarily examined the market reactions of stock prices to green bond issuance as well as the impact on coupon rates and the firm's environmental score, leaving a gap in the literature regarding the effect of green bond issuance on the corporate cost of capital.

To fill this gap, this thesis aims to investigate the impact of frequent green bond issuance on the corporate cost of capital as compared to companies that issue a single green bond and those that issue only conventional bonds. By applying the difference-in-difference (DiD) method, we aim to examine whether there are any changes in the cost of capital after companies issue more than one green bond. Additionally, we analyse how the two determinants of the cost of capital (the cost of debt and the cost of equity) change in the case of repetitive issuance. Our study utilizes a sample of 1462 green bonds issued by 787 distinct public corporations within the universe, spanning from January 2015 to January 2023. The selection of a benchmark group comprising public firms that solely issue conventional bonds and do not issue green bonds during the same period was undertaken with the aim of ensuring a comparable profile to the group of firms that issue green bonds.

This study stands out due to its unique focus on exploring the impact of green bond issuance frequency on an issuer's cost of capital, which distinguishes it from prior research that primarily examined capital market responses to green bond issuance. By addressing this novel research question, it sheds light on the potential relationship between the frequency of green bond issuance and the financial implications for the issuer.

Our thesis findings indicate that repetitive issuers of green bonds enjoy a reduced cost of equity in comparison to first-time issuers of both green and conventional bonds, as well as repetitive issuers of conventional bonds. However, our study does not yield significant

evidence to support the notion that firms with frequent green bond issuance experience a lower overall cost of capital, aligning with the cost of capital argument put forth by Flammer (2020).

Taking into account that the initial purpose of the first green bond issuance was to facilitate lending for climate-focused projects, our study further contributes to the ongoing discourse on climate change mitigation and the role of corporate financing in realizing sustainability objectives by investigating the association between green bond issuance and financial outcomes.

Over the past two decades, climate change has increasingly gained recognition as a significant issue, impacting a wide array of industries and sectors on a global scale. The extensive effects of climate change raise concerns regarding its potential to impede fundamental human functions should the current trajectory persist (Stern, 2007). Considering these potential consequences, regulatory bodies have proactively initiated measures to mitigate the impact of climate change and address its effects.

The introduction of the Paris Climate Agreement in 2015 and the European Green Deal in 2019 have both addressed the threat of climate change by introducing new frameworks and laws to limit greenhouse gas emissions and ultimately achieve climate neutrality by 2050 (United Nations, 2015); (European Commission, 2021). All corporations across the globe must consider these laws and frameworks in their operational activities and reporting. New reporting requirements and standards have made the environmental, social, and governance (ESG) impact of companies measurable.

Investors, specifically institutional investors, have incorporated socially responsible practices as one of their criteria alongside traditional financial factors in response to the increasing trend towards responsible investing. Therefore, corporations that display positive environmental and social signals are more likely to be rewarded by investors (Berry & Junkus, 2013). At the same time, climate change created the need for environmentally friendly and sustainable funding. The concept of green financing was introduced to increase financial flows to sustainable development priorities from the public, private, and non-profit sectors (Bracking, 2019).

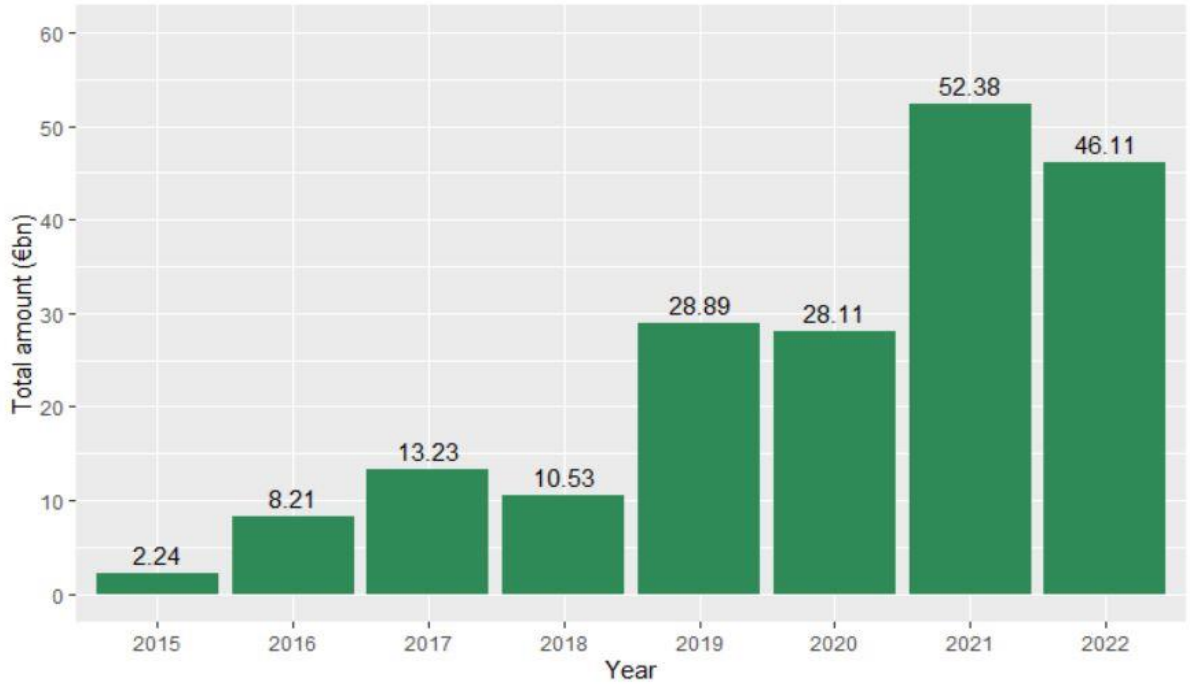
To finance the mitigation and prevention of climate change, new innovative mechanisms

have been created to serve this goal. Green bonds are one of these financial instruments created recently and have become an increasingly important financing method to fund projects with positive environmental impacts. They are like conventional bonds, but they are labeled as green by the issuer with the purpose of allocating capital to beneficial climate and environmental projects (Flammer, 2021).

A healthy green bond market encourages risk sharing in green development, lowers costs for green companies, and promotes economic growth by directing money from the public and private sectors to initiatives with favorable environmental outcomes. Therefore, a properly operating market for green bonds has the potential to facilitate the shift towards a trajectory of sustainable growth. Green bond issuance worldwide increased from USD 2 billion in 2015 to USD 46 billion in 2022 (Figure.1).

Figure 1: Annual Green Bond Market Issuance

Figure 1 visually illustrates the yearly issuance of green bonds in the global market, spanning from 2015 until the last quarter of 2022, offering a clear representation of the market's growth and trends during this timeframe.



Financial markets are aware of the increasing risks associated with climate change and have already started to price such risks, promoting the supply of and demand for green bonds across the world. On the supply side, the literature shows that green bond issuers can benefit

in several ways from issuing green bonds. For instance, green bond issuance might reduce funding costs through a negative premium, known as "greenium", that has been documented several times for green bonds relative to similar conventional bonds (Zerbib, 2019); (Barker et al., 2018). Issuing green bonds can also gain positive recognition and attract a more diversified investor base (Flammer, 2021). On the demand side, green bond investing has various advantages for institutional investors. For example, investing in social initiatives can result in consistent capital inflows (Riedl & Smeets, 2017). Green bond investments also provide hedging and diversification benefits (Naeem et al., 2021).

However, there are several significant challenges in the green bond market. One of the key challenges is the information asymmetry problem, which has always been a key issue in financial markets. Although disclosing information through green bond labels and third-party verification can help reduce information asymmetry, it also comes with additional expenses for issuers, which could affect their decision to use the green bond market for funding. Green bond issuers face higher costs compared to conventional bond issuers since they need to develop the ability to identify green projects, monitor and report the use of the proceeds regularly, and hire a third-party intermediary to examine or certify their green bonds. Notwithstanding the numerous advantages of green bond issuance as documented in the literature, profit-maximizing issuers may be discouraged from doing so due to the additional expenses. The costs associated with issuing and managing green bonds are notably burdensome for first-time issuers and infrequent issuers. This is primarily due to the lack of established infrastructure and expertise that can be leveraged for subsequent green bond issuances.

One possible way to reduce costs for green bond issuers is to issue green bonds frequently. Green bond issuers typically acquire knowledge and expertise after their first green bond issuance, which in turn reduces their marginal costs for subsequent green bond issuances. As a result, frequent green bond issuers provide investors with more information on their issuances at a significantly lower cost compared to first-time green bond issuers or conventional bond issuers. Adopting a green financing policy and issuing frequent green bonds can reduce information asymmetry, lower perceived risk, and improve stock market liquidity. By providing consistent information about environmental commitments and project performance, issuers bridge the information gap with investors, reducing uncertainty. This increased transparency improves the market's perception of risk, making green bonds more attractive. As investor confidence grows, the broader investor base increases, leading to

higher trading volumes and improved stock market liquidity. These factors contribute to a transparent and robust market for sustainable investments, supporting the growth of sustainable finance.

In addition to information asymmetry, frequent issuance also reinforces the signaling impact. (Flammer, 2021) examines how the stock market responds to the issuance of corporate green bonds, and she finds that the stock market responds positively to the green bond issuance announcement, and this response is specifically stronger for certified green bonds and first-time issuers. The stock market's positive response to a first-time green bond issuance may not necessarily translate to an immediate change in the issuer's cost of capital because the cost of capital is determined by different factors such as the issuer's risk profile and market conditions, and the impact of green bond issuance on these factors may take time to manifest.

In the case of frequent green bond issuance, the impact on the issuer's cost of capital could be more pronounced, specifically due to the demonstration of consistent commitment to sustainability and environmental responsibility, which in turn could lead to a sustained positive market response and potentially a lower cost of capital for the issuer.

Moreover, frequent green bond issuers profit more from information disclosure than less frequent issuers since they have a history of issuing green bonds, which further strengthens their social capital. As a result, frequent bond issuance reduces the information gap between issuers and investors while also signaling a company's commitment to sustainability.

This thesis seeks to contribute to a deeper understanding of green bonds. Specifically, we aim to shed light on the effect of frequent green bond issuance on the corporate cost of capital. Flammer (2021) finds no pricing difference between green bonds and conventional bonds issued by the same issuer, and her result is inconsistent with a cost of capital argument, according to which green bonds would provide cheaper financing. This thesis seeks to expand Flammer's (2021) study and investigate whether frequent green bond issuers earn a premium that is not available for first-time green bond issuers and conventional bond issuers.

Thus, we pose the following research question:

> *Does the corporate cost of capital (the weighted average cost of debt and cost of equity) for firms with frequent green bond issuance differ from that of first-time green bond issuers and conventional bond issuers and if so, how significant is the difference? Additionally, is this effect specific to green bond issuance, or is it also observable for conventional bond issuance?*

To our knowledge, there is currently no existing research that directly explores the connection between the cost of capital and the response of green bond issuance. However, comprehending this relationship is of utmost importance in determining whether issuers of green bonds effectively attain measurable enhancements in their financial costs.

In this context, our contribution to the literature on green bonds involves examining two key aspects:

i) The market's perception of repetitive green bond issuance as a signaling mechanism: We aim to understand how the market interprets and responds to the frequent issuance of green bonds by issuers. This investigation will shed light on whether market participants view green bond issuance as a positive signal, indicating a commitment to sustainable and environmentally friendly practices.

ii) The reasonableness of the market's response based on subsequent changes in the issuer's cost of capital: We analyze the market's reaction to green bond issuance and evaluate whether the observed changes in the issuer's cost of capital align with the expectations set by the market. This assessment will help determine whether the market's response is justified and whether green bond issuers experience tangible improvements in their financial costs.

The findings of our thesis suggest that when companies issue green bonds repetitively, they experience a 0.013% decrease in their cost of equity compared to when they issue conventional bonds. This implies that investors perceive frequent green bond issuers as being more committed to environmental responsibility and social consciousness. However, the study does not find significant evidence to support the notion that companies issuing green bonds frequently enjoy a lower overall cost of capital. This suggests that although there may be a cost-of-equity benefit, it is not significant enough to impact the issuer's overall cost of capital, which takes into account both equity and debt components. The only result that we find

statistically significant is that frequent issuance of conventional bonds leads to a decrease in the cost of capital. However, it is important to highlight that the economic impact of this decrease is extremely small, amounting to only 0.005% of the average cost. Consequently, this decrease is considered economically negligible, implying that it holds little practical significance or material impact.

The rest of our thesis is structured as follows: Chapter 2 provides background insights on the green bond market and signaling theory before summarizing the literature to date on the impact of green bond issuance frequency on the issuer's cost of capital. We describe the data used in Chapter 3. In chapter 4, we present and discuss our empirical analysis, which includes information on the methodology and results related to our research question. Finally, we summarize the implications of our findings and discuss suggestions for further research in Chapter 5.

2. Background and Literature Review

The background and literature review section of this study is structured into three main parts. Firstly, the evolution and growth of the global green bond market are examined. Next, we discuss how frequent green bond issuance, signaling theory, and green bond credibility are related to each other. Finally, this study conducts a thorough review of the existing research on green bonds and their implications for financial performance. The literature review is then summarized, and the study's hypotheses are introduced.

2.1 Definition of green bonds

The International Capital Market Association (ICMA) defines green bonds as "any type of bond instrument where the proceeds will be exclusively applied to finance or refinance, in part or in full, new and/or existing eligible green projects and which are aligned with the four core components of the Green Bond Principles" (The Green Bond Principles, 2018, p. 3). The definition of green bond is not consistent in the financial literature. The various definitions of green bonds all have one thing in common: they all allocate at least some of the proceeds to environmentally friendly projects, particularly those focusing on climate change mitigation and adaptation.

There are several different guidelines that green bond issuers are expected to follow. One of these guidelines is called the Green Bond Principles (GBP). GBP were established by the ICMA. These guidelines are meant as a tool to give credibility to green bonds. They are meant to be used broadly in the market to encourage the necessary transparency and disclosure and to promote integrity in the development of the green bond market by clarifying the approach for the issuance of a green bond (The Green Bond Principles, 2017).

The primary distinction between a conventional bond and a green bond is how the proceeds are used. The proceeds of the green bond are used for green projects, most of which focus on environmental, climate, and social benefits (Flammer, 2021). A green bond has the same risk and return profile as any other bond in the fixed-income market. The bond price and yield to maturity (YTM) are comparable. Therefore, the similar YTM, in addition to the green label, might increase investor interest in green bonds.

2.1.1 Development of the green bond market

The development of the green bond market has gained significant momentum in recent years, driven by the growing global concern for environmental sustainability and the urgent need to address climate change. The market has witnessed substantial growth both in terms of issuance volume and diversity of participants. This development can be attributed to various factors, including regulatory initiatives, investor demand for sustainable investments, and the increasing recognition of the business case for environmental stewardship. Moreover, the development of voluntary certification and reporting standards, such as the Green Bond Principles and Climate Bonds Initiative, has improved transparency and provided investors with a consistent framework for evaluating the environmental impact of green bonds.

The European Investment Bank's $600 million issuing of a climate awareness bond in 2007 marked the beginning of the green bond market. The first corporate green bond was issued in Europe by Swedish property company Vasakrona and French utility company EDF in 2013 (Barker et al., 2018); (Rosembuj & Bottio, 2016). In Table 1, we present the evolution of global corporate green bonds issued by public firms since 2015.

Table 1: Corporate green bonds over time

This table shows the number of global corporate green bonds as well as the total issuance amount (in billion euros) on an annual basis. The sample consists of all green bonds issued by public firms from 2015 to 2022. The data has been retrieved from Thomson Reuters Eikon Green Bond database.

Year	***#Bond issued***	***€ Amount (billion)***
2015	22	2.24
2016	42	8.21
2017	70	13.23
2018	102	10.53
2019	205	28.89
2020	230	28.11
2021	433	52.38
2022	358	46.11
Total	**1462**	**189.71**

The New Climate Economy group has estimated that a huge amount of investment of up to $93 trillion will be required across the world's economy by 2030 in order meet the targets of the Paris Agreement (Boulle et al., 2017). Each year, CBI publishes a report called "Green Bonds Global State of the Market", which provides an overview of the most important developments in this market and outlines new guidelines, initiatives, and events. In this section, we will examine the most significant developments in the green bond market from 2016 to 2022.

Energy, construction, and transportation industries dominate capital allocated from green bond financing. The energy sector, which is responsible for a significant portion of global greenhouse gas emissions, has seen an increase due to population growth. In order reduce emissions, the energy sector is now required to shift towards renewable energy sources such as wind, solar, and other forms of mixed renewable energy projects. This trend is reflected in the majority of green bonds issued for this sector (Boulle et al., 2017). The "buildings" category of green bonds is primarily focused on financing energy efficiency initiatives. This includes funding for low-carbon buildings, energy-efficient products, and industrial energy efficiency processes and technology. A significant portion of the funds raised through green bonds is allocated to the development of sustainable buildings (Boulle et al., 2017).

The "buildings" aspect of the climate category pertains mainly to bonds that have received green certification, with the funds raised being utilized to finance initiatives aimed at improving energy efficiency. This includes the funding of low-carbon buildings and energy-efficient products. A significant portion of proceeds are allocated to green buildings (Boulle et al., 2017).

The second-biggest contributor to greenhouse gas (GHG) emissions is the transportation industry, making it a significant focus of the climate category. In order shift away from fossil fuel vehicles, the establishment of clean transportation infrastructure is crucial. Although major automobile manufacturers have pledged to create electric and other environmentally friendly vehicles, numerous bonds in this classification cannot be classified as "climate-aligned" due to their revenue being primarily generated from fossil fuel vehicles. In Table 2, we provide a summary of the sectors that issue global corporate green bonds, which are divided according to the Refinitiv Business Classification (TRBC) codes.

Table 2: Corporate green bonds by sector

This table shows the number of global corporate green bonds as well as the total issuance amount (in billion euros) by sector. The sample consists of all green bonds issued by public firms from 2015 to 2022. Sectors are divided according to the Refinitiv Business Classification (TRBC) codes. The data has been retrieved from Thomson Refinitiv's Eikon Green Bond database.

TRBC Sector	***#Bond issued***	***€ Amount (billion)***
Banks (NEC)	111	24.48
Electric Utilities (NEC)	109	22.88
Multiline Utilities	31	16.11
Real Estate Rental, Development & Operations (NEC)	208	14.83
Construction & Engineering (NEC)	90	9.52
Corparate Financial Service (NEC)	51	8.58
Corparate Banks	33	3.91
Office Real Estate Rental & Development	45	3.54
Fossil Fuel Electric Utilities	35	2.06
Commuting Services	25	1.74
Hydroelectric & Tidal Utilities	26	1.54
Residential Real Estate Rental & Development	35	1.53
Retail Real Estate Rental & Development	32	1.40
Real Estate Services (NEC)	25	1.24
Other Sectors	606	76.35
Total	**1462**	**190**

As can be seen, financial corporations dominate the global green bond market with a total issuance amount of EUR 36.97 billion, making up roughly 20% of the overall market. There are several reasons behind the dominance of financial institutions. Firstly, the financial sector plays a key role in the transition towards a green economy because of its resources, expertise, and experience in marketing different financial instruments, including green bonds. This can help increase the efficiency of the green bond market, improve transparency, and reduce costs related to green bond issuance. Secondly, by issuing green bonds, financial in-

stitutions, such as banks and insurance companies, raise funds for projects like renewable energy, sustainable transportation, and green building that have environmental benefits and promote sustainable development. Finally, regulators and policyholders are increasingly encouraging financial institutions to support sustainable development through green bond issuance. For example, in some countries like the UK, Malaysia, and Indonesia, financial services authorities have issued regulations that require banks to issue green bonds and invest in sustainable projects. From the perspective of banks, which have a dominating role in green bond issuance among all other financial institutions, even if funding green projects through green bond issuance might have a negative impact on bank efficiency in the short term due to higher costs derived from using more screening and monitoring resources when compared to traditional loans, effective regulations can incentivize this type of credit and create competition for this market. In this sense, we expect that with new regulations, the role of the financial sector in green bond issuance will increase soon, and this sector will dominate the green bond market.

In 2015, the green bond market was in its infancy, but had already experienced significant growth compared to previous years. According to the Climate Bonds Initiative (Boulle et al., 2016), the global green bond market reached a total issuance of $41.8 billion in 2015, almost tripling the amount issued in 2013. The majority of the green bonds issued this year were in the renewable energy sector, accounting for 60% of the total issuance. In terms of geographic distribution, Europe dominated the market, with 54% of the total global green bond issuance originated from European issuers, followed by America and Asia with 27% and 19%, respectively.

In 2016, green bond issuance almost doubled the number recorded in 2015, resulting in a record-breaking year by all standards. Most significantly, green debt issued by Chinese entities increased from about US $1 billion to over US $23 billion, making up more than 25% of all debt issued in 2016. This period was marked by significant maturity in the market, with an increasing number of bond types, issuer types, and ratings (Boulle et al., 2016).

In 2017, 25% of the climate-aligned bonds were green-labeled bonds. At the same time, climate bond certification gained popularity, with certified issuance rising from 4% in 2015 to 11% in 2017. Moreover, issuance by corporations and commercial banks increased as well (Boulle, et al., 2017). Europe continued to dominate the market, with 54% of total green bond issuance, followed by America and Asia, with 30% and 13%, respectively.

In 2018, the growing diversity of green bonds continued. The European Commission announced an action plan for sustainable finance in March 2018. Three legislative proposals with the goal of creating a European Union (EU) taxonomy for sustainable finance, improving the reporting on ESG, and setting benchmarks for low-carbon consumption were presented (Filkova et al., 2018).

2019 was the first year since 2016 in which the amount of green bonds issued by corporations increased, with Latin America and Africa having their best years yet. The average green bond size increased from US $108 million in 2018 to US $144 million in 2019, which could increase market liquidity (Almeida, 2020).

In 2020 and 2021, the green bond market was significantly affected by the COVID-19 pandemic. Most of the sustainability bonds issued in this period financed COVID-19 measures, where green bonds were not prioritized. However, since developed markets are less vulnerable to shocks, green bond issuance was less affected in these markets than in emerging markets.

In 2022, cumulative green bond issuance reached US $2 trillion. Green bonds were issued in 10 currencies, and more than half of the volume (53%) were issued in EUR, followed by USD (20%) and CNY (14%). Germany was the largest source of green bonds, responsible for 18% of the total. USA and China took the next two spots, with around 11% each (CBI, 2022). Country-wise distribution of corporate green bond offerings is illustrated below, in Table 3.

As shown in Table 3, the green bond market is especially large in France, the United States, Sweden, Japan, and China. Together, these countries account for nearly 60% of the total issuance amount in the global green bond market. Other countries, such as Sweden and Norway, are found to issue large numbers of green bonds with relatively small issuance amounts.

Table 3: Global corporate green bond issuers by country

This table reports the total issuance amount (in billion euros) as well as the number of corporate green bonds by country, using all corporate green bonds issued by publicly listed corporations from 2015 to 2022.

Country	***# Bonds issued***	***€ Amount (billion)***
Sweden	382	19.41
Japan	263	19.11
China	199	18.65
Norway	190	13.41
South Korea	182	11.90
France	93	46.20
Eurobond	89	31.38
Switzerland	77	13.10
United States	61	32.27
Thailand	54	3.01
Belgium	15	3.34
Spain	13	3.40
Argentina	12	0.41
New Zealand	12	1.14
Panama	11	0.05
Rest of world	107	12.10
Total	**1462**	**190**

2.2 Green bond credibility and signaling theory

Credibility is a crucial factor in the success of green bonds. Investors in the green bond market heavily rely on third-party certification and other credibility signals, such as listing on green exchanges, to assess the environmental credentials of bond issuers. The purpose of certification and green exchange listing is to address information asymmetries by offering investors access to transparent and comparable information regarding the specific projects financed by the proceeds of these bonds. By undergoing certification, bond issuers demon-

strate their commitment to meeting predefined environmental criteria and standards. This process helps to instill confidence among investors, as they are provided with a reliable framework for evaluating the environmental impacts of bonds, they consider investing in. Moreover, listing green bonds on dedicated exchanges facilitates the identification and selection of investments aligned with environmental goals, as it signifies compliance with established eligibility criteria. Consequently, the adoption of certification and green exchange listing practices contributes to reducing information asymmetries and enhancing transparency within the green bond market.

Signaling theory is a key concept for understanding the information asymmetries between bond issuers and investors. This information asymmetry induces a transaction cost in identifying companies with desirable characteristics. Consequently, it is beneficial for firms to minimize this information asymmetry by sending a "signal". In signaling theory, a signal is considered reliable if it is costly to mimic by firms with less desirable characteristics.

In our case, a signal is the issuance frequency of green bonds. Since the green label alone is not a credible signal because there is no standard definition for a green bond except for third-party certification, which is costly, repetitive issuance allows separating equilibrium between those issuers genuinely committed to sustainability and those just trying to create false signals in the market, also known as “greenwashing”. Repetitive issuance of green bonds also provides greater visibility for listed bonds, allowing environmentally aware investors to find green bonds more easily.

Frequent issuance of green bonds can yield positive outcomes in markets characterized by a pronounced appetite for sustainable investments and a substantial commitment to endorsing environmentally conscious initiatives. These markets often exhibit well-established frameworks for green finance, substantial government backing for sustainable development, and increasing investor awareness regarding the risks linked to climate change. Illustrative instances of such markets encompass Europe, which has witnessed a rapid expansion of the green bond market in recent years, and China, where the government has actively fostered the advancement of green finance.

The investigation of the issuer's cost of capital reaction to frequent green bond issuance in our study serves the purpose of understanding two key aspects: i) the market's perception of this signaling mechanism, and ii) the reasonableness of the market's response based on the

subsequent changes in the issuer's cost of capital.

By examining the issuer's cost of capital in response to frequent green bond issuance, we can discern whether the market views this signal in a positive light. A positive market response would indicate that investors have a favorable perception of frequent green bond issuance as an indication of the issuer's commitment to sustainability and environmental responsibility. Furthermore, analyzing the subsequent changes in the issuer's cost of capital allows us to assess the reasonableness of the market's response. If the market's reaction is reasonable, we would expect to observe a correlation between frequent green bond issuance, and a reduction in the issuer's cost of capital.

During the discussion of the preliminary thesis report, an important concern was raised regarding the potential scenario of frequent green bond issuers who have failed to fulfill their green commitments in the past but continue to issue green bonds. This raises the possibility of weakening the signaling effect and diminishing investor confidence, leading the market to price these bonds as conventional bonds. To investigate this issue, we conducted an analysis of our raw green bond data to identify sectors that exhibit a tendency to issue frequent green bonds. Our findings reveal that within the real estate sector, there are issuers who have issued more than 10 green bonds during the specified period.[1]

Real estate sector has been traditionally relied on bank loans. However, the observed shift from bank loans to green bond issuance within this sector indicates a significant demand for energy-efficient buildings from environmentally conscious households and companies. The green bond market offers greater flexibility and cost efficiency compared to bank loans for financing projects in this specific sector. By utilizing frequent green bonds, the real estate sector reduces its reliance on banks while simultaneously signaling its strong commitment to environmental sustainability to the market. Considering that issuing green bonds incurs costs and requires additional reporting, the example of the real estate sector leads us to conclude that the potential expenses associated with continuing to issue green bonds without delivering on previous green projects would outweigh any short-term gains from greenwashing

[1] Appendix Table A.3 provides information on the number and total amount of green bonds issued by selected issuers that have conducted more than 10 green bond issuances within the specified period.

practices.

Although our investigation of the real estate sector does not serve as direct evidence for the point raised during the discussion, the findings emphasize a clear trade-off between being perceived as a green-washer and being a genuine green bond issuer.

Consequently, we can conclude that the likelihood of issuing additional green bonds without fulfilling previous green commitments is highly improbable. The associated costs and reputational risks make such practices economically unviable for issuers, thereby reinforcing the credibility and integrity of the green bond market.

2.3 Previous academic literature

Compared to equity investment, there has been relatively limited research focused on examining the environmental, social, and financial impact of fixed income investment. Despite the fact that global bond markets significantly outweigh global equity markets, with bond markets valued at USD 133 trillion in 2020, surpassing the USD 105.7 trillion value of equity markets, academics and industry practitioners initially directed their attention towards equity investment, primarily due to the absence of voting rights and the lack of participation in the potential financial gains experienced by bondholders in contrast to equity investors (Schoenmaker & Schramade, 2019).

The concept of a "green bond premium" or "greenium", which refers to the yield difference between green bonds and similar conventional bonds, has received considerable attention from both academics and practitioners. A negative premium indicates that investors are willing to accept lower returns because of their non-financial preference for the green label, which enables issuers to enjoy lower financing costs. Despite several studies, findings are inconsistent, with some scholars discovering evidence of a premium (Ehlers & Packer, 2017); (Barker et al., 2018); (Zerbib, 2019); (Bachelet et al., 2019), while others find no premium (Fossum & Teigland, 2020).

Early studies mainly focused on conventional bond characteristics such as sector, credit rating, or issue amount to explain variations in the size or significance of the green bond premium. However, the most compelling factor proposed thus far has been the high demand from investors driven by sustainability concerns (Barker et al., 2018); (Zerbib, 2019) and the perceived "green credibility" or environmental friendliness of the bond (Hyun, et al., 2020);

(Kapraun et al., 2021). Hyun, et al. , 2020) and Kapraun et al. (2021) conduct studies that find no significant evidence of a premium between green and conventional bonds. However, they identify a notable premium ranging from 4 to 6 basis points (bps) for certified green bonds. Moreover, this premium increased to a range of 15 to 26 bps for green bonds certified by verifiers approved by the Climate Bonds Initiative (CBI) (Barker et al., 2018); (Hyun et al., 2020). Kapraun et al. (2021) additionally discover a significant premium for green bonds traded on a green bond exchange with stringent listing requirements (4 bps) as well as for bonds issued by entities with high environmental ratings (7-9 bps). One possible explanation is that continuously signaling the "greenness" of a green bond can reduce the information costs borne by investors when gathering the necessary information for making investment decisions. As a result, credible green bonds attract greater demand from environmentally motivated investors, consequently lowering the financing costs for issuers (Barker et al., 2018); (Hyun et al., 2020). Different from the above-mentioned studies, in this thesis we are interested in investigating whether repetitive green bond issuance reduces the cost of capital for issuers.

Research on how frequent green bond issuance affects a firm's financing costs is scarce. Fatica et al. (2021) investigate whether repeated issuers earn a premium, and they find out that repeat issuers benefit from an extra premium compared to first-time issuers and conventional issuers, which they take as evidence of a reputation effect on the green bond segment. Hachenberg & Schiereck (2018) discover limited evidence that green bonds are priced differently than regular bonds in the secondary market. Zerbib (2019), on the other hand, finds a slight advantage for green bonds issued between 2013 and 2017 compared to regular bonds. Alternatively, our research aims to examine whether there is a causal effect between the frequency of green bond issuance and the cost of capital for issuers.

Earlier literature mainly focused on the pricing of municipal bonds rather than corporate green bonds. Larcker & Watts (2020) analyze U.S. municipal issuers between 2013 and 2018 to see if there is a "greenium," as these issuers were among the largest issuers of green bonds, and they find little evidence of a pricing differential between green and non-green bonds after creating a matched sample, indicating that U.S. municipal investors were generally unwilling to accept lower yields to invest in green bonds compared to conventional bonds. Flammer (2021) follows a similar methodology to Larcker & Watts (2020), but with a different focus. She shifts attention to corporate green bonds issued between 2010 and

2018 and finds that the stock market responds positively to the announcement of green bond issuance, and the response is stronger for green bonds that are certified by independent third parties and first-time issuers. In contrast, our study investigates a different aspect: the relationship between green bond issuance frequency and firm-level performance.

Tang & Zhang (2020), Pedersen & Thun (2019), and Flammer (2021) find that the stock market reaction is only significant for initial green bond issuances but not for subsequent ones. They suggest that the first green bond issuance draws attention to the issuer's commitment to sustainability, while subsequent issuances do not provide as much new information. In addition to the findings presented by previous studies, this study asserts that despite the absence of a comparable significant stock market reaction to subsequent green bond issuances, as seen in the case of the initial issuance, these subsequent issuances can still influence the issuer's cost of capital. The argument put forth is that these subsequent issuances serve as a signal of the issuer's ongoing dedication to sustainability, leading to a reduction in the perceived risk associated with the issuer's overall sustainability performance. As a result, even without a strong market reaction, the continued issuance of green bonds conveys a message that positively impacts the issuer's cost of capital.

In summary, existing research on reliable signals of credibility in the context of green bonds has predominantly concentrated on certification, overlooking alternative indicators such as the repetitive issuance effect. First-time issuers face uncertainties regarding their ability to sustain future green bond issuances due to various challenges, including a lack of expertise, a limited project pipeline, and higher costs associated with the issuance process. Given these obstacles and the stringent requirements involved, this study proposes that repetitive issuers, through learning effects gained from previous issuances, can enhance their visibility in the green bond market. The accumulated expertise and experience of repetitive issuers enable them to reduce issuance costs over time, establishing them as more credible participants within the green bond market.

Grullon et al. (2004) offer empirical support for the notion that highly visible firms tend to attract a significant number of individual and institutional investors, with increased attention from institutional investors leading to enhanced liquidity and improved financing conditions. Consequently, it is reasonable to argue that frequent green bond issuers convey a stronger signal to the market compared to both first-time green bond issuers and conventional bond issuers, which in turn reduces information asymmetry between the issuers and investors and

leads to a lower cost of capital. Building upon this rationale, we propose the following hypotheses:

Hypothesis 1. *Firms that repeatedly issue green bonds benefit from lower cost of debt compared to frequent conventional bond issuers.*

Hypothesis 2. *Frequent green bond issuers have lower cost of equity and weighted average cost of capital (WACC) compared to frequent conventional bond issuers.*

Hypothesis 3. *First -time green bond issuers benefit from lower cost of debt compared to first-time conventional bond issuers.*

Hypothesis 4. *First-time green bond issuers have lower cost of equity and weighted average cost of capital (WACC) compared to first-time conventional bond issuers.*

Hypothesis 5. *Firms that repeatedly issue green bonds benefit from lower cost of debt compared to first-time green bond issuers.*

Hypothesis 6. *Firms that repeatedly issue green bond have lower cost of equity and weighted average cost of capital (WACC) compared to first-time green bond issuers.*

3. Data Description and Matching method

This section explains the selection of our green bond sample and describes the key data used to conduct our analysis, including bond-level information and indicators of corporate financial performance. Finally, after explaining the matching method, we present summary statistics describing our green and conventional bond samples in detail.

3.1 Sample selection and green bond data

We construct our green bond dataset by filtering out the bonds labeled "green bonds" from the Thomson Reuters Eikon corporate bond database. To ensure cross-sector comparability, we eliminate supranational bonds, sub-sovereign bonds, and municipal bonds since their tax treatment differs from corporate bonds. Several studies have been conducted on municipal bonds, but less on corporate bonds. Flammer (2021) points out that the corporate bond market is still in its early stages and that further studies are required. Therefore, we conduct our research on corporate green bonds.

We include all the nations around the world that have issued green and conventional bonds on several exchanges, as we are focusing on investigating the whole corporate green bond market. We find 1462 green bonds and 38610 conventional bonds issued by public corporations between January 2015 and January 2023. This corresponds to 787 unique green bond issuers and 4586 conventional green bond issuers in our sample. From these bonds, we retrieve information about the sector, issue data, coupon type, maturity, domicile, and issued amount. We chose to start our sample in January 2015 because only two years ago, in 2013, the first US $1 billion green bond issued by the International Finance Corporation (IFC) sold within an hour; also, from this year on, the green bond market started to grow significantly (CBI, 2021d). Additionally, we limit our sample to bonds issued only by public firms, as our study is based on financial, accounting, and environmental data, which are typically not available for private firms.

3.2 Firm level data

In this section, we define both accounting and financial data, which are used in DiD regression analyses.

3.2.1 Accounting data

All accounting data are obtained from the Refinitiv Eikon database (henceforth "Eikon"). Eikon is a financial markets database and contains, inter alia, comprehensive historical financial data, making it a useful resource for performing economic regressions. The main accounting variables obtained and constructed from Eikon's database are as follows: Total asset (TA) represents the total asset of a firm reported for the year t. Leverage is the ratio of total debt to the value of total assets. To mitigate the impact of extreme outliers, we winsorize all accounting ratios at the 1st and 99th percentiles.

3.2.2 Financial data

For the DID analysis, we measure financing costs using the following dependent variables:

Cost of equity: The return a firm theoretically pays its equity investors It is calculated by multiplying the equity risk premium of the market with the beta of the stock plus an inflation-adjusted risk-free rate. The equity risk premium is the expected market return minus the inflation-adjusted risk-free rate.

Cost of debt*:* Represents the marginal cost of issuing new debt to the company. It is calculated by adding the weighted cost of short-term debt and the weighted cost of long-term debt based on the 1-year and 10-year points of an appropriate credit curve.

Cost of short-term debt: Represents the marginal cost of issuing new short-term debt now and uses the 1-year yield point on the appropriate credit curve.

Cost of long-term debt: Represents the marginal cost of issuing long-term debt now and uses the 10-year yield point on the appropriate credit curve.

Cost of capital (WACC): A financial metric used to calculate a firm's cost of capital in which each category of capital is proportionately weighted. All sources of capital, including equity stock, preferred stock, and debt, are included in the calculation.

All financial data is retrieved from Refinitiv Thomson Eikon.

3.3 Matching Method

Prior to conducting the matching process, a data cleaning procedure was initiated. The three datasets, namely the green bond data, conventional bond data, and financial data, were obtained from Eikon. The financial and accounting data were subsequently merged with the bond data, using the company name as the sole shared column across all three datasets. The resulting outcome of this merging process, specifically in terms of the number of bond issuers categorized as either single or multiple for both green and conventional bond types, is succinctly presented in Table 4.

Table 4: Number of single and multiple bond issuers

The table provided below displays the count of bonds issued by both green and conventional issuers, classified as single and repetitive. The data is presented separately for the periods before and after the merging of bond data with financial data. The data was retrieved from the Thomson Reuters Eikon datastream and covers the period from January 2013 to January 2023.

	# Single issuance	***# Repetitive issuances***	***#Total issuances***
Before merging with financial Data			
Green bond	367	1095	1462
Conventional bond	5763	32847	38610
After merging with financial Data			
Green bond	59	247	306
Conventional bond	309	789	1098

According to Table 4, it is evident that after merging financial and accounting data, a significant portion of our bond data has been lost. Specifically, we are left with a total of 306 green bond issuers and 1098 issuers for conventional bonds.

For the purpose of our regression analysis, we utilize a total of 306 green bonds and 306 conventional bond issuers. This sample size aligns closely with the one used by Flammer (2020) in her regression analysis for a similar research study. Therefore, we consider this sample size to be representative of the population and suitable for our research.

This thesis's aim is to measure the issuance frequency effect on the issuer's cost of capital, by separating it from the effects that other factors might bring upon it. A dataset constructed without controlling for these factors would mask the presence of issuance frequency effect and would not be very insightful. Therefore, we use the similar matching method as Flammer (2020) used in her research. Even though we are able to match bonds with similar characteristics in several areas[2], perfect match based on issue size, coupon size, maturity and issue date is not straightforward. Out of the remaining candidates we select nearest neighbor based on two firm-level characteristics: firm size and leverage. We started matching bonds issued by single conventional issuers with bonds issued by single green issuers with similar characteristics. In the same way we match bonds issued by repetitive conventional bond issuers with the bonds issued by repetitive green bond issuers with similar characteristics. This matching process is designed to ensure that control issuers are highly like the treated issuers. Specifically, for each of the 306 public firms that issue green bonds ("treated" firms), we match a "control" firm that is as similar as possible to the treated firm. In total, nine matching variables are used in the process. Table 5 provides a comprehensive summary of the matching process, including the selection criteria and outcomes utilized to determine the eligibility of conventional bonds for pairing with their corresponding green bond. It presents descriptive statistics for the nine matching characteristics, aiming to demonstrate the resemblance between the treated and control firms. The table includes means, medians, and standard deviations for both the 306 treated firms and the 306 matched control firms. Additionally, the last two columns of the table display the p-values from the difference-in-means test and the difference-in-medians test, respectively.

The results indicate that the treated and control firms exhibit remarkable similarity across all the characteristics. These statistics affirm that the control firms closely resemble the treated firms, suggesting they can serve as a reliable benchmark for understanding how the treated firms would have performed in the absence of the green bond issuance.

[2] Appendix Table A.1 presents the bond-level matching characteristics that were employed to match conventional bonds with green bonds. These matching characteristics were utilized to identify and pair conventional bonds with corresponding green bonds in order to ensure comparability between the two categories during the analysis process.

Table 5: Matching

*This table presents descriptive statistics comparing treated and matched control firms. Log (asset) is the natural logarithm of the firm's asset. Log (debt) is the natural logarithm of the firm's debt. The issued amount is taken into account when calculating the mean, median, and within standard deviation for all bond characteristics, except for the coupon rate. The last two columns report the p-values of the difference-in-means and difference-in-medians tests, respectively. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.*

		Obs.	***Mean***	***Median***	***Within SD. Dev.***	***p-value (diff. in Means)***	***p-value (diff. in Medians)***
Firm characteristics							
Log_asset	Green bond	306	22.412	22.35	1.556	0.811	0.490
	Matched control	306	22.391	22.398	0.101		
Log_debt	Green bond	306	21.336	21.52	1.384	0.866	0.000
	Matched control	306	21.323	21.319	0.060		
Bond characteristics							
Issued_ amount (bn)	Green bond	306	0.082	0.05	0.097	0.862	0.000
	Matched control	306	0.081	0.081	0.004		
Coupon type (same)	Green bond	306	0.082	0.05	0.097	0.575	0.037
	Matched control	306	0.091	0.048	0.269		
Coupon_rate	Green bond	306	4.106	3.68	4.622	0.953	0.002
	Matched control	306	4.091	4.097	0.075		
Maturity-issue in years	Green bond	306	4.619	5.00	2.436	0.088	0.452
	Matched control	306	4.859	4.983	0.239		
Maturity date (same)	Green bond	306	0.082	0.05	0.097	0.990	0.000
	Matched control	306	0.082	0.033	0.140		
Issue date (same)	Green bond	306	0.082	0.05	0.097	0.032	0.024
	Matched control	306	0.120	0.047	0.299		
TRBC Sector (same)	Green bond	306	0.082	0.05	0.097	0.306	0.000
	Matched control	306	0.073	0.044	0.105		

3.4 Summary Statistics

In this section, we present and overview of Global market for green and conventional bonds. This includes summary of the data at the green bond, conventional bond, and financial level.

Table 6: Summary statistics of single and multiple bond issuers before and after match

This table presents comparative summary statistics, including mean, standard deviation, maximum, and minimum issuance amounts, for single and multiple issuers of green and conventional bonds before and after matching. The data was retrieved from the Thomson Reuters Eikon datastream and covers the period from January 2013 to January 2023.

	Observations	***Mean (€bn)***	***SD (€bn)***	***Max (€bn)***	***Min (€000)***
Panel A: Before Matching					
Single green bond issuance	367	0.15	0.23	2.73	204.18
Single Conventional bond issuance	5763	0.30	12.61	890.56	4.84
Multiple green bond issuance	1095	0.12	0.19	1.85	909.17
Multiple conventional bond issuance	32847	0.09	0.26	14.19	0.02
Panel B: After Matching					
Single green bond issuance	59	0.11	0.11	0.50	9.50
Single Conventional bond issuance	475	1.91	40.19	890.56	0.01
Multiple green bond issuance	247	0.08	0.09	0.91	6.24
Multiple conventional bond issuance	5944	0.08	0.26	14.19	0.01

Table 6 provides a comprehensive overview of green and conventional bond data before and after merging with financial and accounting data. Before the merger, there were approximately 27 times more conventional bonds issued compared to green bonds. The total amount issued for green bonds during the period was 190 billion euros, which is 25 times lower than the amount for conventional bonds. The average amount for green bonds was slightly higher than for conventional bonds, but the standard deviation for green bond

amounts was significantly lower. The maximum amount for conventional bonds was approximately 330 times higher than for green bonds, while the minimum amount for green bonds was 10 times higher than for conventional bonds. After matching, there were 59 issuers with single green bond issuances and 475 issuers with single conventional bond issuances. For issuers with multiple bond issuances, there were 247 green bond issuers and 5944 conventional bond issuers. The average amount for single green bonds was similar to that for multiple green bonds before and after matching, but the average amount for single conventional bonds increased significantly after matching compared to multiple conventional bonds. The standard deviations decreased for green bonds but increased for conventional bonds after matching.

In Table 7, we present a summary of the dependent variables[3] used to measure financing costs in the DiD analysis, with 39683 observations available for each variable.

Table 7: Summary statistics of all dependent variables used to measure financing costs

This table displays summary statistics for all dependent variables measuring financing costs, including the mean, standard deviation, minimum, and maximum values. The data was retrieved from the Thomson Reuters Eikon datastream and covers the period from January 2013 to January 2023.

	Observations	***Mean***	***SD***	***Max***	***Min***
Cost of capital	39683	7.761	5.61	11.547	0.011
Cost of equity	39683	9.275	5.13	9.278	0.001
Cost of debt	39683	2.559	7.21	17.012	0.001
Short term debt	39683	3.270	9.34	21.541	0.005
Long term debt	39683	4.397	8.92	20.981	0.276

[3] Appendix Table A.3 presents a comprehensive summary of statistical measures for all dependent variables that assess financing costs. The table includes the mean, standard deviation, minimum, and maximum values, categorized according to green and conventional bonds and further categorized as single and multiple issuances.

4. Empirical analysis

This section begins with an explanation of the methodology used in our study. We then introduce our DiD regression model, which we utilize to examine how the frequency of green bond issuance affects the issuer's cost of capital. We subsequently present and discuss the regression results obtained from our analysis.

4.1 Methodology

To test the hypotheses we formulated, we apply DiD specification with a matched control group. By using this methodology, we aim to solve the sample selection bias by pairing each green bond issuer ("treated" firms) with a conventional bond issuer ("control" firms) that is as similar as possible to the green bond issuer. The treated group is a list of firms that have issued green bonds (single and multiple issuers separately) in the period of from January 2015 to January 2023. The control sample is constructed from all firms that issued conventional bonds (single and multiple issuers relatively) and never issued green bonds in the same period. We set up our difference-in-differences regression equation model as follow:

$$Yit = \alpha_i + \alpha_t + \beta_1 \, x \, SingleGreen_{it} + \beta_2 \, x \, FrequentGreen_{it} + \beta_3 \, x \, FrequentConventional\_it + x_{it} + \varepsilon_{it} \; (1)$$

where,

1) Y_{it} = the outcome variable of interest for firm i at time t
2) α_i = firm specific fixed effects
3) α_t = time specific effects
4) x_{it} = control variables
5) $SingleGreen_{it}$ = a dummy that that takes 1 if a firm i has only 1 green bond issued at time t.
6) $FrequentGreen_{it}$ = a dummy that equals to 1 if a firm i has more than 1 green bond issued at time t.
7) $FrequentConventional_{it}$ = a dummy that equals to 0 if a firm i has more than 1 conventional bond issued at time t.
8) ε_{it} = error term

We include a vector of control variables, $x_{it,}$ that may have a significant impact on financing costs. In our regressions, we control for total assets (natural logarithm) as a measure of firm size. We also include Leverage, which is the ratio of total liabilities to total assets.

4.2 Results

In this section, we present the results of the DiD regression model, which mainly aims to analyse: 1) Is there any effect of green bond issuance frequency on the issuer's cost of capital? 2) Do we observe the same effect for frequent conventional bonds? If yes, for which type of bond is this effect stronger? 3) Do we observe the same effect for single bond issuances?

Table 8 and Table 9 present the result of our DiD analysis on the impact of the issuance frequency of green bonds on the issuer's cost of capital and its determinants, which are the cost of equity and the cost of debt, distinguished by the cost of short-term debt and the cost of long-term debt.

Table 8: Impact of GB issuance frequency on the cost of debt

This table displays the findings of a difference-in-difference regression analysis, indicating the influence of frequent green and conventional bond issuance on the issuer's cost of debt, categorized as short-term and long-term costs, in comparison to single conventional bond issuance. Green_single = a dummy that takes 1 if a firm i has only 1 green bond issued at time t. Green_freq = *a dummy that equals 1 if a firm i has more than 1 green bond issued at time t.* Con_freq = *a dummy that equals 0 if a firm i has more than 1 conventional bond issued at time t. Firm fixed effects and time fixed effects measured in years to account for unobserved heterogeneity across firms and time-related factors that could potentially influence the outcome variable. The sample includes all firm-year observations of the treated and matched control firms from January 2013 to January 2023. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.*

	Dependent variable:		
	Overall cost of debt (1)	***Short-term cost of debt (2)***	***Long-term cost of debt (3)***
Green_single	-0.002 (t = -0.34)	-0.004 (t = -0.55)	0.0001 (t = 0.02)
Green_freq	-0.005 (t = 0.24	-0.003 (t = -1.03)	-0.002 (t = -0.87)
Con_freq	-0.0005 (t = -0.45)	-0.002 (t = -1.11)	-0.001 (t = -0.45)
Log_assets	-0.001*** (t = -2.93)	-0.002*** (t = -2.74)	-0.002*** (t = -3.20)
Log_debt	0.002*** (t = 3.02)	0.002*** (t = 2.74)	0.002*** (t = 2.85)
Firm fixed effects	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes
Observations	700	700	700
R2	0.14	0.14	0.016
Adjusted R2	0.004	0.004	0.006
Note:			*p<0.1; **p<0.05; ***p<0.01

The analysis shows that there is insufficient evidence to support the idea that the frequent green and frequent conventional bond issuance, when compared to a single conventional

issuance, leads to a significant reduction in the cost of debt. This conclusion is drawn from the small and statistically insignificant coefficients obtained from the analysis. This finding suggests that neither the frequency of green bond issuance nor conventional bond issuance generally has a substantial effect on the issuer's cost of debt.

Additionally, the analysis indicates that there is no substantial evidence supporting the notion that first-time or one-time green bond issuance leads to a reduction in the cost of debt, specifically when considering short-term and long-term costs compared to first-time conventional bond issuance, as the coefficients obtained from the analysis are both small in magnitude and statistically insignificant. This finding might be explained by the fact that the cost of debt is influenced by various factors beyond the scope of our analysis and cannot be directly controlled. These factors may include macroeconomic conditions, regulatory changes, industry-specific risks, investor sentiment, and company-specific characteristics such as reputation and financial health. Although we have accounted for firm fixed effects and time fixed effects in our regression model to control for unobserved heterogeneity, there may still be residual effects from these unmeasured factors that could influence the cost of debt. Therefore, while our analysis provides insights into the specific effects of first-time or one-time green bond issuance, it is essential to recognize that the observed cost of debt is a result of a complex interplay between multiple factors, some of which may not be captured in our analysis.

To test hypotheses one, three, and five, we conducted an additional F-test to determine whether the coefficients of frequent green bond issuance and frequent conventional bond issuance, single green bond issuance and single conventional bond issuance, and frequent green bond issuance and single green bond issuance are statistically different from each other. The obtained results reveal that the p-values from the F-tests are very high. This indicates that there are no significant differences between the aforementioned pairs of bond issuances regarding the variable under examination. Therefore, we reject our hypotheses one, three, and five, as the evidence does not support the presence of statistically significant distinctions among these bond issuance types based on the tested variable.

Table 9: Impact of GB issuance on the cost of equity and the cost of capital

This table exhibits the results of a difference-in-difference analysis, illustrating the impact of frequent green and conventional bond issuance, as well as first-time green bond issuance, on the issuer's cost of equity and cost of capital when compared to a single conventional bond issuance. Green_single = a dummy that takes 1 if a firm i has only 1 green bond issued at time t. Green_freq = *a dummy that equals 1 if a firm i has more than 1 green bond issued at time t.* Con_freq = *a dummy that equals 0 if a firm i has more than 1 conventional bond issued at time t. Firm fixed effects and time fixed effects measured in years to account for unobserved heterogeneity across firms and time-related factors that could potentially influence the outcome variable. The sample includes all firm-year observations of the treated and matched control firms from January 2013 to January 2023. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.*

	Dependent variable:	
	Cost of equity (1)	***Weighted average cost of capital (2)***
Green_single	0.09 (t = 0.49)	0.06 (t = 0.51)
Green_freq	-0.013** (t = -1.92)	-0.006 (t = -1.28)
Con_freq	-0.004 (t = -0.96)	-0.005* (t = -1.95)
Log_assets	0.001 (t = 0.56)	0.006*** (t = 5.13)
Log_debt	0.003 (t = 1.61)	-0.007*** (t = -5.53)
Firm fixed effects	Yes	Yes
Time fixed effects	Yes	Yes
Observations	700	700
R2	0.045	0.055
Adjusted R2	0.035	0.045
Note:		*p<0.1; **p<0.05; ***p<0.01

As depicted in Table 9, a difference in the issuance frequency effect with regard to the single conventional bond issuance is particularly visible for the cost of equity in column (1). The issuance frequency effect of increasing the number of green bond issuances is negative and significant (-0.013%), while the result for frequent conventional bond issuance remains insignificant. However, when comparing this number with the mean cost of equity of frequent green bond issuers, which is 0.08%, we can conclude that the decrease in the cost of equity resulting from frequent green bond issuance is not substantial. In other words, although there is a significant impact on the cost of equity, the actual reduction in the cost of equity is relatively small when considering the average cost of equity for issuers who frequently issue green bonds.

The results of the F-test indicate that the F statistic is high, and the associated p-value is very small. This suggests that frequent green bond issuance has a significant impact on the issuer's cost of equity when compared to the issuance of a single conventional bond. In other words, the analysis provides strong evidence to support the idea that issuing green bonds frequently leads to a noticeable effect on the cost of equity for the issuer.

One potential explanation might be that investors may view green bond issuers as more environmentally responsible and socially conscious. This perception can enhance the company's reputation and attractiveness, leading to a lower cost of equity as investors are willing to accept a lower return for investing in sustainable initiatives.

The table describes that frequent green bond issuance's impact on the issuer’s cost of capital is not significant, indicating no relationship between green bond issuance frequency and the issuer’s WACC. This result is consistent with previous research by Flammer (2020) that find no pricing differential for corporate green bonds.

Compared to single conventional bond issuances, repetitive conventional bond issuances are linked to a decrease in the issuer's cost of capital by 0.005%. In contrast, the effect of repetitive green bond issuances remains insignificant. However, when comparing this decrease to the mean cost of capital of repetitive conventional bond issuances, which is 0.07%, we can conclude that the reduction in the cost of capital associated with repetitive bond issuances, regard less of type, is very minor.

The results of the F-test for the joint significance test indicate that the F-statistic is high, and the associated p-value is very small. This implies that frequent conventional bond issuance has a substantial impact on the issuer's cost of capital when compared to the issuance of a single conventional bond. In other words, the analysis provides strong evidence to support the notion that issuing conventional bonds frequently leads to a significant effect on the issuer's cost of capital as opposed to issuing a single conventional bond. One explanation for this relationship might be that the market for conventional bonds may be more mature and standardized, with established pricing benchmarks and expectations. This maturity and standardization could contribute to lower transaction costs, reduced risk premiums, and ultimately a lower cost of capital for repetitive conventional bond issuers. In contrast, the market for green bonds may still be developing, lacking consistent pricing mechanisms and investor confidence, leading to an insignificant effect on the cost of capital for repetitive green bond issuers.

Our findings indicate that frequent green bond issuers have a lower cost of equity, which supports our second hypothesis. However, the impact of frequent green bond issuance on the weighted average cost of capital (WACC) is found to be statistically insignificant, which does not fully support our second hypothesis. The F-test conducted to compare the cost of capital coefficients between frequent green bonds and frequent conventional bonds reveals a high p-value, indicating that there are no significant differences between these bond issuances with respect to the variable being examined. Therefore, we fail to find evidence of a significant disparity in the cost of capital between frequent green bond issuance and frequent conventional bond issuance, suggesting a lack of support for our second hypothesis.

First-time green bond issuance remains insignificant in terms of its effect on the issuer's cost of equity. This means that the initial issuance of green bonds does not have a measurable impact on the cost of equity for the issuer. One possible explanation is that investors might be cautious about the environmental commitments of new issuers or may require more evidence of their sustainable practices before adjusting their required return. Additionally, Table 9 shows that the impact of issuing green bonds for the first time on the issuer’s cost of capital is still not significant, which is consistent with the findings of the frequent issuance case. In other words, there is no meaningful difference in the effect of issuing green bonds for the first time or issuing them frequently on the issuer’s cost of capital, which is again consistent with Flammer’s (2020) finding on the cost of capital argument.

To test hypotheses four and six, we performed additional F-tests to assess the potential differences in the coefficients of cost of equity and cost of capital between frequent green bond issuance versus single green bond issuance and single green bond issuance versus single conventional bond issuance, respectively. However, the results revealed that the p-values obtained from the F-tests were very high. This implies that no significant differences exist between these pairs of bond issuances with respect to the variable under scrutiny. Consequently, we reject hypotheses four and six, as the evidence does not support the presence of statistically significant disparities among these bond issuance types based on the tested variable.

4.3 Limitations and future research

The chosen research methodology is subject to limitations, primarily due to the time horizon considered in the analysis. Given that green bonds are a relatively new development, the availability of data for assessing their impact on corporate performance is still limited. This poses a challenge for conducting a comprehensive analysis with a sufficiently long-term perspective. Additionally, it is crucial to acknowledge that a significant amount of data was lost during the merging process of our bond data with the financial data. Consequently, we encounter limitations in utilizing a broad sample for our analysis, which hampers our ability to draw robust conclusions and make generalizations that would have been feasible with a more extensive dataset.

Furthermore, the effects of green bonds on corporate financial performance are not immediate. The benefits derived from adopting green practices, such as cost savings and increased customer trust, typically accrue over the long term. It takes time for firms to realize the efficiency gains and for the positive impacts on financial outcomes to materialize. It is therefore expected that the environmental commitments associated with issuing green bonds will yield both environmental and financial benefits years down the line.

To accurately measure the influence of green bonds on corporate performance, future research should prioritize longer time horizons. By extending the analysis period, researchers can better capture the full impact of green bonds on various financial and sustainability indicators. This would allow for a more accurate assessment of the long-term benefits and outcomes associated with the issuance of green bonds by firms.

Finally, the chosen difference-in-differences (DiD) methodology has certain limitations that should be acknowledged. Although creating a matched control group helps address endogeneity concerns associated with green bonds, it does not fully substitute for an experimental empirical setting where firms issue green bonds in a quasi-random manner.

Future developments in the green bond market may offer opportunities to address endogeneity concerns through the use of instrumental variables. For example, several Asian countries, such as Singapore and Japan, have introduced green bond subsidies and grant programs in recent years. If similar schemes become more widespread, they could potentially enable the construction of relevant instrumental variables in future research.

5. Conclusion

This thesis contributes to the literature by investigating the cost-of-capital advantage of green bonds in the green bond market. By employing a difference-in-difference (DiD) methodology, the study examines the impact of frequent green bond issuance on the corporate cost of capital.

The findings of this research indicate that frequent green bond issuance leads to a 0.013 % reduction in the cost of equity for issuers compared to conventional bond issuance. This suggests that investors view frequent green bond issuers as more environmentally responsible and socially conscious, which can enhance the issuer's reputation and attractiveness, resulting in a lower cost of equity.

However, the study does not find significant evidence supporting the idea that firms with frequent green bond issuance experience a lower overall cost of capital. This implies that while there may be a cost-of-capital advantage at the equity level, it is not significant enough to influence the issuer's overall cost of capital, which encompasses both equity and debt components. This finding is consistent with similar previous research by Flammer (2020) that find no pricing differential for corporate green bonds. The only result that we find statistically significant is that the frequent issuance of conventional bonds leads to a decrease in the cost of capital. However, it is important to highlight that the economic impact of this decrease is extremely small, amounting to only 0.005% of the average cost. Consequently, this decrease is considered economically negligible, implying that it holds little practical significance or material impact.

Future research in this area could further explore the mechanisms through which green bond issuances impact the cost of capital and investigate additional factors that may influence these dynamics. Understanding the cost-of-capital advantages and limitations of green bonds is crucial for policymakers, issuers, and investors seeking to promote sustainable finance and make informed investment decisions.

References

Almeida, M. (2020). *Green Bonds Golbal State of the Market 2019.* Climate Bonds Initiative. https://www.climatebonds.net/files/reports/cbi_sotm_2019_vol1_04d.pdf

Bachelet, M., Becchetti, L., & Manfredonia, S. (2019). The Green Bonds Premium Puzzle: The Role of Issuer Characteristics and Third-Party Verification. *Sustainability, 11*(4:1098). doi:10.3390/su11041098

Barker, M. P., Bergstresser, D., Serafeim, G., & Wurgler, J. (2018). Financing the Response to Climate Change: The Pricing and Ownership of U.S. Green Bonds. *SSRN Electronic Journal*. doi:10.2139/ssrn.3275327

Berry, T., & Junkus, J. (2013). Socially Responsible Investing: An Investor Perspective. *Journal of Business Ethics,, 112*(4), 707-720. doi:10.1007/s10551-012-1567-0

Boulle, B., Frandon-Martinez, C., Pitt-Watson, J., Olsen-Rong, T., Meng, A., & Partridge, C. (2016). *Bonds and Climate Change The State of the Market in 2016.* HSBC Climate Change Centre of Excellence. Climate Bonds Initiative. Retrieved from https://www.climatebonds.net/files/files/CBI%20State%20of%20the%20Market%202016%20A4.pdf

Boulle, B., Meng , A., Frandon-Martinez, C., McAvinue, R., Giuliani , D., & Elliott, C. (2017). *Bonds and Climate Change The State of the Market in 2017.* the Climate Bonds Initiative. the Climate Bonds Initiative September 2017 in association with HSBC Climate Change Centre of Excellence. Retrieved from https://www.climatebonds.net/files/reports/cbi-sotm_2017-bondsclimatechange.pdf

Bracking, S. (2019). Financialisation, Climate Finance, and the Calculative Challenges of Managing Environmental Change. *Antipode: a radical journal of geography, 51* (3), 709-729. Retrieved from https://doi.org/10.1111/anti.12510

CBI. (2021d). *Explaining green bonds*. Retrieved from Climate Bonds Initiative: https://www.climatebonds.net/market/explaining-green-bonds

CBI. (2022). *Climate Bonds Interactive Data Platform. Data retrieved from CBI*. Retrieved from Climate Bonds Initiative: https://www.climatebonds.net/market/data/

Commission, E. (2021). *The 2021-2027 EU budget – What's new? The main novelties of the EU's long-term budget, its revenue and spending areas and the NextGenerationEU recovery instrument.* Retrieved from European Commission: https://commission.europa.eu/strategy-and-policy/eu-budget/long-term-eu-budget/2021-2027/whats-new_en

Ehlers, T., & Packer, F. (2017). *Green bond finance and certification.* BIS Quarterly Review September 2017.

Fatica, S., Panzica, R., & Rancan, M. (2021). The pricing of green bonds: Are financial institutions special? *Journal of Financial Stability, 54*(100873). doi:https://doi.org/10.1016/j.jfs.2021.100873

Filkova, M., CFA, Frandon-Martinez, C., & Giorgi, A. (2019). *Green Bonds The State of the Market 2018.* Climate Bonds Initiative. Retrieved from https://www.climatebonds.net/files/reports/cbi_gbm_final_032019_web.pdf

Flammer, C. (2021). Corporate green bonds. *Journal of Financial Economics, 142*(2), 499-516. doi:10.1016/j.jfineco.2021.01.010

Fossum, M., & Teigland, H. (2020). Does certification of green bonds add value to investors? The role of CBI-certification in informational efficiency. *Master Thesis*. Bergen, Norway: Norwegian School of Economics.

Grullon, G., Kanatas, G., & Weston, J. (2004). Advertising, Breadth of Ownership, and Liquidity. *The Review of Financial Studies, 17*(2), 439-461.

Hachenberg, B., & Schiereck , D. (2018). Are green bonds priced differently from conventional bonds? *Journal of Asset Management, 19*(6 No 2), 371-383. doi: 10.1057/s41260-018-0088-5

Harrison, C. (2017b). *Green Bond Pricing in the Primary Market: Jan 2016-March 2017*. Retrieved from Climate Bonds Initiative and IFC: https://www.climatebonds.net/files/files/CBI-Green-Bond-Pricing-Q2-2017.pdf

Hyun, S., Park , D., & Tian, S. (2020). The price of going green: the role of greenness in green bond markets. *Accounting and Finance, 60*(1), 73-95. doi:https://doi.org/10.1111/acfi.12515

ICMA. (2017). *The Green Bond Principles.* Paris: ICMA Paris Representative Office. Retrieved from https://www.icmagroup.org/assets/documents/Regulatory/Green-Bonds/GreenBondsBrochure-JUNE2017.pdf

ICMA. (2018). *Green Bond Principles Voluntary Process Guidelines for Issuing Green Bonds.* Paris: ICMA Paris Representative Office. Retrieved from https://www.icmagroup.org/assets/documents/Regulatory/Green-Bonds/%20Green-Bonds-Principles-June-2018-270520.pdf

Kapraun, J., Latino, C., Christopher , S., & Christian , S. (2021). (In)-Credibly Green: Which Bonds Trade at a Green Bond Premium? *Proceedings of Paris December 2019 Finance Meeting EUROFIDAI - ESSEC*. doi:http://dx.doi.org/10.2139/ssrn.3347337

Larcker , D., & Watts, E. (2020). Where's the greenium? *Journal of Accounting and Economics, 69*(2-3: 101312).

Naeem, M., Nguyen, T., Nepal , R., Ngo , Q.-T., & Taghizadeh–Hesary, F. (2021). Asymmetric relationship between green bonds and commodities: Evidence from extreme quantile approach. *Finance Research Letters, 43*. doi:https://doi.org/10.1016/j.frl.2021.101983

Pedersen, A., & Thun, J. (2019). Stock Market Reaction to Green Bond Announcements An empirical study on firms listed on European stock exchanges. *Master Thesis*. Bergen, Norway: Norwegian School of Economics.

Riedl, A., & Smeets, P. (2017). Why Do Investors Hold Socially Responsible Mutual Funds? *The Journal of FINANCE, 72*(6), 2505-2550.

Riley, J. (1979). Informational Equilibrium. *Econometrica, 47*(2), 331-359.

Rosembuj, F., & Bottio, S. (2016). *MOBILIZING PRIVATE CLIMATE FINANCE—GREEN BONDS AND BEYOND.* Fresh Ideas about Business in Emerging Markets. Washington, DC: International Finance Corporation.

Schoenmaker, D., & Schramade, W. (2019). *Principles of Sustainable Finance.* Oxford University Press.

Stern, N. (2007). *The Economics of Climate Change: the Stenr Review.* Cambridge: Cambridge University Press: Cambridge University Press. doi:https://doi.org/10.1017/CBO9780511817434

Tang, D. Y., & Zhang, Y. (2020). Do shareholders benefit from green bonds? *Journal of Corporate Finance, 61*(101427). doi:https://doi.org/10.1016/j.jcorpfin.2018.12.001

United Nations. (2015). Framework Convention on Climate Change Adoption of the Paris Agreement. *21st Conference of the Parties.* Paris, United Nations.

Zerbib, O. D. (2019). Is There a Green Bond Premium? The Yield Differential Between Green and Conventional Bonds. *Published in the Journal of Banking and Finance, 98*(C), 39-60. doi:10.1016/j.jbankfin.2018.10.012

Appendix

Table A. 1: Selected repetitive green bond issuers with more than 10 issuances

The table provides information on the number and total amount of green bonds issued by selected issuers that have conducted more than 10 green bond issuances within the specified period.

Issuer	***#Bond issued***	***Amount (€bn)***
Engie SA	12	8.78
Gecina SA	14	5.72
Vasakronan AB (publ)	41	1.80
Entra ASA	13	1.72
Hyundai Capital Services Inc	13	1.27
Fabege AB	34	1.24
Humlegarden Fastigheter AB	24	1.12
Atrium Ljungberg AB	26	1.12
Svensk FastighetsFinansiering AB (publ)	23	1.10
Jernhusen AB	20	0.73
Korea South-East Power Co Ltd	15	0.70
Korea Western Power Co Ltd	15	0.64
Kungsleden AB	12	0.59
Willhem AB (publ)	13	0.59
Sveaskog AB	11	0.56
Korea Southern Power Ltd	11	0.52
Corporacion Interamericana Para el Financiamiento de Infraestructura SA	11	0.05
Other issuers	1154	161.45
Total	**1462**	**189.71**

Table A. 2: Matching Criteria

The table provided below describes the bond matching criteria that were utilized during the matching process.

Bond Characteristics	***Matching Criteria***
Maturity	± 2 years
Amount issued	± 25% -400%
Coupon rate	± 0.25
Issue date	± 6 years
Issuer	Same sector
Coupon type	Same

Table A. 3: Comprehensive summary statistics of dependent variables

This table presents a comprehensive summary of statistical measures for all dependent variables that assess financing costs. The table includes the mean, standard deviation, minimum, and maximum values, categorized according to green and conventional bonds and further categorized as single and multiple issuances.

	Observations	***Mean***	***SD***	***Max***	***Min***
Weighted average coft of capital					
single green	59	0.07	0.02	0.15	0.02
single conventional bond	309	0.07	0.03	0.21	0.02
multiple green	247	0.06	0.02	0.13	0.03
multiple conventional bond	789	0.07	0.03	0.18	0.02
cost of equity					
single green	59	0.09	0.03	0.22	0.04
single conventional bond	309	0.10	0.04	0.25	0.02
multiple green	247	0.08	0.03	0.19	0.03
multiple convetional bond	789	0.10	0.04	0.23	0.02
Overall cost of debt					
single green	59	0.03	0.01	0.06	0.00
single conventional bond	309	0.03	0.01	0.08	0.00
multiple green	247	0.03	0.01	0.07	0.02
multiple conventional bond	789	0.03	0.01	0.09	0.00
short-term cost of debt					
single green	59	0.04	0.01	0.09	0.00
single conventional bond	309	0.04	0.02	0.17	0.00
multiple green	247	0.03	0.01	0.08	0.02
multiple conventional bond	789	0.04	0.02	0.09	0.00
long-term cost of debt					
single green	59	0.05	0.01	0.09	0.01
single conventional bond	309	0.05	0.01	0.13	0.01
multiple green	247	0.04	0.01	0.09	0.03
multiple conventional bond	789	0.05	0.01	0.10	0.01