Master Thesis U.S.E.

Scaling up Investment in Corporate Green Bonds

Abstract

This study examines how various bond- and firm-specific characteristics influence green bond performance, measured by bond yield. Several significant findings are revealed using cross-sectional data on green bonds issued between 2013 to 2023. By employing a self-compounded dummy variable, it is proven that green bonds issued by mission-oriented companies can offer lower yields to investors. Furthermore, the results imply that bonds from repeat issuers perform better, which is especially true for issuers with frequent issues. These findings are consistent with the signaling argument commonly used in literature. The demonstrated lower cost of capital could help scale up the corporate green bond market by incentivizing companies to issue green bonds on a regular basis, and to become mission oriented.

JEL Classification: C21, G12, O52, Q42, Q56

Keywords: green bonds, sustainability, cross-sectional regression, Europe

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Year: 2023

The author is grateful especially to Catalina Papari for her valuable insights and advice throughout the process.

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Contents

Acronyms

CBI Climate Bonds Initiative
ESG Environmental, social, and governance
EU European Union
N Number of observations
OECD Organisation for Economic Co-operation and Development
OLS Ordinary Least Squares
ROA Return on assets
SD Standard Deviation
UK United Kingdom
UN United Nations
US United States
USD United States dollar *(currency)*
VIF Variance Inflation Factor
YTM Yield to maturity

1 Introduction

With growing concerns about climate change, the need for sustainable investments has become more urgent. Green bonds – debt instruments issued to fund environmentally-friendly projects – have risen as one of the possible solutions in 2007 and have gained significant attention since. Apart from providing funding for the significant investments associated with green projects, they also incentivize investment in sustainable practices for firms and governments, which makes them a suitable tool for the transition. Yet, the scale at which green bond issuance occurs is insufficient for fulfilling the Paris Agreement and transitioning to a net-zero economy.

To address the call for scaling up the corporate green bond market, it is crucial to understand the link between the determinants of green bond yields and the scale-up effects. The rationale behind scaling up the market lies in the potential benefits it offers to both issuers and investors, particularly in terms of reducing the cost of capital and signaling sustainable commitment of the companies. By identifying the factors that influence green bond yields, this thesis aims to shed light on the mechanisms through which scale-up effects can be achieved. The main hypotheses focus on the effect of repeat issuance, mission-oriented issuers, and market maturity on green bond performance, measured as yield to maturity. The results can help policymakers, market participants, and stakeholders come up with effective strategies to promote the growth of the green bond market and mobilize the necessary capital for driving sustainable projects on a global scale.

The green bond market has seen impressive growth in recent years, with green bond issuance reaching a record high of $523 billion in 2021 (Climate Bonds Initiative 2022). However, green bonds still account for only about 3.5% of the overall bond issuance (European Parliament 2022) and are mostly used in developed countries. Over 40% of the green bond market is concentrated in China, Germany, and the United States (S&P Global Market Intelligence 2023). These statistics highlight the pressing need to overcome the policy-, mechanism-, and firm-level barriers hindering the expansion of the green bond market. Doing so is crucial for mobilizing the necessary capital to drive sustainable projects worldwide. By scaling up the green bond market, we can effectively address environmental challenges and pave the way for a more sustainable future. However, this requires a better understanding of the mechanism of green bond issuance and performance.

A growing body of literature has investigated the performance and efficiency of green bonds, focusing mostly on the presence of a green premium, and on supply-side factors affecting issuance and performance. Several studies have found evidence of a green premium, which refers to the higher price green bonds can command relative to conventional bonds, based on the perceived social and environmental benefits, and the increasing demand from socially responsible investors (Wang et al. 2020; Partridge and Medda 2020; Karpf and Mandel 2018; Gianfrate and Peri 2019). Yet the worldwide existence of a green premium is still inconclusive, as many papers did not find evidence of a pricing difference (Larcker and Watts 2020; Flammer 2021). Other studies have examined supply-side and macroeconomic factors, such as regulatory framework, issuer characteristics, and market conditions, which affect the number and quality of green bonds issued (Cicchiello et al. 2022; Wang et al. 2019; Russo et al. 2021). Commonly cited factors include external certifications, debt structure, credit rating, issue size, and maturity of the bond. These can be related to the signaling, cost of capital, and greenwashing arguments used by Flammer (2021).

This thesis contributes to existing literature by showing how bond- and issuer-specific characteristics influence green bond yield, using cross-sectional data in different OLS regression models. The sample consists of 977 corporate green bonds from Europe and the US, issued between the years 2013 and 2023. As has been highlighted by Cortellini and Panetta (2021), prior research on green bond performance mostly focused on China and the US. Therefore, this thesis provides much-needed insight into green bond performance in other markets, especially at the EU level. The focus of sub-questions is on the effect of repeat issuance and market maturity. A special variable is constructed to study if green bonds issued by mission-oriented companies perform better than those by non-mission-oriented issuers.

The results show that the performance of green bonds mostly depends on bond- and company-level characteristics, rather than market-related conditions. According to the regression results, mission-oriented companies and repeat issuers can offer a lower yield on their green bonds, which is consistent with the signaling argument used by Flammer (2021). This reduces their cost of capital and makes sustainable projects more financially viable. The findings should provide an incentive for companies to issue green bonds on a regular basis, and thus scale up the corporate green bond market. On the other hand, no evidence was found of an effect of market maturity. Due to the associated limitations, this should be re-tested in future research. Lastly, the results show that maturity, coupon, and operating margin of the issuer all affect the yield to maturity positively. A negative relationship is found between the yield and amount outstanding, as well as between yield and CO_2 emissions. This can be explained by large companies being able to offer lower yields due to being well-known and perceived as stable, despite having high emissions.

The rest of the thesis is structured as follows. Chapter 2 summarizes existing literature on green premium, factors influencing green bond issuance and performance, and known barriers of scaling up the green bond market. An overview of the data sources, variables, and methods used is provided in Chapter 3. Chapter 4 lists and interprets the obtained regression results and highlights limitations which could be addressed in future research. Finally, Chapter 5 summarizes the study and provides concluding remarks.

2 Literature Review

The following chapter summarizes existing literature on green bonds. Section 2.1 focuses on explaining green bond issuance. Subsection 2.1.1 presents literature focused on the possible presence of a green premium, while Subsection 2.1.2 provides an overview of literature studying the supply-side factors affecting green bond issuance. Known barriers of scaling up the green bond market are examined in Subsection 2.1.3. Finally, Section 2.2 formulates and explains hypotheses for the empirical research.

2.1 Green Bonds

A green bond differs from a conventional bond by receiving a 'green' label, which signifies a commitment by the issuer to use the green bond's proceeds for environmentally beneficial projects, in a transparent manner. While the use of proceeds varies, bond financing can be especially fitting for renewable energy infrastructure, which comes with large up-front costs and long-term, often inflation-linked, income streams (OECD 2015; Gibon et al. 2020). Despite the additional costs associated with green bond issuance, such as certification fees or reporting expenses, green bonds can have positive reputation effects for the company. These can include increased institutional ownership, improved liquidity, and even a boost in stock prices upon announcement. By providing more transparency and disclosure on their sustainability efforts, companies issuing green bonds can enhance their overall reputation and attract new investors who are looking for socially responsible investment opportunities (Kapraun et al. 2021).

2.1.1 Greenium

A large sub-group of literature on green bonds aims to find the presence of a green premium, usually referred to as 'greenium', both in primary and secondary markets. A greenium suggests that it is possible for green bonds to be priced at a lower (interest rate) level than their conventional 'brown' bond counterparts. Understanding the existence and magnitude of the green premium is crucial for scaling up the green bond market. It indicates that investors may have green preferences and a willingness to pay more for the environmental attributes associated with green bonds, thereby benefiting issuers with a lower cost of capital. This can incentivize issuers to increase their green bond issuance, attracting more capital for sustainable projects and facilitating the expansion of the market. However, empirical evidence regarding the presence of a greenium remains mixed.

Wang et al. (2020) found a pricing premium of corporate green bonds in the Chinese primary market. This does not seem to be the case in the US primary market. Larcker and Watts (2020) observed identical pricing for green and brown bonds, and the results of Partridge and Medda (2020) were mostly inconclusive. However, it seems that green premium does exist in the US secondary market (Partridge and Medda 2020; Karpf and Mandel 2018). Evidence of greenium was also found in the EU secondary market by Gianfrate and Peri (2019), who highlighted the financial benefits of green bond issuance. Factors such as market characteristics, investor behavior, and regulatory frameworks contribute to these variations, emphasizing the need for further research and a comprehensive understanding of the market dynamics in different contexts.

Flammer (2021) used a sample of corporate green bonds to study the impact of green bond issuance on the environmental and financial performance of the issuing company. She highlighted three possible rationales for green bond issuance - signaling of the firm's environmental commitment, greenwashing, and reduced cost of capital. The cost of capital argument is closely related to green premium and green bond performance. She did not find evidence of a greenium, consistent with Larcker and Watts (2020). More importantly, she found that green bond issuers decrease their carbon dioxide emissions post-issuance, confirming the signaling argument. Issuing green bonds credibly signals the firm's environmental commitment, as they improve their ecological behavior. This helps disprove the frequent greenwashing concerns. Flammer also underlined the need for better governance of the green bond market, ideally as a combination of private third-party certifications and public governance.

Overall, the literature suggests that in markets where green bond premium exists, it results in various benefits for issuers, including reduced cost of capital, higher demand and liquidity, and improved financial and environmental performance. Yet, the actual evidence of a greenium remains controversial. It is important to note that the existence of a greenium and its benefits to issuers may not be immediately apparent. It may take longer for the premium to materialize, as the market becomes more used to the concept of green bonds and their associated benefits. Additionally, the potential for a sustainability premium, which encompasses not only green bonds but all sustainable investment options, may also become more pronounced as investors increasingly prioritize ESG factors in their investment decisions (Kumar 2022).

2.1.2 Supply-side Factors

Another important group of research papers focuses on the supply side, studying how the green bond issuer characteristics influence bond performance and issuance. Cicchiello et al. (2022) examined the factors affecting issuers' decisions on whether to issue green or conventional bonds. Using a European sample for the period 2015–2020, they found that the issuer's choice is significantly affected by its corporate characteristics, such as current ratio, long debt, and director independence. Green bond issuance is also positively influenced by gender diversity of the firm's board and by the debt maturity of the issuer. This suggests possible solutions of scaling up the green bond market both on policy and managerial level.

Wang et al. (2019) studied factors influencing green bond risk premium in China. Using cross-sectional data on green bond issuance, they found that the green bond risk premium is affected by third-party certifications (which help against greenwashing concerns), debt credit rating, debt principal, issue size, and issue period. On the issuer side, the main factors include return on assets (ROA) and the nature of property rights. Furthermore, green bond risk premium is also influenced by the market interest rate. Therefore, the factors influencing risk premium seem to be on 3 levels: bond-, issuer-, and macro-level.

Russo et al. (2021) examined the determinants of green bond performance by analyzing a sample of corporate green bonds issued between 2013 and 2016. Their results suggest that green bond performance depends on project characteristics, which can be related to both the greenwashing and signaling arguments. From firm-level characteristics, commitment to environmental activities and being a 'pure-play' green company both positively influence the bond's performance. Once again, this shows that signaling actual environmental commitment is an important sign for investors. Lastly, the country of issuance also has a significant effect, or more specifically the number of environmental technologies developed in the country. On the other hand, performance of the bond decreases with a higher credit risk rating.

As has been highlighted by Cortellini and Panetta (2021) in their systematic literature review, the focus of existing literature on green bond performance and return has mostly been on China (Chang et al. 2021; Li et al. 2020; Wang et al. 2019). Thus, future research should replicate these studies for other regions (such as the EU) or on a global scale. Additionally, updating of existing data sets of Russo et al. (2021) and Hyun et al. (2021) should take place to provide newer insight into the fast-changing green bond market. As the market expands, more data becomes available, which can provide more reliable regression results.

2.1.3 Barriers of Scaling up the Green Bond Market

The green bond market has been facing several challenges, limiting its growth potential. The most commonly cited barrier is the lack of standardization and transparency in green bond issuance, which in turn leads to lower confidence of investors in the market and in real environmental impact. It raises questions regarding the efficiency of green bonds, which might be used as a greenwashing tool. While there is no universally accepted standard, several initiatives and countries do provide guidelines and certification options. Their development has surged recently. For example, Switzerland became the first national government member to join the Climate Bond Partners program in 2015, financially supporting the development of the Climate Bonds Standard (Climate Bonds Initiative 2015*b*). Currently, the Climate Bonds Standard certification is one of the most respected standards, with a total value of certified debt of over $250 billion as of October 2022 (Climate Bonds Initiative 2023). China took a different approach and developed its own Green Bond Guidelines, constituting a component of a new green financial system (People's Bank of China 2015). According to OECD (2015), it is essential to converge towards commonly accepted definitions and uniform reporting procedures to increase market efficiency and integrity.

Standardization can provide many benefits to all parties concerned. Slager et al. (2012) explore the emergence of the FTSE4Good index as a socially responsible corporate behavior standard. Their results explain how different types of standardization work - calculative framing, engaging, and valorizing - aid in the design, monitoring, and legitimation processes connected to the regulatory power of the standard. Maragopoulos (2022) examines the

European Commission's legislative proposal for the European Green Bond Standard, focusing on the importance of standardization in the green bond market. The proposal aims to establish a uniform framework for green bonds, addressing deficiencies related to definitions of green projects, disclosure requirements, and external reviews performance. The paper also highlights the importance of an alignment of green bond proceeds with the EU Taxonomy.

Another limitation is the insufficient pipeline of sustainable investment opportunities (Climate Bonds Initiative 2015*a*). Concerns regarding the availability and quality of the linked green projects are valid, especially in developing countries, where more fundamental actions will be needed by the government. Furthermore, there is a scale mismatch between projects and institutional investors, which complicates the situation (OECD 2015). This further hinders scaling up the green bond market.

Balancing sustainability with financial returns poses yet another challenge for green bonds. They need to provide competitive financial returns to investors. While the previously discussed presence of a green premium might allow for slightly lower compensation and thus offer a lower cost of capital to issuers, green bonds still have to be profitable enough for investors. This can be difficult in some cases, due to possibly higher upfront costs and longer payback periods than traditional investments. That is why the efforts to promote green finance through tax incentives and subsidies are so important (IMF 2022).

The OECD (2015) report also provides a summarization of which advantages and disadvantages of green bonds are most frequently cited by investors and by issuers. While investors mostly complain about the small size of the market and bonds, the lack of unified standards, and the very limited legal enforcement of green integrity, issuers mostly mention the high transaction costs associated with certification and labeling, as well as reputational risk in case the green credentials of the bond are questioned. Most of these claims are closely related to the greenwashing argument discussed by Flammer (2021).

2.2 Hypotheses

Despite the above-demonstrated surge in popularity of academic literature focused on green bonds, there are still several unexplored literary gaps. Answering them can help us better understand the mechanics of green bond performance, and as a result provide additional knowledge necessary for scaling up the green bond market and overcoming barriers thereof. Specifically, this research primarily focuses on the effect of repeat green bond issuance, mission-oriented issuers, and market maturity. Using data on corporate green bond performance and firm-level characteristics, the following hypotheses are tested:

> **Hypothesis #1: Green bonds from repeat issuers provide a lower yield than green bonds from one-time issuers.**

A commonly used term in the green bond market is 'repeat issuers', that is issuers who have issued multiple green bonds (CBI 2023; Institute of Energy for South-East Europe 2023). Repeat green bond issuers are more likely to have an established track record of successful sustainable projects. This is expected to lead to increased investor confidence in the impact of their investment, and thus a lower required remuneration. According to an analysis by the European Commission (2020), a negative greenium is usually larger for bonds issued by repeat issuers and externally reviewed bonds. This is likely due to the fact that both factors serve as a signaling device of actual environmental commitment. In case of repeat issuance, investors are able to gather more information about the debtor, and subsequently reduce the information asymmetry and riskiness of the investment. This in turn leads to their willingness to accept a lower compensation. As per the results of a survey conducted by the Climate Bonds Initiative (2020), the biggest benefits of repeated green bond issuance include better visibility in the market and an established investor pool. Fatica et al. (2021) found evidence of a larger greenium for repeat issues by non-financial companies, linking it to the aforementioned signaling argument. However, there is no thorough empirical research on the difference in yield between green bonds by first-time and repeat issuers. By showing that frequent issuance of green bonds lowers the cost of capital for the issuer, the thesis aims to incentivize companies to participate in scaling up the green bond market.

Hypothesis #2: Green bonds issued by mission-oriented companies perform better than green bonds issued by non-mission-oriented issuers.

Many firms nowadays have a mission statement or business model that is centered around sustainability. They often prioritize environmental concerns in their operations and decision-making processes. Their willingness to improve their environmental footprint is expected to work as yet another part of the signaling argument mentioned by Flammer (2021), whereas the greenwashing argument is likely to be minimized in this case. Therefore, mission-oriented companies are expected to issue green bonds which perform better and have a lower yield. The focus in previous literature has mostly been on mission-oriented banks (Mazzucato and Penna 2015) or mission-oriented policies (Larrue 2022). In the context of green bonds, there has been no comprehensive research testing the effect of mission statements on bond yields. A new self-compounded dummy variable is thus constructed, as is described in Subsection 3.1.1. Since there is no comprehensive list of mission-oriented companies available, the construction of a new variable is required to be able to measure the difference in yield between mission-oriented and non-mission-oriented companies. Proving that mission-oriented issuers incur a lower cost of capital might motivate more companies to become mission oriented, which provides two main advantages: a positive effect on the environment and a decrease in greenwashing concerns. This can attract more potential environmentally conscious investors and increase the demand for green bonds.

Hypothesis #3: Market maturity can positively influence green bond performance.

Market maturity and market conditions are expected to have a significant effect on green bond yields. Specifically, governments and regulators play a key role in creating a supportive environment for green bond issuance by providing clear and consistent policy frameworks which encourage sustainable investment. These can include tax reductions, subsidies, or disclosure requirements. An independent variable measuring market maturity will be included in the main model to account for overall market conditions which are closely tied to regulatory and policy interventions. A mature market tends to have a more established regulatory framework and sustainable investment standards, which is known to increase investors' confidence in the green bond market (OECD 2015) through mitigating greenwashing concerns.

An increase in investor demand should in turn boost bond performance (which can be seen as a decrease in yields) and make green bond issuance more attractive for potential issuers due to the lower cost of capital. While market maturity is a commonly studied factor in other types of markets such as real estate (Chin et al. 2006; Keogh and D'Arcy 1994), it presents a mostly unexplored area for green bonds. Showing that green bond performance depends on market maturity and regulatory framework can serve as motivation for policymakers to further support an expansion of the green bond market.

3 Data and Methodology

This section describes the data sources used for each dependent and independent variable. It then summarizes the methods used for the base regression as well as hypotheses-testing regressions and additional robustness checks.

3.1 Data Collection and Description

3.1.1 Collected Data

The green bonds sample, and also a majority of variables, was sourced from *FactSet*. The sample of green bonds, with issue dates ranging from 2013 to 2023, was created using the following characteristics as filters:

- Bond type: Corporate
- GSS Bond type: Green Bond
- Regions: EU, US, UK, Switzerland
- Data available for all variables, no missing values

To measure green bond performance, yield to maturity (YTM) is used as a dependent variable in the models. YTM is a commonly used bond performance measure in comparable research, including Russo et al. (2021) and Hyun et al. (2021). A lower yield typically means better bond performance because it indicates a higher value of the bond for investors. A decreased yield is connected with a rise in price, representing an increased demand for the bond or an improvement of the issuer's rating.

In the base model, several bond- and firm-specific characteristics are used as independent variables. Variables carrying bond information include maturity, coupon, and amount outstanding. These variables are often employed when measuring bond performance. For example, the issue period and size have been used in research regarding supply-side green bond factors by Wang et al. (2019) and Chang et al. (2021).

The first firm-specific independent variable included is the annual return on assets (ROA). ROA measures the effectiveness of profit-generating from assets by the issuer, so a higher ROA usually signals better financial stability of the issuer, and thus lower default risk. In the context of green bonds, it has previously been used by Flammer (2021) or Wang and Wang (2022). Next, total assets of the issuing company are taken into account. A strong asset base can help withstand economic shocks, and can therefore be connected with lower risk of the company defaulting. Furthermore, operating margin is used as another possible indicator of financial stability. It represents the percentage of revenue that is left after deducting operating expenses and shows the operating efficiency. A higher operating margin is expected to help absorb unexpected expenses or market volatility, and thus decrease the credit risk of the green bond.

Lastly, CO_2 emissions of the issuing company are included. The data was sourced from *Refinitiv Eikon*, using the variable CO_2 Equivalent Emissions Total, which is measured in metric tonnes. It is expected that companies with lower carbon dioxide emissions issue better-performing bonds. By issuing green bonds, companies raise capital for projects which meet sustainability criteria, such as reducing greenhouse gas emissions. Over time, this can lead to a reduction in the firm's carbon footprint (Flammer 2021). This is in turn expected to positively influence bond performance (both through the signaling argument and better ESG ratings) so that the company can incur a lower cost of capital.

To test the hypotheses presented in Section 2.2, several additional variables had to be sourced. For testing Hypothesis #3, a market maturity indicator variable is needed. The required data was downloaded from *Refinitiv Indices*, using the Refinitiv Total Return Index variable for each country (Refinitiv 2023). The market maturity variable should account for market conditions which can be closely tied to regulatory and policy interventions in the given market.

A self-compounded dummy variable, indicating if an issuer is mission oriented, is necessary for testing Hypothesis #2. The variable, further referred to as mission-oriented issuer dummy variable, is created using data from 3 different sources. It distinguishes between green mission-oriented (value of 1) and non-mission-oriented companies (value of 0). Three possible conditions to earn a mission-oriented status have been determined. If an issuer fulfills at least one of the 3 conditions, it is deemed mission oriented. By using 3 different criteria, the advantage of larger companies decreases, as opposed to using membership in only one organization. The first condition focuses on green bond certification - if the issuer already has at least one green bond certified by the Climate Bonds Initiative under the Climate Bonds Standard (CBI 2023), this means that the company had to fulfill multiple sustainability and transparency criteria, and has also shown effort and willingness to issue properly certified green bonds. Thus, a previously CBI-certified green bond indicates an issuer is mission-oriented. Secondly, participation in the United Nations Global Compact, the world's largest corporate sustainability initiative, is also considered a mission-oriented firm characteristic. The UN initiative helps companies align operations and strategies with human rights and environmental principles, creating a global movement of environmentally-friendly firms (UN Global Compact 2023). The third condition is membership in the Ceres Company Network, an initiative formed by major firms committed to sustainable business actions and proper incorporation of ESG principles into decision-making at all levels. The network includes many companies from the Fortune 500 list, and can thus have significant global environmental impact (Ceres 2023). Overall, mission-oriented issuers play an active role in the fight against climate change by prioritizing environmental concerns in their decision making. By issuing certified green bonds or joining one of the aforementioned movements, they signal willingness to improve their environmental footprint. Thus, their green bonds are likely part of such strategy, rather than a mere greenwashing tool. Such bonds are therefore expected to be favored by investors and perform better.

For testing Hypothesis #1, a repeat issuer dummy variable is created. A value of 1 indicates the sample includes multiple green bonds from the given issuer, while a value of 0 means the given green bond is the only one in the sample issued by that issuer. Furthermore, 3 categories of issuers based on the number of green bond issues are created, with a subsequent dummy variable creation for each category. Category 1 represents issuers with 1–2 green bonds, Category 2 issuers with 3-5 green bonds, and Category 3 issuers with 6+ green bond issues. This more complex distribution aims to fully capture the effect of repeated issuance.

For additional analysis, a set of categorical dummy variables for the various GSS Use of proceeds of the green bond is created, with data from the main green bond dataset sourced from *FactSet*. This should help answer if certain use of proceeds project types require a higher yield than others. A visualization of the use of proceeds data is included in the next section.

3.1.2 Summary Statistics and Visual Representation

An overview of the green bonds sample is provided in Table 3.1. As can be seen from the number of green bonds issued in each year, there is an overall rising trend. The number of bonds in 2023 is lower because the data was extracted in March 2023, and thus represents only the first quarter of the year. The table also includes the average yield to maturity (YTM), as well as the average amount outstanding (in millions of US dollars) for bonds issued in each year.

Table 3.2 summarizes the unit of measurement, number of observations, mean, standard deviation, and data source for each variable used in the cross-sectional regressions. While most data was sourced from *FactSet*, other sources also include *Refinitiv Eikon*, *Refinitiv Indices*, *CBI*, *UNGC*, and *CERES*. All variables are previously described in more detail in Subsection 3.1.1.

Table 3.1: Sample overview

Year	# of bonds	YTM *(%)*	Amount outstanding
2013	1	3.352	218.0
2014	4	3.845	655.6
2015	63	6.849	38.69
2016	18	3.838	478.1
2017	29	3.701	618.8
2018	43	4.086	567.4
2019	121	4.251	490.9
2020	156	4.835	494.3
2021	267	5.266	502.0
2022	220	4.620	564.3
2023	55	4.169	650.1

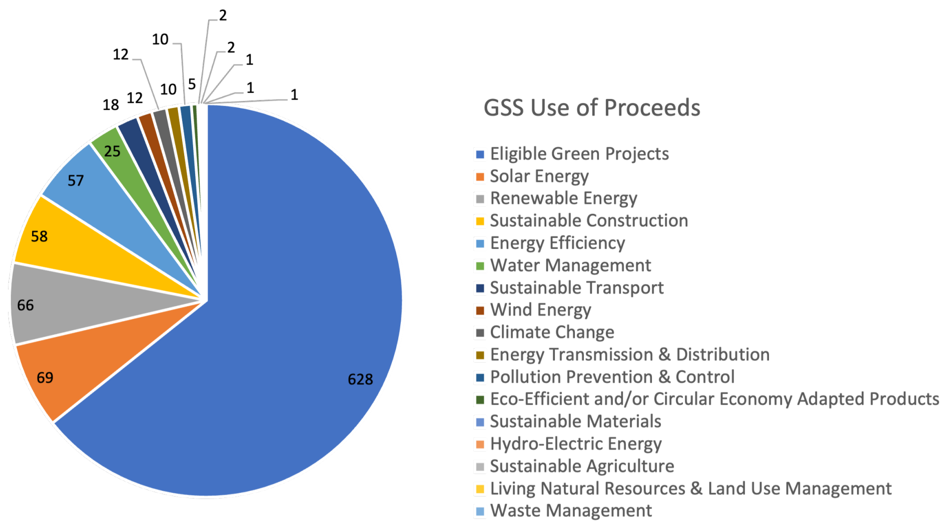
Amount outstanding measured in millions USD

Table 3.2: Summary statistics

Variable	N	Mean	SD	Source
Yield to maturity *(%)*	977	4.834	1.891	FactSet
Maturity *(years)*	977	14.73	71.20	FactSet
Coupon *(%)*	977	2.501	1.754	FactSet
Amount outstanding *(mill. USD)*	977	498.1	381.7	FactSet
Return on assets *(%)*	977	3.100	5.198	FactSet
Total assets *(billion USD)*	977	445.7	1,689	FactSet
Operating margin *(%)*	977	23.87	23.03	FactSet
CO_2 emissions *(mill. metric tonnes)*	977	5.203	1.423	Refinitiv Eikon
Market maturity indicator *(USD)*	977	377.1	168.9	Refinitiv Indices
Mission-oriented issuer *(0 / 1)*	977	0.603	0.490	CBI, UNGC, CERES
Repeat green bond issuer *(0 / 1)*	977	0.862	0.345	FactSet

Figure 3.1 illustrates the use of proceeds of green bonds in the sample, divided into several categories based on the aim of the project. As can be seen from the chart, more than half of the projects have a very vague categorization of 'Eligible Green Projects'. This could be an issue for both investors and issuers, as the demand for such bonds might be lower due to greenwashing concerns. It will be further investigated in the empirical analysis.

Figure 3.1: Use of proceeds



As can be seen in Figure 3.2, the country represented the most in the corporate green bond sample is the United States, followed by Sweden, Germany, and France. Figure 3.3 shows that when grouped into regions (EU, US, UK, and Switzerland), European Union has by far the strongest position in the sample.

Figure 3.2: Country of risk

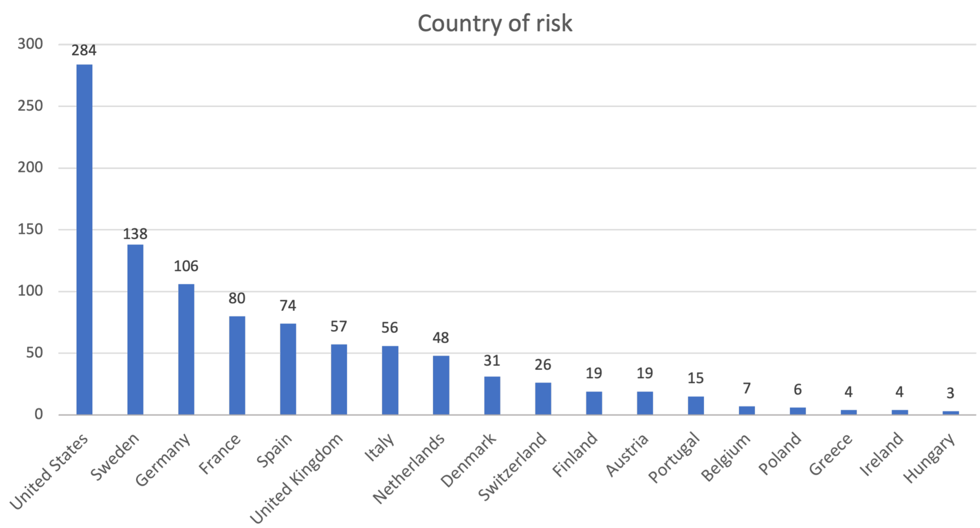
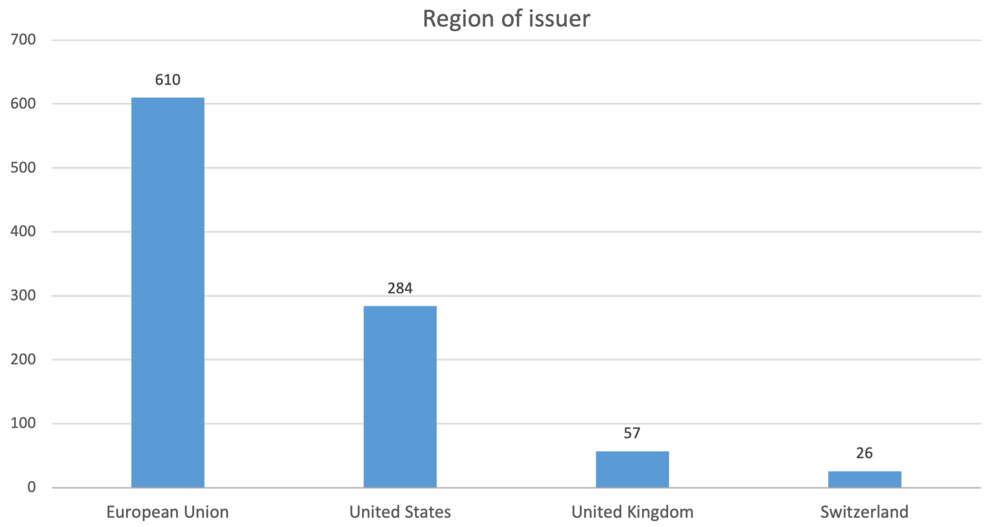


Figure 3.3: Issuer region



3.2 Methodology

The following section summarizes the expected methods for the empirical research. Specifically, Subsection 3.2.1 focuses on the main green bond performance regressions, while Subsection 3.2.3 describes an additional analysis studying the effect of the bond's use of proceeds on its performance.

3.2.1 Regression Models

Base Model

The estimated base model, focused on confirming green bond performance factors, has the following form:

$$\begin{aligned} YTM_i = \beta_0 + \beta_1 maturity_i + \beta_2 coupon_i + \beta_3 \log(amount\ outst.)_i + \\ + \beta_4 ROA_i + \beta_5 \log(total\ assets)_i + \beta_6 operating\ margin_i + \\ + \beta_7 \log(CO_2\ emissions)_i + \epsilon_i \end{aligned} \tag{3.1}$$

$$i \quad \{1, ..., 977\},$$

examining cross-sectional data formed by 977 green bonds from Europe and the US, extracted on 24 March 2023. The dependent variable YTM stands for yield to maturity of the bond and acts as a bond performance indicator. Furthermore, the model includes seven independent variables, specifically three bond-specific characteristics (maturity, coupon, amount outstanding) and four firm-specific characteristics (return on assets, total assets, operating margin, and CO_2 emissions of the issuer). For the amount outstanding, total assets, and CO_2 emissions, natural logarithms are used for better scale. All variables are described in detail in Subsection 3.1.1, including the reasoning behind their inclusion.

To test the main hypotheses, additional variables are added to the base model. The following models show the regression equations of each case.

Repeat Issuers

To test Hypothesis #1, the base model is first extended by adding a dummy variable indicating if the bond issuer is a repeat green bond issuer (1) or not (0). The equation thus has the following form:

$$\begin{aligned} YTM_i = \beta_0 &+ \beta_1 maturity_i + \beta_2 coupon_i + \beta_3 \log(amount\ outst.)_i + \\ &+ \beta_4 ROA_i + \beta_5 \log(total\ assets)_i + \beta_6 operating\ margin_i + \\ &+ \beta_7 \log(CO_2\ emissions)_i + \beta_8 repeat\ issuer_i + \epsilon_i \\ &i \quad \{1, ..., 977\}, \end{aligned} \tag{3.2}$$

Furthermore, a different approach is tested. Categorical dummy variables are added to the model based on the number of green bond issues by the issuer. Category 1, representing issuers with 1–2 green bonds, is used as the reference variable, and thus omitted. Category 2 stands for issuers with 3-5 green bonds, and Category 3 for issuers with 6+ green bond issues. The model then becomes:

$$\begin{aligned} YTM_i = \beta_0 &+ \beta_1 maturity_i + \beta_2 coupon_i + \beta_3 \log(amount\ outst.)_i + \\ &+ \beta_4 ROA_i + \beta_5 \log(total\ assets)_i + \beta_6 operating\ margin_i + \\ &+ \beta_7 \log(CO_2\ emissions)_i + \beta_8 Cat.\ 2_i + \beta_9 Cat.\ 3_i + \epsilon_i \\ &i \quad \{1, ..., 977\}, \end{aligned} \tag{3.3}$$

Mission-oriented Issuers

A dummy variable for mission-oriented issuers is added to the base model to test Hypothesis #2. The creation of the variable is described in Subsection 3.1.1. The equation therefore has the following form:

$$\begin{aligned} YTM_i = \beta_0 &+ \beta_1 maturity_i + \beta_2 coupon_i + \beta_3 \log(amount\ outst.)_i + \\ &+ \beta_4 ROA_i + \beta_5 \log(total\ assets)_i + \beta_6 operating\ margin_i + \\ &+ \beta_7 \log(CO_2\ emissions)_i + \beta_8 mission\text{-}oriented\ issuer_i + \epsilon_i \\ &i \quad \{1, ..., 977\}, \end{aligned} \tag{3.4}$$

In addition, the base model on the full sample is compared to a base model on a subsample comprised of bonds by mission-oriented issuers only. This serves as an additional robustness check.

Market Maturity

A market maturity indicator is added to the base model in order to test Hypothesis #3. The estimated model then becomes:

$$\begin{aligned} YTM_i = {} & \beta_0 + \beta_1 maturity_i + \beta_2 coupon_i + \beta_3 \log(amount\ outst.)_i + \\ & + \beta_4 ROA_i + \beta_5 \log(total\ assets)_i + \beta_6 operating\ margin_i + \\ & + \beta_7 \log(CO_2\ emissions)_i + \beta_8 market\ maturity_i + \epsilon_i \\ & i \quad \{1, ..., 977\}, \end{aligned} \tag{3.5}$$

3.2.2 Method and Tests

Before performing the regression, there are several aspects to take into account. After cleaning the data, the distribution of variables is examined using histograms to check normality. Then, multicollinearity is checked by using both a correlation matrix and a Variance Inflation Factor (VIF). The cut-off value for the VIF is commonly equal to 10, with larger values signalling a multicollinearity problem (O'Brien 2007). Results of the multicollinearity tests can be found in Table A.1 and Table A.2 in the Appendix. Neither test found a multicollinearity problem among the variables tested. Therefore, a regression can be performed.

The chosen regression technique to estimate all the models is the ordinary least squares (OLS) method. It relies on minimizing the sum of squared residuals between the observed values and the values predicted by a linear regression model. OLS is a widely used method in empirical research analyzing the supply-side factors of green bond issuance and performance. For instance, it has been employed by Li et al. (2020), Deng et al. (2020), and Barua and Chiesa (2019). The application of the OLS method in this study thus aligns with the established literature on analyzing green bond performance, and ensures a robust and rigorous analysis of the supply-side factors driving the green bond market.

It is then necessary to check for heteroskedasticity in each model. The Breusch-Pagan test is employed. In the presence of heteroskedasticity, OLS estimators are still unbiased and consistent, but no longer efficient. Therefore, if the null hypothesis (homoskedasticity) is rejected, heteroskedasticity-consistent standard errors should be used, estimating the model with the 'robust' option. This turns out to be the case in all the models. Results of the Breusch-Pagan test are always presented at the bottom of the result tables in Chapter 4.

Finally, several extra robustness checks are employed. These mostly include slight modifications of the tested model such as excluding a certain category or variable, and adding time and country dummy variables to the models. They are described in more detail in Chapter 4 for each specific case. Furthermore, an additional analysis of the use of proceeds is performed, as is demonstrated in the next subsection.

3.2.3 Additional Analysis - Use of Proceeds

Apart from the main regressions, the thesis also includes an additional analysis examining how the use of proceeds of the bond influences the bond yield and thus performance. While no previous academic research has focused on this specific research question, Löffler et al. (2021) found a surge in renewable energy projects compared to other types of projects. A high share of green bonds was also identified in the real estate and construction sectors. These findings hint at the possibility of a better fit of green bonds for certain types of projects in the current regulatory and market conditions. To test the hypothesis, dummy variables for the categories of use of proceeds are added to the base model. The omitted category, to avoid the dummy variable trap, is the most general 'Eligible Green Projects'. The regression equation becomes:

$$\begin{aligned} YTM_i = {} & \beta_0 + \beta_1 maturity_i + \beta_2 coupon_i + \beta_3 \log(amount\ outst.)_i + \\ & + \beta_4 ROA_i + \beta_5 \log(total\ assets)_i + \beta_6 operating\ margin_i + \\ & + \beta_7 \log(CO_2\ emissions)_i + \beta_j use\ category_{ji} + \epsilon_i \\ & i \quad \{1, ..., 977\},\ j \quad \{Use\ of\ proceeds\ categories\} \end{aligned} \tag{3.6}$$

Additionally, a different version is tested, comparing the base model run on Eligible Green Projects only with the model including the other categories as dummy variables. The aim is to understand if certain types of projects are more likely to lead to better green bond performance. In case of evidence of underperforming project categories, future focus should be on how to tackle the related barriers and scale up the green bond market for the given categories.

4 Empirical Results

This chapter summarizes and interprets regression results, obtained using methods described in Section 3.2. Apart from testing the main hypotheses, other related concepts are examined for additional robustness. Lastly, limitations of the work are highlighted along with possible directions of future research. All tests and regressions were performed in *Python*.

4.1 Base Model

First, an OLS regression is run on the base model which includes bond-specific and firm-specific characteristics as independent variables. The dependent variable is the yield to maturity of the bond, representing the bond's performance. Due to the presence of heteroskedasticity, heteroskedasticity-robust standard errors are used. Results of the regression are presented in Table 4.1.

Most of the independent variables have a statistically significant effect. Firstly, the performance of a green bond is related to several bond characteristics. Ceteris paribus, a 1 percentage point higher amount outstanding of a bond is associated with a decrease in the yield to maturity by approximately 0.16 percentage points. This might indicate that larger-scale bonds can offer lower yields to investors, as they are likely to be issued by big companies and perceived as safer. Moreover, they may be issued by companies whose projects bring direct profit while requiring large investments - this is the case for example in the energy sector. According to the results, the green bond's maturity also slightly affects its yield. An increase in maturity by 1 year increases the yield to maturity by 0.001 percentage points. This makes economic sense, as long-term bonds usually offer higher yields than short-term bonds. Furthermore, a 1 percentage point increase in the coupon of a bond is associated with an increase in the yield to maturity by 0.40 percentage points. Coupon is closely related to the yield, therefore the strong positive relationship matches initial expectations.

Green bond performance also depends on the issuers' characteristics. Out of the control variables in the base model, CO_2 emissions and operating margin have a statistically significant effect, while return on assets and total assets do not. A 1 percentage point increase in CO_2 emissions is associated with a decrease in the yield to maturity by approximately 0.08 percentage points, which might seem counterintuitive. Due to the unexpected direction of effect, the model was also re-run without the CO_2 variable for an additional robustness check. The coefficients for other variables remained practically the same. Since the variable is not causing problems in the overall model, it is kept as one of the control variables for further models. There are two main explanations for the initially surprising result, most likely intertwined. It is possible that the companies with the highest CO_2 emissions are also the largest and most well-known companies. Thus, they might be able to offer lower yields, unrelated to their environmental performance. Companies with high CO_2 emissions may also be proactively managing their environmental risks by investing in emission reduction and offsetting initiatives. This can reduce the perceived risk associated with their high level of emissions. Investors may view their efforts positively and be willing to accept a lower yield.

Table 4.1: Regression results – Base model

Yield to maturity	OLS
Maturity	0.0009***
	(0.000)
Coupon (%)	0.4037***
	(0.032)
Amount outstanding (log)	-0.1578***
	(0.039)
ROA (%)	-0.0034
	(0.025)
Total assets (log)	-0.0533
	(0.053)
Operating margin (%)	0.0086**
	(0.004)
CO_2 emissions (log)	-0.0787***
	(0.022)
Constant	6.0121***
	(0.879)
Observations	977
R^2	0.257
Adjusted R^2	0.251
F–statistic	52.96
Prob(F–statistic)	<0.01
Breusch–Pagan test	<0.01
Robust SE	Yes

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Standard errors are in parentheses.

In addition, a 1 percentage point increase in operating margin of the issuer increases the yield to maturity of the green bond by 0.01 percentage points. While the effect is fairly small, it might indicate that companies with higher operating margins use green bonds for funding riskier projects, as they may cover less risky projects with bank loans or other instruments. Further issuer-specific characteristics are explored in subsequent sections.

Several additional robustness checks are performed. The model is re-tested with year dummy variables and country dummy variables. This is done to account for possible yield variation across years and countries. These changes do not significantly change the results. Furthermore, regional categorical dummy variables - for the EU, US, UK, and Switzerland - are added to the base model to be able to see regional effects. The European Union is used as the reference category and thus not included in the regression. The results are reported in Table A.3 in the Appendix.

Compared to green bonds issued in the European Union, the yield to maturity is ceteris paribus 2.10 percentage points lower for bonds issued in Switzerland. This indicates a relatively low cost of capital for projects by Swiss companies financed by green bonds. While the Swiss green bond market certainly needs further development, the cost of capital argument provides good motivation for scaling up the issuance of green bonds. For green bonds issued in the United States, the yield is ceteris paribus 0.72 percentage points higher than the yield of EU green bonds. As can be seen in Figure 3.3, green bonds are much more prevalent in the European Union, which is part of EU programs and regulations supporting environmental causes. To scale up the US green bond market, more investor motivation might be required to allow for a lower cost of capital.

4.2 Repeat Issuers

To test Hypothesis #1, which states that green bonds from repeat issuers provide a lower yield than green bonds from one-time issuers, two methods are used. First, a simple dummy variable is added to the base model, indicating if the issuer issued any other green bonds. Results of the regression can be found in Table A.4 in the Appendix. The effect of the dummy variable is not statistically significant.

The second approach consists of creating 3 categories of issuers based on the number of green bond issues. Category 1 represents issuers with 1–2 green bonds, Category 2 issuers with 3-5 green bonds, and Category 3 issuers with 6+ green bond issues. Each category is then assigned to a dummy variable, with Category 1 serving as the reference category and thus being omitted from the regression model. The results are reported in Table 4.2.

The yield on a green bond by an issuer from Category 2 is 0.24 percentage points lower than on a bond by an issuer from Category 1, ceteris paribus. The difference becomes even larger for Category 3, which includes companies with frequent green bond issues. The yield on a green bond by an issuer from Category 3 is 0.35 percentage points lower than on a bond by an issuer from Category 1, ceteris paribus. Therefore, Hypothesis #1 is partially proven. Taking into account the results of both approaches, it is clear that while issuing more than 1 green bond does not automatically lead to a lower yield required, the more green bonds a company issues, the lower the yield to maturity can get. This argument could help with scaling up the green bond market through the lower cost of capital argument.

Table 4.2: Regression results – Repeat issuers categories

Yield to maturity	OLS
Maturity	0.0011^{***}
	(0.000)
Coupon (%)	0.3968^{***}
	(0.032)
Amount outstanding (log)	-0.1750^{***}
	(0.040)
ROA (%)	-0.0037
	(0.026)
Total assets (log)	-0.0314
	(0.051)
Operating margin (%)	0.0088^{**}
	(0.004)
CO_2 emissions (log)	-0.0781^{***}
	(0.022)
Category 2	-0.2428^{*}
	(0.135)
Category 3	-0.3500^{**}
	(0.139)
Constant	6.0734^{***}
	(0.881)
Observations	977
R^2	0.262
Adjusted R^2	0.255
F–statistic	41.48
Prob(F–statistic)	<0.01
Breusch–Pagan test	<0.01
Robust SE	Yes

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Standard errors are in parentheses.
Reference category for dummy variables: Category 1.

For additional robustness of the results, the regression is re-run with year dummy variables and country dummy variables, as has been done for the base model, to account for possible yields variation across years and countries. This does not significantly change the results.

4.3 Mission-oriented Issuers

A dummy variable for mission-oriented issuers is built to test Hypothesis #2, as is described in Section 3.1. An OLS regression is performed, with a dummy variable for mission-oriented companies added to the base model. The results are summarized in Table 4.3. It shows that the yield on green bonds issued by mission-oriented issuers is ceteris paribus 0.23 percentage points lower than the yield on bonds issued by non-mission-oriented companies. This is in line with Hypothesis #2. The evidence can help motivate companies to become mission-oriented through the lower cost of capital argument. The overall impact on the environment is expected to be positive, however, it is necessary to ensure that companies do not use mission-oriented statements lightly as a greenwashing tool but rather as an actual promise of positive environmental impact.

To better understand the effect being a mission-oriented firm has, a regression using the base model on a sub-sample consisting of bonds by mission-oriented companies only is compared to the base model on the whole sample, described in Section 4.1. The side-by-side results are reported in Table 4.4. In the mission-oriented sub-sample, return on assets (ROA) and total assets of the company become statistically significant, both having a slight negative effect on the bond's yield. On the other hand, CO_2 emissions are no longer statistically significant. This finding shows that for mission-oriented companies, the level of CO_2 emissions does not influence the yield on the green bonds issued.

As an additional robustness check, the models are re-estimated with year dummy variables as well as country dummy variables. The aim is to account for any variation in yields across different years and countries. These changes do not significantly affect the results.

Table 4.3: Regression results – Mission-oriented issuers

Yield to maturity	OLS
Maturity	0.0010^{***}
	(0.000)
Coupon (%)	0.3945^{***}
	(0.033)
Amount outstanding (log)	-0.1481^{***}
	(0.037)
ROA (%)	-0.0033
	(0.025)
Total assets (log)	-0.0329
	(0.054)
Operating margin (%)	0.0081^{**}
	(0.004)
CO_2 emissions (log)	-0.0827^{***}
	(0.022)
Mission-oriented issuer dummy	-0.2284^{*}
	(0.132)
Constant	5.9443^{***}
	(0.872)
Observations	977
R^2	0.260
Adjusted R^2	0.253
F–statistic	49.29
Prob(F–statistic)	$<$0.01
Breusch–Pagan test	$<$0.01
Robust SE	Yes

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Standard errors are in parentheses.

Table 4.4: Regression results – Only mission-oriented issuers compared to the whole sample

Yield to maturity	Mission-oriented	Whole sample
Maturity	0.0013^{***}	0.0009^{***}
	(0.000)	(0.000)
Coupon (%)	0.2736^{***}	0.4037^{***}
	(0.037)	(0.032)
Amount outstanding (log)	-0.1827^{***}	-0.1578^{***}
	(0.065)	(0.039)
ROA (%)	-0.0555^{**}	-0.0034
	(0.027)	(0.025)
Total assets (log)	-0.1009^{*}	-0.0533
	(0.053)	(0.053)
Operating margin (%)	0.0209^{***}	0.0086^{**}
	(0.003)	(0.004)
CO_2 emissions (log)	-0.0392	-0.0787^{***}
	(0.030)	(0.022)
Constant	6.3210^{***}	6.0121^{***}
	(0.834)	(0.879)
Observations	589	977
R^2	0.254	0.257
Adjusted R^2	0.245	0.251
F–statistic	26.37	52.96
Prob(F–statistic)	<0.01	<0.01
Breusch–Pagan test	<0.01	<0.01
Robust SE	Yes	Yes

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Standard errors are in parentheses.

4.4 Market Maturity

To test Hypothesis #3, a market maturity indicator is added to the base model. Results of the regression can be found in Table A.5 in the Appendix. The results indicate that market maturity does not have a statistically significant effect on the yield of green bonds. However, it is important to note that the market maturity indicator is only available for the market as a whole, not solely for the green bond market. For additional robustness, year and country dummy variables are then added to the model. This does not lead to any significant result changes.

Overall, it seems that currently bond- and company-level characteristics, rather than market-related conditions, influence the yield of green bonds. A key takeaway from evaluating the three main hypotheses is that the most important next step is to motivate companies to become mission-oriented and issue green bonds regularly, in order to achieve lower cost of capital. This will in turn help further scale up the green bond market.

4.5 Additional Analysis - Use of Proceeds

For additional robustness of the results, the effect of the use of proceeds of a green bond on its yield is tested. Dummy variables are created for each use of proceeds category and added to the model. The most general category, Eligible Green Projects, is used as the reference category omitted from the model. Results of the OLS regression are reported in Table 4.5.

The yield to maturity is higher for certain categories with statistical significance, compared to the base category. Specifically, it is ceteris paribus 3.97 percentage points higher for Waste Management projects and 1.50 percentage points higher for Sustainable Agriculture. These types of projects might be viewed as more risky, less environmentally important, or overall less appealing by investors. In addition, energy-related projects also seem to have a higher yield required than the base category of Eligible Green Projects. The yield to maturity is ceteris paribus 0.82 percentage points higher for Hydro-Electric Energy projects, 0.45 percentage points higher for Renewable Energy, and 1.19 percentage points higher for Solar Energy, compared to the base category. It is possible that the base category of Eligible Green Projects includes a lot of projects from reputable issuers who can offer a lower yield to investors. This would explain the disparity between yields in the categories.

Since the negative relationship between CO_2 emissions and yield is slightly more pronounced in this model, several modifications are run as an additional robustness check. First, Eligible Green Projects are excluded from the model, which decreases the coefficient of CO_2 emissions to -0.0994. Then, the model is re-tested on Eligible Green Projects only. The coefficient is higher, equal to -0.0820. This difference is likely due to the fact that companies in certain emission-heavy industries, such as power generation, bring direct profit and can thus offer lower bond yields to investors.

The model is also re-tested with the inclusion of year and country categorical dummy variables, as an additional robustness check accounting for any time and country variations. This does not significantly affect the results.

Table 4.5: Regression results – Use of proceeds dummy variables

Yield to maturity	OLS
Maturity	0.0011***
	(0.000)
Coupon (%)	0.3900***
	(0.032)
Amount outstanding (log)	-0.0983***
	(0.036)
ROA (%)	-0.0232
	(0.029)
Total assets (log)	-0.0755
	(0.056)
Operating margin (%)	0.0102***
	(0.004)
CO_2 emissions (log)	-0.0868***
	(0.023)
Climate Change	0.2971
	(0.443)
Eco-Efficient Products	-0.5538
	(0.410)
Energy Efficiency	0.2208
	(0.221)
Energy Transmission & Distrib.	-0.3145
	(0.218)
Hydro-Electric Energy	0.8213***
	(0.254)
Land Use Management	0.4898
	(0.317)
Pollution Prevention & Control	-0.4209
	(0.351)
Renewable Energy	0.4511**
	(0.186)
Solar Energy	1.1938***
	(0.331)
Sustainable Agriculture	1.4861***
	(0.368)

Sustainable Construction	-0.0272
	(0.228)
Sustainable Materials	0.1198
	(0.323)
Sustainable Transport	0.0891
	(0.217)
Waste Management	3.9689***
	(0.179)
Water Management	0.3629
	(0.238)
Wind Energy	0.0573
	(0.239)
Constant	5.9587***
	(0.903)
Observations	977
R^2	0.278
Adjusted R^2	0.261
F–statistic	223.7
Prob(F–statistic)	<0.01
Breusch–Pagan test	<0.01
Robust SE	Yes

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Standard errors are in parentheses.
Reference category for the use of proceeds dummy variables: 'Eligible Green Projects'.

4.6 Limitations and Future Research

When interpreting the results, several limitations of the study should be taken into consideration. The research relies on cross-sectional data, which provides a snapshot of the variables at a particular point in time. This restricts the ability to observe trends and changes over time. Future research might try to accumulate a panel data set to better identify effects which are not immediate.

Furthermore, the specific choice of variables heavily influences the results. Some variables not included in this study, such as ESG scores of the issuers, might improve the model. It would also be beneficial to have more specific data for the use of proceeds variable, as more than half of the green bonds included have the vague Eligible Green Projects categorization. Some categories have a very limited representation in the sample, for example, only 1 Waste

Management green bond is included. Therefore, better data regarding the use of proceeds of green bonds might be accumulated by future researchers.

The data used as a market maturity indicator was formed by an index for the whole market, rather than the green bond market only. In the future, the variable should be re-tested if such index becomes available. The same goes for the mission-oriented variable, which currently had to be self-compounded by considering three different factors, including memberships in mission-oriented organizations and previous issuance of CBI-certified green bonds. A worldwide initiative uniting mission-oriented companies would be a step in the right direction, beneficial for investors and researchers alike.

Finally, the sample used in the study might not fully represent the population of interest. The selection of bonds was based on the availability of data for all the necessary variables, potentially resulting in a sample that does not accurately reflect the entire green bond market. It is also important to note that since it is a relatively new market, most of the sample comes from 2019 to 2022, as can be seen in Table 3.1 in Subsection 3.1.2. Thus, as the market expands in the years to come, more data will become available, providing even more reliable regression results.

5 Conclusion

Green bonds have gained popularity since their introduction in 2007, yet the scale at which they are issued is still very limited. They still account for only around 3.5% of the overall bond market (European Parliament 2022) and are mostly issued in developed countries such as the US, China, and Germany (S&P Global Market Intelligence 2023). To help fight climate change and fulfill the Paris Agreement, it is vital to scale up the corporate green bond market. This thesis analyzes how different bond- and firm-specific characteristics influence green bond performance (measured as yield to maturity of the bond), with the aim to motivate further corporate green bond issuance.

Using cross-sectional data on green bonds issued between 2013 and 2023 in the European Union, United States, United Kingdom, and Switzerland, several OLS regressions are performed. Firstly, a base model is tested, including control variables selected according to existing academic literature. These include bond-specific characteristics – coupon, maturity, and amount outstanding (Wang et al. 2019; Chang et al. 2021) – as well as firm-level characteristics such as operating margin, total assets, return on assets, and CO_2 emissions (Flammer 2021; Wang and Wang 2022). According to the regression results, maturity, coupon, and operating margin of the issuer all affect the yield to maturity positively, while the amount outstanding and CO_2 emissions relate to the yield negatively. The surprising direction of the effect of CO_2 emissions on YTM can be explained by large companies being able to offer low yields due to being perceived as well-known and stable, despite their high emissions. They also often proactively manage their environmental risks by investing in emission offsetting, which is usually viewed positively by investors, and can result in better green bond performance.

Afterwards, variables are added to the base model to test the three main hypotheses, focused on the effect of repeat issuers, mission-oriented issuers, and market maturity on green bond performance. Hypothesis #1 predicts a lower yield on green bonds issued by repeat issuers. While no effect is found by using a simple dummy variable that distinguishes between 1 and more issues, the hypothesis is confirmed by dividing issuers into categories of 1–2, 3–5, and 6+ green bonds issued. The yield on a green bond issued by a company from the second category is lower than on a bond by an issuer from the first category, and the difference becomes even larger for the category of most frequent issuers. While there has been no previous research on the yield difference between green bonds issued by first-time and repeat issuers, evidence of a larger greenium for repeat issues by non-financial companies was found by Fatica et al. (2021). The new findings follow a similar logic, being linked to the signaling argument used by Flammer (2021).

Hypothesis #2 anticipates green bonds issued by mission-oriented companies to perform better than those issued by non-mission-oriented issuers. To test it, a self-compounded dummy variable for mission-oriented bond issuers is added to the base model. The novel results show that mission-oriented companies can offer lower yields to investors, incurring a lower cost of capital. This can motivate firms to commit to sustainable business practices and become mission-oriented, which will have further positive effects on the environment.

On the other hand, no effect of either market maturity is found. Therefore, there is no evidence in support of Hypothesis #3, which predicted that market maturity can positively influence green bond market performance. However, it is important to note the main limitation of the given model - the market maturity variable is formed using an index for each market as a whole, rather than the green bond market only, due to the unavailability of such data. Thus, the hypothesis should still be re-tested in the future.

For additional robustness, time and country dummy variables are added to the models. Some models are also retested on sub-samples or without certain variables. These changes do not bring any significant changes. Further analysis is also performed to test the effect of the use of proceeds of the green bond. The yield to maturity is higher for certain project categories, such as Waste Management or Sustainable Agriculture, compared to the base category of Eligible Green Projects.

The main limitation of this thesis lies in the cross-sectionality of data, which restricts the ability to observe changes and trends over time. With increasing data availability, future research might manage to obtain panel data and re-test the hypotheses. Furthermore, certain variables might become more specific and have better sources. Completely new variables, such as ESG scores, might also be added to the base model.

Overall, this study contributes to existing literature on green bonds by proving that green bonds by mission-oriented companies and repeat issuers can offer lower yields to investors. This has important implications for scaling up the green bond market. By offering green bonds at lower yields, the companies can reduce their overall cost of capital and make sustainable projects more financially viable. Therefore, it addresses a critical barrier in driving sustainable investments, and encourages greater participation from both traditional and impact-driven investors. Ongoing collaboration between policymakers, financial institutions, and mission-oriented companies is crucial to optimize the market, with policymakers creating favorable regulatory frameworks, financial institutions developing innovative solutions, and companies driving sustainable practices. As the green bond market expands with more affordable financing options, it has the potential to accelerate the transition to a sustainable economy, while benefiting companies seeking to incorporate sustainability into their core strategies.

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Appendix A Tables

Table A.1: Correlation matrix

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1)	Maturity	1.00									
(2)	Coupon	0.02	1.00								
(3)	Amount outst.	0.02	-0.13	1.00							
(4)	ROA	0.03	0.26	-0.24	1.00						
(5)	Total assets	-0.01	0.02	0.04	-0.09	1.00					
(6)	Operat. margin	-0.07	-0.05	-0.20	0.04	-0.04	1.00				
(7)	CO_2 emissions	0.01	0.02	0.15	-0.07	-0.06	-0.18	1.00			
(8)	Repeat issuer	0.03	-0.06	-0.03	0.04	0.02	0.02	-0.02	1.00		
(9)	Mission-oriented	0.04	-0.22	0.17	-0.21	0.07	-0.13	-0.10	0.09	1.00	
(10)	Market maturity	-0.04	0.10	0.21	0.20	-0.16	-0.32	0.20	-0.12	-0.40	1.00

Table A.2: Variance Inflation Factor

Variable	Variance Inflation Factor
Maturity	1.054
Coupon	2.967
Amount outstanding	3.346
ROA	1.657
Total assets	1.103
Operating margin	1.915
CO_2 emissions	1.231
Repeat issuer	5.556
Mission-oriented	2.573
Market maturity	5.526

Table A.3: Regression results – Regional dummy variables

Yield to maturity	OLS
Maturity	0.0012***
	(0.000)
Coupon (%)	0.3377***
	(0.033)
Amount outstanding (log)	-0.1577***
	(0.039)
ROA (%)	-0.0215
	(0.027)
Total assets (log)	-0.0429
	(0.050)
Operating margin (%)	0.0106***
	(0.004)
CO_2 emissions (log)	-0.1015***
	(0.023)
Switzerland	-2.1022***
	(0.369)
United Kingdom	0.2724
	(0.217)
United States	0.7246***
	(0.149)
Constant	6.1617***
	(0.838)
Observations	977
R^2	0.314
Adjusted R^2	0.307
F–statistic	48.83
Prob(F–statistic)	<0.01
Breusch–Pagan test	<0.01
Robust SE	Yes

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Standard errors are in parentheses.
Reference category for the region dummy variables: EU.

Table A.4: Regression results – Repeat issuers

Yield to maturity	OLS
Maturity	0.0010***
	(0.007)
Coupon (%)	0.3997***
	(0.031)
Amount outstanding (log)	-0.1622***
	(0.039)
ROA (%)	-0.0034
	(0.025)
Total assets (log)	-0.0450
	(0.050)
Operating margin (%)	0.0088**
	(0.004)
CO_2 emissions (log)	-0.0777***
	(0.022)
Repeat issuer dummy	-0.1941
	(0.216)
Constant	6.0992***
	(0.929)
Observations	977
R^2	0.258
Adjusted R^2	0.252
F–statistic	46.29
Prob(F–statistic)	<0.01
Breusch–Pagan test	<0.01
Robust SE	Yes

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Standard errors are in parentheses.

Table A.5: Regression results – Market maturity

Yield to maturity	OLS
Maturity	0.0010***
	(0.000)
Coupon (%)	0.4025***
	(0.032)
Amount outstanding (log)	-0.1599***
	(0.039)
ROA (%)	-0.0053
	(0.026)
Total assets (log)	-0.0477
	(0.053)
Operating margin (%)	0.0093**
	(0.004)
CO_2 emissions (log)	-0.0800***
	(0.022)
Market maturity indicator	0.0003
	(0.000)
Constant	5.8627***
	(0.852)
Observations	977
R^2	0.257
Adjusted R^2	0.251
F–statistic	46.78
Prob(F–statistic)	<0.01
Breusch–Pagan test	<0.01
Robust SE	Yes

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Standard errors are in parentheses.