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Looking at the European market: Does the greenium exist?

And if so, do it apply uniformly across different industries?

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BI NORWEGIAN BUSINESS SCHOOL

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Abstract

The green bond market has emerged as a significant funding source to address the challenges posed by climate change. Researchers have identified a phenomenon known as the "green premium" or "greenium". Green bonds trade at a premium because they are in high demand, and as a result, investors accept a lower return. By examining the yield of green bonds in relation to comparable conventional bonds, we can assess the existence of a premium. Furthermore, we will explore variations in the greenium across different businesses and sectors. Over the period from 2012 to 2022, we will construct a European panel comprising both traditional and green corporate bonds, utilizing bond-level data sourced from Refinitiv. In order to examine the data, we will run fixed-effects regressions on an unbalanced panel of corporate bonds, using the bond's issue yield spread as the dependent variable. This research is motivated by our interest in the expansive and significant topic of green finance.

In our study, we find that the presence of a greenium in the total sample of green bonds is not statistically significant, suggesting no clear evidence of its existence. However, our analysis reveals the potential reemergence of the greenium when examining different industries, with significant results indicating variations in the premium across sectors.

Keywords – Green Bonds, Conventional Bonds, Climate change, high yield, Greenium, Europe, Fixed Regression, Green Finance

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1 Introduction

Climate change is one of the biggest challenges we face for humanity. The Paris Agreement recognizes the need for innovation to deal with climate change. The ultimate goal of the agreement is to limit global warming to 1.5 degrees Celsius over pre-industrial levels since doing so will reduce the risks and consequences of climate change (United Nations, 2015). Lowering greenhouse gas emissions is necessary to succeed with the mitigation strategy. Additionally, there is a requirement for adaptation, which is responding to already-occurring repercussions of climate change (NASA, 2021).

The concept of ESG (Environmental, Social, and Governance) has gained significant recognition in portfolio management in recent years, according to Verheyden et al. (2016). Financial investors have become significant players in accelerating the shift to a more sustainable world. In order to promote a sustainable future, their capacity to reroute funds toward environmentally beneficial assets is essential. The principles for responsible investments (PRI) were formed in 2006 in response to the rising awareness of the effects of climate change on the economy. Many investors have pledged to contribute money to projects that result in lower carbon emissions, in keeping with the goals stated in the Paris Agreement. This collective effort reinforces the commitment to combat climate change and advance a sustainable global economy by highlighting the growing significance of incorporating environmental issues into investment plans.

With the advent of products like green bonds, the financial industry is rapidly realizing the importance of climate change. By directing cash toward environmentally friendly investments, green bonds help investors actively contribute to a greener economy. In 2020, Fatica and Panzica researched the long-term benefits of green bonds issued by non-financial companies. Corporations that issue green bonds experience a reduction in the carbon intensity of their assets when compared to conventional bond issuers of similar financial characteristics and environmental ratings. When green bonds used for refinancing are excluded, the reduction in emissions is more apparent and long-lasting, pointing to a stronger relationship with new climate-friendly projects. Furthermore, according to Fatica and Panzica (2020), green bonds that are subject to external evaluations and those that are issued after the Paris Agreement result in a greater reduction in emissions. These results highlight the potential for green bonds to promote favorable environmental outcomes and support long-term climate goals.

Simultaneously as green bonds are growing, several studies also address the pricing of green bonds to identify a potential presence of a green bond premium, also called the "greenium". Over the past few years, there has been significant growth in the market for green bonds. With

the prospect of more significant development in the years to come, particularly with the United States recommitting to the Paris Agreement, a total of 487.1 USD billion green bonds was issued in 2022 (Climate Bonds Initiative, 2023). The green bond market experienced a growth rate of 49% from 2016 to 2021, and by 2023, the annual issuance of green bonds is expected to reach $1 trillion (The World Bank, 2021).

Hartzmark and Sussman (2019) investigated if investors value sustainability and found that investors marked comprehensive care about sustainability, and according to experimental data, sustainability is thought to predict future performance positively. However, Stubbington (2021) discusses indications that this so-called "greenium" is eroding despite a boost in the issuance of bonds where the proceeds are allocated to sustainable activities. In addition, many investors are starting to question the rationale for paying more for a bond designated as "green," claiming that there are more effective ways to encourage governments or corporations to increase their spending on green initiatives. There are indications that other investors are adopting a similar mindset, as there is limited research on the accurate measure of the greenium (Stubbington, 2021). However, issuing green debt pushes businesses to reveal additional details regarding sustainable operations, assisting investors in assessing the whole business' ESG credentials. Other investors also think green debt, which trades less often than traditional debt, will perform better in an economic downturn (Stubbington, 2021).

Our analysis is inspired by the continuing and related discussion concerning investors' readiness to pay more for a bond with the label "Green" (i.e., accept lower yields) when compared to an otherwise similar conventional bond. This thesis aims to contribute to the body of knowledge on the green bond premium, which Zerbib (2019) defines as the yield difference between a green bond and a conventional bond that is otherwise identical. We will determine whether there is a green bond premium by comparing the yield of a green bond to that of an identical conventional bond. We will also investigate if the greenium differs across industries and sectors, especially considering renewable energy, sustainable transport, and green building projects. Further research is needed to comprehensively explore the concept of 'greenium' across various industries. Prior studies about the green premium have relied on information from the years prior to the significant expansion of the green bond market beginning in 2017. This inspires us to research the subject by studying historical data from more recent years, particularly from 2012 to 2022, to find out more about the impact that the last years have had on the green bond premium.

1.1 Research Question

Based on the introduction above, our research question will be the following:

Looking at the European market: Does the greenium exist? And if so, do it apply uniformly across different industries?

1.2 Hypotheses

As mentioned in the introduction, the research question is the following; "Looking at the European market: Does the greenium exist? And if so, do they apply uniformly across different industries?

To answer the research question, we have identified two hypotheses:

1.2.1 *Hypothesis* $H_0(1)$*: There is no premium for green bonds.*

The yields on green bonds and conventional bonds are not significantly different.

1.2.2 *Hypothesis* $H_A(1)$*: Green bonds have a premium.*

There is a premium for green bonds, which suggests that investors accept a lower yield because they pay a higher price. The greenium manifests as a negative yield differential between green bonds and conventional bonds.

1.2.3 *Hypothesis* $H_0(2)$*: Greenium apply evenly across industries.*

The greenium apply evenly across industries and do not vary across different sectors nor industries.

1.2.4 *Hypothesis* $H_A(2)$*: Greenium apply differently to different industries.*

The greenium apply differently to different industries, meaning that the premium observed in green bond yields varies across sectors or industries.

The appearance of greenium may differ across industries. To investigate this, our second hypothesis examines the premium associated with the use of proceeds. We classify the green bonds based on their intended debt objectives and analyze the differences in the green bond premium among these segments. This analysis forms the foundation for evaluating our second hypothesis and understanding how the greenium manifests in different industries.

1.3 Structure of the Thesis

The structure of this thesis is as follows. In Chapter 2, we provide background information on the green bond market and signaling theory. Chapter 3 compiles the literature on past research concerning the connection between corporate social responsibility and financial performance, as well as the evidence on the relationship between green bonds and the greenium. In Chapter 4, we outline the methodology. Before delving into our empirical analysis in Chapter 6, we provide a comprehensive overview of the data used in Chapter 5. Finally, in Chapter 7, we conclude by summarizing and discussing our findings.

2 Background

2.1 Definition of Green Bonds

According to ICMA, green Bonds are any type of bond instrument where the proceeds or an equivalent amount will be exclusively applied to finance or re-finance, in part or in full, new and/or existing eligible Green Projects (see Use of Proceeds section below) and which are aligned with the four core components of the GBP (ICMA, 2021). The definition offers a precise framework for classifying bonds as green, guaranteeing uniformity and transparency in the market for green bonds. The "use of proceeds" or asset-linked bonds make up a sizeable chunk of the green bond market (Climate Bonds Initiative, 2021a). These kinds of bonds are essential for boosting sustainable investments because they are made to support particular green projects or assets. Green bonds must track, monitor, and report on how funds are used, which might result in greater transaction costs than for conventional bonds. This is one of their main characteristics. Investors can have trust that the money raised through green bonds will be used for its intended environmental purposes thanks to this reporting and transparency mechanism, which also encourages responsibility in the green bond market.

Green bonds have emerged as one of the most renowned financing tools for green projects. The volume of green debt is on the rise, with a significant portion being in the form of green bonds. Green bonds are long-term fixed income debt products, just as conventional bonds. The seniority, recourse, and rating are often the same as those of an issuer's traditional bonds. The primary distinction between green and conventional bonds is that the proceeds of a green bond are set aside for projects that are friendly to the environment and the climate. Investments in renewable energy, energy-efficient construction practices, green transportation, or green buildings often fall under this category (Barbosa, 2018).

Green bonds are a significant breakthrough for institutional investors like pension funds, insurance companies, mutual funds, and sovereign wealth funds since they are a financial innovation created to facilitate sustainable investments. By increasing the liquidity of infrastructure assets, green bonds, for instance, are frequently cited as an innovation that can encourage institutional investors to invest more in sustainable infrastructure (Maltais and Nykvist, 2020).

2.2 Development of Green Bonds

The World Bank issued the first green bond in 2008 in collaboration with the Swedish bank SEB. Since then, the global green bond market has increased from 11 billion dollars issued in 2013 and 36 billion dollars issued in 2014 to 167 billion dollars issued in 2018 (Maltais and Nykvist, 2020). In 2021, the issuance of green bonds was almost $400 billion (Caramichael and Rapp, 2022).

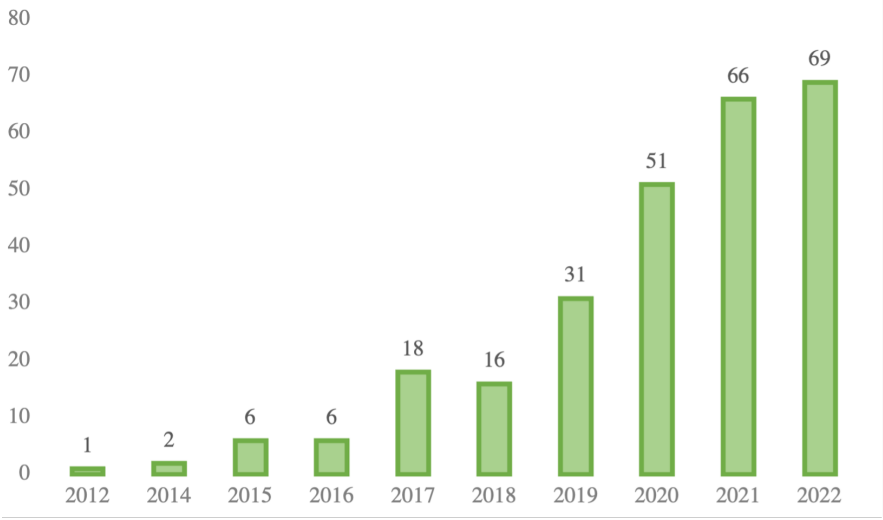

Figure 2.1: *The development of green corporate bonds issued in Europe between 2012 and 2022, based on our data sample. The data was gathered using Refinitiv.*

The issuance of green corporate bonds has consistently increased over the years, as evident from the table above. Starting with only one bond in 2012, the number has steadily grown, reaching a peak of 69 bonds in 2022. This upward trend indicates a growing interest in and adoption of green bonds as a favored means of financing environmentally friendly initiatives. The table reveals a significant surge. This notable increase underscores the scale and importance of green bond issuances, highlighting their pivotal role in financing sustainable projects within the European market. The overall trend suggests a maturing market for green bonds, accompanied by a heightened investor interest in sustainable investment alternatives. However, it is important to note that there may be fluctuations in the issuance of green bonds from year to year. These fluctuations could be influenced by various factors such as market conditions, regulatory changes, and specific project opportunities. Nonetheless, the long-term trajectory demonstrates a growing recognition and adoption of green bonds as a viable financing option for environmentally conscious initiatives.

Green bonds have been mentioned as a potential catalyst for large-scale, quick climate investment during this moment of fast growth. However, they have come under fire for lacking

standards, having high issuance costs, and having the ability to engage in "greenwashing," or applying a green label to a bond that does not finance approved green projects. Furthermore, it's not obvious whether green bonds genuinely encourage green investment or if they are only a tool for identifying green investments that would have been developed and financed with a conventional bond in the absence of green bonds.

2.3 The Greenium

The greenium refers to the additional return investors receive for investing in green bonds compared to traditional bonds. Green bond issuers may have several direct and indirect benefits that boost green investment. The greenium also reflects the possibility that green bond issuers can offer a lower interest rate than standard bond issuers. If a corporation issues a green bond, the demand for the bond may increase since it may attract new investors interested in sustainable investing. The yield differential between a green bond and an equivalent or fictitious conventional bond should increase demand because it is known as the green premium, or "greenium" (Caramichael and Rapp, 2022).

But even if a green bond issue provides a greenium, it might still be more expensive to issue a green bond than a regular conventional bond. For sophisticated green projects and small or first-time issuers, the certification, issuance, monitoring, and reporting procedure takes a lot of time. For certain issuers, it might require a number of green bond issues or a sizable greenium for the borrowing cost advantage to make up for the high issuing and compliance costs.

There a number of reasons why an investor could be willing to accept a lower yield on a green bond compared to a comparable conventional bond. The greenium´s most prevalent argument is that investors are ready to forgo quick financial gains in exchange for environmental benefits. Investors are said to give a positive value to the green promise and are willing to pay a higher price for a bond at issuance, which implies they accept a lower yield, because a green bond is essentially made up of a conventional bond plus a green promise (Caramichael and Rapp, 2022).

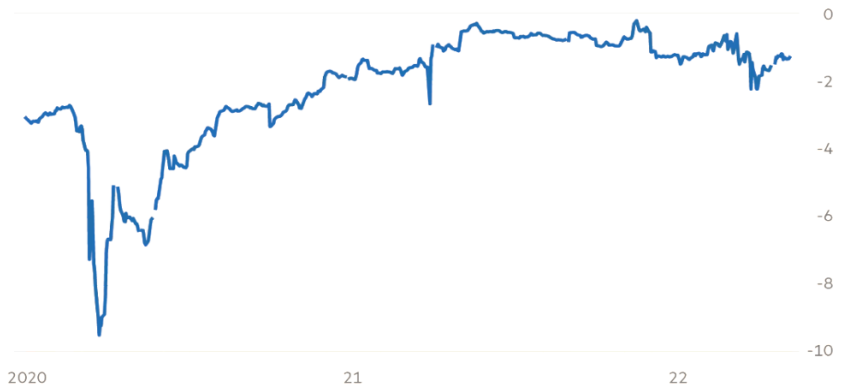

Figure 2.2: *Since 2020, the premium for ESG bonds has decreased. Spreads of corporate ESG bonds denominated in euros measured against non-ESG benchmarks (basis points) (Duguid, 2022).*

The diminishing green premium can be attributed to several factors. Firstly, the market saturation resulting from increased green bond issuance has reduced their uniqueness and exclusivity, leading to a decline in the premium they used to command (Duguid, 2022). Secondly, investors have become more discerning, seeking genuine environmental initiatives and avoiding greenwashing attempts. This increased scrutiny has contributed to a decline in the premium as investors demand greater transparency and credibility. Additionally, the surge in green bond supply has diluted prices and increased borrowing costs, further diminishing the premium. Despite these factors, the greenium, the lower borrowing costs for issuers of green bonds, still plays a role in pricing, although its significance is evolving as the market matures and investor perceptions change. Stricter regulations and a focus on higher environmental and social standards may result in a more robust greenium for select issuers. However, the overall trend suggests a diminishing green premium as the market adjusts to changing dynamics and investor preferences (Duguid, 2022).

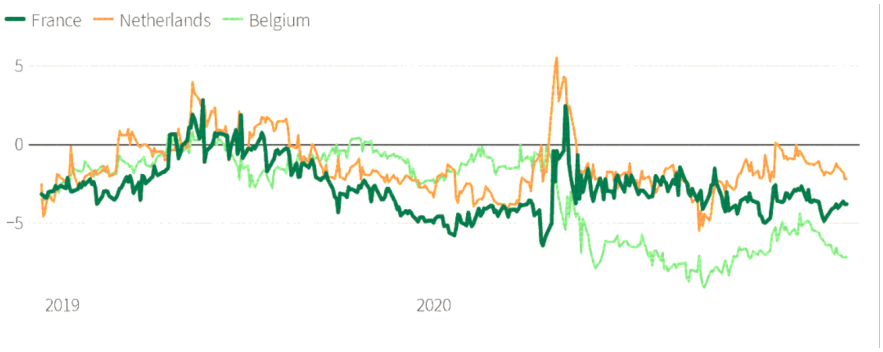

Figure 2.3: *On the issuer's yield curve, data compares the trading levels of green bonds to the conventional bonds that are around them. A negative level means the green bond is selling at a premium (Bahceli, 2020).*

In 2019, the yield curves for the three countries appeared similar, indicating comparable borrowing costs for the issuers. However, in 2020, a slight divergence in yield spreads occurred, with Belgium

exhibiting a higher spread. Several factors can influence these yield spreads, including differences in economic conditions, fiscal policies, and market perceptions of risk and future interest rates. Country-specific events, regulations, and investor sentiment can also impact pricing.

2.4 Green Bonds Principles

A group of investment banks formed the "Green Bond Principles" (GBPs) in 2014 as a voluntary set of best practices standards. Since then, the ICMA has hosted it as an independent secretariat (Climate Bonds Initiative, 2021b). Transparency, disclosure, and reporting are encouraged by the GBPs' standards, which aim to enhance integrity in the green bond market (ICMA, 2018). They comprise four main parts: using the proceeds, selecting and evaluating projects, managing the proceeds, and reporting. It is also necessary to disclose the relevant eligibility requirements or any other procedure to detect and manage potential material, environmental, and social hazards connected to the projects (ICMA, 2018). The third key component, management of proceeds, stipulates that the issuer should credit a subaccount, transfer funds to a sub-portfolio, or track the net proceeds of the green bond. Additionally, this should be supported by an internal procedure connected to the lending and investment processes. Then, so long as the bond is outstanding, the balance shall be amended concerning the allocation of proceeds (ICMA, 2018).

Furthermore, green bond issuers should produce current data on the use of proceeds, ensure that they are renewed annually until complete allocation, and do so promptly in the event of significant events (ICMA, 2018).

2.5 Green Bond Certification

The Climate Bonds Initiative (CBI) offers certification requirements and standards. To determine an asset's low carbon value and its appropriateness for issuance as a green bond, the CBI's Climate Bonds Standard specifies sector-specific eligibility requirements. After an approved external verification that the bond complies with environmental criteria and that the issuer has the relevant controls and processes, assets that fulfill the CBI standard are eligible for Climate Bond Certification (Ehlers and Packer, 2017). The CBI standard has the drawback of only sometimes requiring continuous monitoring and verification. Investors benefit significantly from having a company renew its accreditation regularly, especially if they want to hold onto their investment for several years (Ehlers and Packer, 2017).

2.6 Classification of Green Bonds

Green bonds have their own labels. The risk of "greenwashing" - declaring something to be green when it is not - and the many interpretations of what makes up green bond both clearly increased by this. 115 agencies and governments have worked to allay these worries by developing more reliable and uniform categorization.

2.6.1 Greenwashing

The practice of creating unfounded or false environmental claims is referred to as “greenwashing.” Greenwashing in the context of green bond investing can be defined as investors being more worried about bonds having a green label than the bonds´ real environmental impact and using the bond proceeds for green investment projects (Sangiorgi and Schopohl, 2021).

There is no guarantee that the green projects of a green bond are connected with a long-term, genuine commitment to green investment, even while the issuance of a green bond may signal that a company is more environmentally conscious than its competitors (Caramichael and Rapp, 2022).

2.6.2 External Reviews

Due to investor preferences for green investments, green bonds should be more reliable or of higher quality if investors are willing to pay more than their conventional bond equivalents. By confirming the caliber of green bonds, external reviewers act as information middlemen in the market for green bonds.

Financial industry issuers can effectively use external reviews as a tool. The primary responsibility of external reviewers is to offer unbiased assessments by attesting to the green bonds’ compliance with a particular framework or set of requirements. Investors can see from external reviews that the bond proceeds are going to initiatives that care about the environment (Simeth, 2022).

Investors look to information issued by issuers and independent evaluations to determine whether green bonds are credible. The Green Bond Principles advise that "issuers use external assurance to validate their alignment with the essential elements of Green Bonds," even if external audits are not required. Several external evaluations are possible, such as ratings, third-party assurances, and second-party opinions (SPOs). Nearly 90% of green bonds in 2018 underwent external scrutiny. Additionally, a certification from the Climate Bonds Initiative is obtained by some issuers.

2.6.3 Second Party Opinions

Second-party opinions dominates the market in terms of outside reviews. SPOs or "second opinions" offer a perspective on the environmentally friendly features of a green bond or the green bond framework of an issuer. Typically, an external sustainability expert evaluates the issuer's green bond structure and certifies that it abides by the Green Bond Principles. Organizations or consultants offer these services with a proven track record in environmental sustainability, such as CICERO, an Oslo-based climate research institute, or Environmental Social Governance (ESG) service providers like Oekom, Sustainalytics, Vigeo Eiris, or DNV GL (Allman and Lock, 2022).

2.6.4 Third Party Assurances

Accounting or audit companies like KPMG and Deloitte give third-party assurances (or verifications) to determine whether a green issuance complies with a renowned worldwide framework like the Green Bond Principles. The criteria for the green bond, project selection and appraisal, internal mechanisms for tracking funds, non-financial statistics on environmental results, and processes for gathering progress are all areas where assurances might be concentrated (Allman and Lock, 2022).

2.6.5 Ratings

Finally, issuers also have the option to certify green bonds following an acknowledged external green standard or label, such as the CBI's certification program for climate bonds. The CBI certified 17% of green bonds in 2019 (Climate Bonds Initiative, 2019). Pre- and post-issuance third-party verification is required by the Climate Bonds Certification to demonstrate that the asset complies with the Climate Bond Standards, which incorporate the GBPs (Allman and Lock, 2022).

2.7 Green Bonds and Use of Proceeds

A "use of proceeds" clause in green bonds specifies that the money will be applied to green company investments. Determining how green bonds affect a company's sustainability profile is complicated. A green bond can replace conventional financing from already-existing green projects and encourage additional corporate involvement in green projects. As a result, a business may issue a green bond while boosting its funding for brown initiatives. Climate Bonds Initiative (n.d.) states that Energy, Buildings, and Transport are the three most significant use of proceeds categories, contributing to 81% of the total volume.

Energy, construction, and transportation industries are significantly responsible for allocating funds from green bond financing. The primary source of global greenhouse gas (GHG) emissions is energy, and as the population and economic levels have grown, so needs energy. The energy industry must decarbonize, which requires a shift to an increasing amount of renewable energy production. Thus, most initiatives in this area are for renewable energy sources that combine wind, solar, and other sources (Climate Bonds Initiative, 2017a).

The " buildings " climate subject primarily relates to green-label bonds that use the money raised to fund energy-saving projects. This covers funding low-carbon structures, energy-efficient goods, and technological advancements in industrial energy efficiency. The earnings are primarily used to fund green constructions (Climate Bonds Initiative, 2017b). Since sustainable transportation infrastructure will be essential in the transition from fossil fuel cars, the transportation sector is the second most significant contributor to GHG emissions and is a dominating climate theme.

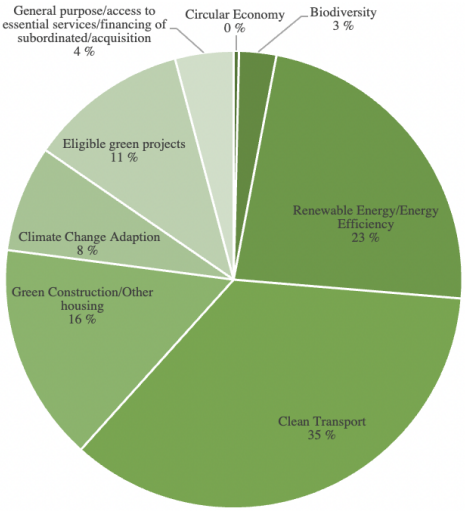

Figure 2.4: *The breakdown of the Use of Proceeds category across the 266 green bonds in our data sample from 2010 to 2022 in the European market.*

The discrepancy in the number of green bonds between industries can be attributed to several factors. Firstly, the Renewable Energy/Energy Efficiency sector has received significant investment and technological advancements, making it a desirable and established sector for green bond issuance. The market demand for renewable energy projects and the availability of profitable investment options contribute to the high number of green bonds in this sector. Additionally, the maturity and feasibility of projects play a role. The renewable energy industry has a solid infrastructure, tested technologies, and a history of completed projects, making it less risky and more attractive to lenders and investors. On the other hand, the circular economy sector may still be in the early stages of growth, resulting in fewer green bonds issued.

3 Literature Review

3.1 ESG and Financial Performance

The relationship Environmental, Social and Governance (ESG) and the financial performance of businesses has been the subject of extensive debate, supported by a substantial body of evidence. Over the past decades, several studies have investigated the connection between corporate social responsibility (CSR) and financial performance. Murphy (2002) showed a direct link between company profitability and environmental performance, particularly for those businesses that do well by independent environmental standards. According to Russo and Fouts (1997), environmental performance and economic performance are positively correlated. Russo and Fouts (1997) showed a high correlation between economic and environmental performance, which grows as an industry expands. They used 243 companies as their sample and attributed their conclusions to the resource-based view. Rehman, Khan, and Rahman (2020) discovered that CSR-related actions favor a company's reputation, enhancing the company's performance and lowering equity risk.

The market for ESG investments has quickly grown as a result of investors' increased attention to ESG factors. Assets managed in the US utilizing SRI strategies increased from $8.7 trillion at the beginning of 2016 to $12 trillion at the beginning of 2018, accounting for 26% of US assets under professional management (US SIF, 2018).

Gerard (2019) highlights that most of the literature in this area focuses on investor social responsibility (SR) participation, ESG, and corporate social responsibility (CSR) initiatives. According to Gerard, few studies in the ESG and CSR sectors that specifically address fixed income are currently published. The concepts of CSR and ESG, which are marginally different, are discussed in Gerard's article from 2019. The literature review also finds that few studies have looked at the impact of ESG on bond prices and that the evidence from previous studies needs to be more consistent. Hence, further research to investigate this market segment would contribute to the literature.

3.2 Green Bonds and Greenium Evidence

Multiple studies have examined the presence of the green bond premium by comparing green bonds with conventional bonds (Ehlers and Packer, 2017; Baker et al., 2018; Hachenberg and Schiereck, 2018; Karpf and Mandel, 2018; Zerbib, 2019; Larcker and Watts, 2020; Flammer, 2021). Other research shows that companies benefit from the lower cost of capital on green bonds, while newer research finds no green bond premium and indicates that businesses issue green bonds

solely to demonstrate their dedication to sustainability (Larcker and Watts, 2020; Flammer, 2021).

Zerbib (2019) uses green bonds to identify the effect of pro-environmental preferences on prices. In a study using 110 green bonds, the research paper covered the premium from mid-2013 to the end of 2017 and discovered evidence of a negative premium of -2 basis points. Zerbib (2019) uses a matching method to compare the yield differential between conventional and green bonds. The two nearest conventional bonds from the same issuer with the same characteristics are matched with the green bonds. By generating a synthetic, conventional twin and performing a panel regression with the difference in yield as the dependent variable and the difference in liquidity as the independent variable, Zerbib (2019) can determine the green bond premium. The quality of the data is this study's primary source of limitation. In some instances, a bond yield only partially reflects the bond's market value because they are not regularly traded, for example, for corporate bonds. The impact of proceeds is also not considered in Zerbib's (2019) research, and to determine whether the usage of proceeds impacts the premium differently, an empirical study could be conducted. Once the market is sufficiently developed, this study could be expanded to social impact bonds to examine how pro-social preferences affect bond pricing.

Green municipal bonds are more expensive, according to Baker et al. In comparison to common bonds, the after-tax yields at issue for green bonds are, on average, roughly six basis points lower. The American sample includes 2083 green municipal bonds and 19 green corporate bonds, all issued between 2010 and 2016. They discover that this premium doubles or triples for bonds that are both externally verified as green following industry standards and publicly registered with the Climate Bonds Initiative (CBI), in addition to being self-labeled as green (as confirmed by Bloomberg). According to Baker et al. (2018), the green bond premium is more common if the bond is externally verified as a green bond.

The price impact of the green label is examined by Ehlers and Packer (2017), who compare the credit spreads at the issuance of a cross-section of 21 green bonds issued between 2014 and 2017 with the credit spreads at the issuance of conventional bonds from the same issuers at the earliest available issue date. The findings show that green bond issuers have, on average, borrowed at spreads lower than those they would have paid for conventional bonds. In their study, the average spread difference is about 18 basis points (Ehlers and Packer, 2017).

Study	**Ehlers and Packer (2017)**	**Baker et al. (2018)**	**Caramichael and Rapp (2022)**
Dataset	Corporate	Bloomberg Green Muni	Corporate
Market	Primary	Primary	Primary
Sample Size	21	2,083	1,169
Timeframe	2014-2017	2010-2016	2014-2021
Method	Nearest Neighbors	OLS Regression + Fixed Effects	Fixed Effects Panel Regression
Greenium	-18 bps	-7 bps	-8 bps
Study	**Karpf and Mandel (2018)**	**Zerbib (2018)**	**Larcker and Watts (2019)**
Dataset	Bloomberg Green Muni	Bloomberg Green Labeled	Bloomberg Green Muni
Market	Secondary	Secondary	Primary
Sample Size	1,880	1,065	640
Timeframe	2010-2016	2013-2017	2013-2017
Method	OLS Regression + Oaxaca Blinder Decomposition	Synthetic Pairs + OLS with Fixed Effects	Matched Pairs
Greenium	-18 bps	-2 bps	Negligible

Table 3.1: *An overview of the research on greenium to date, including the datasets, research techniques, and conclusions.*

An overview of the current study on greenium is given in table 3.1, with particular attention paid to datasets, market, sample size, timeframe and methodology. Key findings from the studies undertaken by researchers including Ehlers and Packer (2017), Baker et al. (2018), Karpf and Mandel (2018), Zerbib (2018), Larcker and Watts (2019), and Caramichael and Rapp (2022), are presented in the table. The collection of research findings supports the understanding of the pricing dynamics affecting green investments and provides insightful information on the topic of green finance.

4 Methodology

4.1 Empirical Approach

Our investigation is centered on the yield difference between green and conventional bonds. Every bond transaction allows for the observation of the yield for a specific maturity.

Our methodology is inspired by Baker et al (2022) and Carmichael and Rapp (2022). We will estimate a fixed effect regression across an unbalanced panel of bonds, using the bonds yield spread at issuance as the dependent variable. This method allows us to account for both issuer-and bond-specific time fluctuations and possibly nonlinear relationships in our regression formulation. This enables us to study how different variables affect the bonds‘s yield spread while taking into account the distinctive qualities of various issuers and bonds across time.

Firstly, the inclusion of fixed effects allows us to capture issuer-specific time fluctuations. By including fixed effects for each issuer, we are effectively controlling for time-invariant issuer-specific factors that may influence the yield spread of bonds. This ensures that any observed variations in the yield spread can be attributed to time-varying factors rather than constant issuer-specific characteristics. Secondly, by utilizing an unbalanced panel of bonds, we can capture bond-specific time fluctuations. The unbalanced panel comprises bonds with varying maturities and issuance dates, providing a diverse set of observations over time. This approach allows us to account for bond-specific factors that may change over time, such as market conditions or investor sentiment. Furthermore, the flexibility of the fixed effect regression model enables us to capture potential nonlinear relationships between the independent variables and the yield spread. Nonlinear relationships may arise due to various factors, such as threshold effects or diminishing returns. By estimating the regression equation with fixed effects, we can capture these nonlinear dynamics and better understand the nuanced impact of the independent variables on the yield spread.

The YTM assumes the bond will be held to maturity, disregarding potential changes in market conditions and liquidity risk. However, the YTM provides valuable market pricing information and enables consistent comparison across bonds, allowing us to examine the impact of independent variables on yield spreads. By using YTM as the dependent variable, our analysis aligns with the research objective of understanding factors influencing borrowing costs. This choice is supported by prior research and industry practices, contributing to the understanding of the impact of green bond characteristics on yield spreads.

We chose a fixed-effects regression method over a matching method to create a localized conventional yield curve. While the matching method typically necessitates one green bond and two corresponding conventional bonds from the same issuer, this stipulation severely restricts in favor of issuers that have good access to the capital markets and the capacity to issue comparable bonds on a regular basis. Smaller companies and issuers from emerging countries, who would not issue equivalent bonds as frequently, would therefore be underrepresented in the analysis. Using a regression approach requires no more than one conventional bond from the same issuer to perform the regression analysis. This requirement ensures that we have a reference point for comparison and enables us to examine the specific effects of green bonds while accounting for issuer-specific factors. By incorporating at least one conventional bond from the same issuer, our methodology allows for a more robust analysis of the green bond market, capturing the issuer-specific dynamics alongside the impact of green bond characteristics.

4.2 The Regression

As mentioned, we want to do a fixed effects regression across an unbalanced panel of corporate bonds, with a given bond's yield spread at issuance as the dependent variable. We want to compare the borrowing costs of green and conventional bonds using an indicator variable that flags green bonds, while holding other factors constant. Our empirical baseline model is as follows:

$$\text{Yield spread}_{i,f} = \alpha \text{Green}_i + \beta \text{Controls}_{T^i,r,t} + \mu_{T^i,r,m,f} + \epsilon_{i,f} \tag{4.1}$$

Where:

1) i = bond
2) f = ultimate parent company
3) r = currency region
4) t = issue date
5) m = year month

The indicator variable $Green_i$ which takes the value of one if $Bond_i$ is a green bond, is the main variable of interest in the equation. Holding other variables constant, the coefficient on this indicator variable, represents the typical difference in primary market yield spreads for green and conventional bonds. A negative value (or a positive greenium) denotes a reduced yield spread for green bonds and, thus, a benefit in terms of borrowing costs compared to traditional bonds.

The bond-level numerical and macro-level controls that were noticed for $Bond_i$ in currency region r on issue date t, as well as their interactions ir and it, are contained in the vector $Bond_{T^i,r,t}$ Bond-level, firm-level, and time-level fixed effects for bond i, ultimate parent f, and year-month m, as well as an interaction between year-month and currency region, mr, are all included in the vector T^i, m, f. The interaction terms in the vector $Bond_{T^i,r,t}$, such as ir and it, capture the combined effects of bond-level characteristics ($Bond_i$) with the currency region (r) and issuance date (t). These interactions allow us to examine how the relationship between green bonds and yield spreads varies across different currency regions and over time. The vector T^i, m, f includes fixed effects at the bond-level (i), ultimate parent-level (f), and year-month-level (m), which account for factors specific to individual bonds, issuers, and time periods. Additionally, the interaction between year-month and currency region (mr) captures any time-varying differences in the relationship between green bonds and yield spreads across different currency regions. By including these fixed effects and interactions, we can control for potential confounding factors and isolate the specific effects of green bonds on borrowing costs. The grouping of standard errors at the issuer ultimate parent and year-month levels helps to address issues of cross-sectional dependence and serial correlation, ensuring the robustness of our statistical analysis.

4.2.1 The Control Variables

The regression model's control variables are crucial in capturing the impact of numerous factors on the yield spread of bonds. Each of the control variables specified in the model is presented below:

- The log years to maturity
- The log notional amount issued
- The issuer ultimate parent
- The rating bucket (credit ratings)
- The year-month of issuance
- The currency of issuance interacted with year month
- Use of proceeds

4.2.2 Variables Construction

Year to maturity (log_years_to_maturity) is important to include for capturing the effect of bond maturity on yield spreads. It allows us to examine how the time remaining until bond maturity influences the perceived risk and pricing of bonds. By considering the maturity term, we can analyze whether investors demand higher yields for longer-dated bonds to compensate

for the increased uncertainty and market risks associated with longer investment horizons. This variable provides valuable information for assessing the term structure of green bond pricing and understanding investor preferences for different investment durations.

Including a variable for the amount issued (log_notional_amount) is important as it accounts for the size or scale of the bond issuance. The amount issued reflects the magnitude of the bond offering, and its inclusion allows us to examine whether larger bond issuances are associated with different yield spreads compared to smaller issuances. This variable helps us assess the impact of bond size on investor perceptions of risk, liquidity, and market demand. Additionally, it provides insights into the pricing dynamics and market reactions to different issuance volumes, which can be useful for understanding the relationship between bond size and yield spreads in the context of green bond offerings.

Including a variable for the bond's ultimate parent or issuer in our regression is important as it captures the influence of the parent company on the bond's characteristics and yield spread. By incorporating this variable, we account for the impact of the parent company's financial strength and reputation on the bond's perceived risk and pricing.

For all bonds included in our data set, we construct compounded credit ratings from Moody's and Fitch (rating). The mean of the bond's credit rating are calculated by using a universal rating converting scale. Lastly, the bond's are put into rating buckets based on their aggregated score. By incorporating credit ratings as a variable in the regression, we can capture the impact of creditworthiness on the bond's yield spread. Higher credit ratings indicate lower default risk and therefore lower yield spreads, while lower credit ratings imply higher default risk and consequently higher yield spreads. Thus, credit ratings serve as a valuable measure to control for the inherent risk associated with the bonds and provide insights into the pricing dynamics of the green bond market.

The issue date provides valuable information on the timing of bond issuance, enabling analysis of how yield spreads vary over different time periods and assessing the impact of market conditions and events on pricing (issue_date). Incorporating the issue date as a variable allows us to explore time-specific factors influencing yield spreads and understand the temporal dimension of bond pricing dynamics.

Including a variable that represents the interaction between the currency of issuance and the year-month of issuance is important as it allows us to examine the combined effect of these two factors on yield spreads (currency_year_month). Currency of issuance reflects the currency denomination of the bond, which can influence investor perceptions of risk and affect

pricing. By interacting it with the year-month of issuance, we can capture any time-varying effects specific to certain currencies or periods. This interaction term helps us investigate how the currency of issuance and temporal factors jointly impact yield spreads, providing insights into the interplay between currency dynamics and market conditions.

To accurately represent the diverse sectors within the green bond market, we have tailored the sector categories to include Clean Transport, Climate Change Adaptation, Eligible Green Projects, Renewable Energy, Green Construction, and Other (use_of_proceeds). This categorization allows us to analyze the green bond sample by industry, providing a comprehensive breakdown of the distribution across sectors, which can be found in Table C1 in the appendix. Including the use of proceeds in our regression is crucial for assessing the impact of different categories of green projects on bond yield spreads. It allows us to examine how the allocation of funds to specific environmentally friendly projects influences market perceptions of risk and return. Furthermore, it helps us understand the pricing effects and market differentiation associated with different sectors or industries, providing insights into investor preferences and expectations regarding environmental and financial performance.

5 Data

5.1 Sample Selection

To examine the presence of the green bond premium in the European bond market, general data was collected regarding both active green and conventional bonds issued in Europe within the time-frame of January 1, 2012, to December 31, 2022.

Using data from a longer time period is valuable for improving statistical robustness, capturing market cycles and fluctuations, revealing long-term effects and trends, enhancing data quality and availability, and facilitating informed decision-making. To assess the consistency, stability, and effectiveness of the green bond premium over time and understand its impact and potential advantages over conventional bonds, it is beneficial to analyze a broader range of observations. Figure 1 illustrates the significant growth in the market for green bonds. The yield differential between the green bond and the conventional bond is used to calculate the green bond premium.

We will create a European panel of conventional and green corporate bonds for 2012 to 2022. The information will be gathered using bond-level data from Refinitiv to build the sample. For the bonds in our sample, Refinitiv data offers comprehensive details on each bond's features, including the issue price, issuance and maturity dates, history of the par amount outstanding, credit ratings, the bond's currency, and a variable to distinguish green bonds.

We disqualify bonds that:

- Are not vanilla
- Are not investment grade
- Are not rated by at least one rating agency (Moody´s or Fitch).

To provide a reliable analysis when evaluating the existence of a green bond premium, it is crucial to rule out bonds that are not plain vanilla, are not investment grade, and are not rated by respectable rating agencies (such as Moody's or Fitch). Further, the comparison between green bonds and conventional bonds becomes more meaningful and standardized by concentrating on vanilla bonds, which are traditional and well-known. The analysis of the impact of green bonds on risk-adjusted rates can be streamlined by excluding non-investment grade bonds, which typically exhibit higher default risk. Research conducted by MSCI in 2020 indicates that ESG factors were less prevalent in the high yield bond market compared to the investment-grade bond market. Specifically, MSCI ESG ratings covered only 16% of high yield

bonds but encompassed 60% of investment-grade bonds. Consequently, the decision was made to exclude green bonds from the research due to their limited availability within the high yield category.

We concentrate on the primary market yield (the yield at issuance), instead of the secondary market yield, which affects the actual interest rate the issuer pays to borrow money. Additionally, many investors choose to buy bonds in the primary market due to the fact that the global corporate bond market is relatively illiquid and has high transaction costs (Flanagan, Kedia, and Zhou, 2021). When constructing their bond portfolios, investors often exhibit a higher inclination to select from a range of comparable primary market bond offerings rather than choosing between an issuer's newly issued primary market bonds and its existing bonds traded on the secondary market. Instead of comparing an issuer's primary market yields to their secondary market yields, it is often more meaningful to compare an issuer's primary market yields with the primary market yields of other issuers within a specific timeframe.

5.2 Data Cleaning

Our sample size for green bonds has been lowered to 266 bonds due to some restrictions, while the sample size for conventional bonds is 8 264. The Appendix includes a summary of the data for the green and conventional bonds in our sample.

To verify the accuracy and completeness of the dataset, we applied specific exclusion criteria during the data cleaning procedure. We specifically disregarded any observations for which any of the necessary variables—Maturity, Issue Date, Amount Issued, Issue Price, or Registered CBI—had missing data.

We sought to maintain the integrity and validity of the dataset by removing such partial or missing data, making sure that all necessary variables were present for analysis. This phase was vital in preventing any biases or mistakes that might have resulted from having insufficient information.

It is important to note that the data exclusion based on missing values was carried out methodically and objectively, without any prejudice towards particular observations. Using this strategy, we were able to protect the variables under investigation's integrity while maintaining the dataset's overall representativeness.

To analyze the data, we will use fixed-effects regressions across an imbalanced panel of corporate bonds, using the bond's yield spread at issuance as the dependent variable. By doing this, we enable our regression specification to consider time variation particular to the issuer and

bond and any potential nonlinearities. This data method is inspired by Baker et al. (2022) and Charmichael and Rapp (2022).

Using the issue price, coupon rate, frequency, and day-count convention for each bond in this initial sample, we determine the precise yield to maturity of each bond at issuance. The yield to maturity and the linearly interpolated maturity-matched government bond yield curve for the given bond´s currency on the date of issuance are then subtracted to get each bond´s yield spread at issuance.

5.3 Summary Statistics

We display descriptive data for the conventional and green bonds in our sample in the tables.

The term "Coupon" refers to the (fixed-rate) coupon rate. Issued Amount describes the entire amount or number of bonds that a business or other entity has issued. It stands for the total nominal value, also known as face value, of all bonds that have been sold to buyers. The formal day that the bonds are issued and made available for purchase by investors is referred to as the "Issue date." It denotes the start of the bond's term as well as the point at which investors can buy the bonds. Maturity refers to the specific day that the bond's principal amount is due and must be paid in full to the bondholders. It symbolizes the end of the bond's term and signals that its life cycle is over. Lastly, Yield is the term used to describe the actual interest rate or rate of return that a bond investor would receive over the course of the bond's whole holding period. It shows the bond's cash flows, such as coupon payments and principal repayment at maturity, as an annualized percentage return.

Green Bonds	**Min**	**Average**	**Max**
Coupon	0.0	1.0	5.8
Issued Amount (€)	525 946.7	852 317 263.8	30 904 248 946.1
Issue Date	27.03.2012		13.12.2022
Years to Maturity	2		100
Yield	0.6	3.5	9.7

Table 5.1: *Descriptive statistics of the total sample of 266 green bonds. Issued Amount is expressed in EUR.*

Conventional Bonds	**Min**	**Average**	**Max**
Coupon	0.0	1.1	15.0
Issued Amount (€)	5 449.1	1 113 726 511.3	60 222 384 120.2
Issue Date	05.01.2012		30.12.2022
Years to Maturity	1		100
Yield	-13.7	3.5	35.0

Table 5.2: *Descriptive statistics of the total sample of 8 264 conventional bonds. Issued Amount is reported in EUR.*

Descriptive statistics for the green bonds and conventional bonds are presented in the two tables. These tables include information on a number of bond sample features, including as coupon rates, issued amounts, issue dates, years to maturity, and yields. The statistics enable for a comparison of the characteristics of both types of bonds by providing a thorough summary of the essential variables for each.

The yields between conventional bonds and green bonds show a significant difference. Conventional bonds have a wider yield range, ranging from -13.7 to 35.0. In contrast, green bonds have a narrower range, with yields ranging from 0.6 to 9.7. The variation in yield ranges can be attributed to several factors. Differences in risk perception, market conditions, credit quality, supply and demand dynamics, and market sentiment all contribute to these disparities.

Risk perception involves the assessment of creditworthiness and market perception of issuer risk, influencing bond yields. Market conditions, such as changes in interest rates and economic indicators, impact the yields of both conventional and green bonds. Credit quality plays a significant role, with higher-rated issuers offering lower yields, while lower-rated issuers may need to provide higher yields to attract investors. Supply and demand dynamics also influence bond yields, with high-demand bonds typically offering lower yields and vice versa. Market sentiment, driven by factors like events, regulations, and economic or political developments, can further contribute to yield differences among bonds.

6 Results

6.1 Hypothesis 1: There is no premium for green bonds

In order to test Hypothesis 1 we run the following regression:

$$\begin{aligned} \text{YTM} &= \beta_0 \\ &+ \beta_1 \cdot \text{green\_bond\_flag} \\ &+ \beta_2 \cdot \text{log\_years\_to\_maturity} \\ &+ \beta_3 \cdot \text{log\_notional\_amount} \\ &+ \beta_4 \cdot \text{rating} \\ &+ \varepsilon \end{aligned}$$

Using an unbalanced panel of corporate bond data, we conducted a fixed effects regression analysis to examine the relationship between the dependent variable (YTM or yield to maturity) and the independent factors (green_bond_flag, log_years_to_maturity, log_notional_amount, and rating).

A regression analysis was conducted to test Hypothesis 1, examining the potential yield difference between conventional bonds and green bonds. The selection of regression variables was based on their relevance to bond yield analysis and capturing influential factors.

The regression focused on the yield level, using the yield-to-maturity (YTM) as the dependent variable. The independent variable was a binary indicator called "green_bond_flag," distinguishing between green bonds and traditional bonds. This variable allowed for an examination of the impact of being a green bond on the yield.

Additional variables included log_years_to_maturity, representing the logarithm of years to maturity, accounting for the time impact on bond rates. The variable log_notional_amount captured the bond issuance size's potential influence on yield, considering differences in market dynamics. The rating variable reflected the bond's credit rating, considering its effect on bond rates.

By incorporating these variables, the regression comprehensively assessed factors that could affect bond yields. The analysis specifically addressed the presence or absence of a premium for green bonds compared to conventional bonds, considering the green_bond_flag variable. The remaining variables considered known characteristics influencing bond yields. Accounting for these factors allowed for isolating the potential effect of having a green bond on the yield.

	Estimate	Std. Error	t value	$\Pr(>\|t\|)$
(Intercept)	0.0011	0.0006	1.696	0.090
green_bond_flag	-0.0009	0.0008	-1.067	0.286
log_years_to_maturity	0.0032	0.0003	12.078	$< 2e-16$ ***
log_notional_amount	0.0000	0.0000	1.277	0.202
rating	0.0010	0.0000	19.785	$< 2e-16$ ***

Table 6.1: *Relationship between the dependent variable (YTM or yield to maturity) and the independent variables (green_ bond_ flag, log_ years_ to_ maturity, amount_ issued_ EUR, and rating)*

6.1.1 Green Bond Flag

The green_bond_flag variable has a coefficient estimate of -0.0009. The yield spread is not statistically significantly affected by the green bond flag variable, which is meant to capture any potential variation in yield spread between green bonds and conventional bonds. The finding suggests that there is no indication of a material difference in borrowing costs (as determined by the yield spread) between green bonds and conventional bonds in this particular scenario. The result indicates the average difference in YTM between green bonds and conventional bonds, holding other independent variables constant. This implies that investors may be willing to accept a slightly lower return on their investment in green bonds, potentially due to the environmental benefits associated with these bonds. This finding is not statistically significant, which should be noted.

Given previous studies and market expectations, the non-significant coefficient for the green_bond_flag variable in this study may come as a surprise. Baker et al. (2018)'s thorough research and the influential study by Ehlers and Packer from 2017 both consistently reported a statistically significant greenium, showing a yield advantage for green bonds. These results have received a lot of attention and have influenced how conventional bonds and green bonds are typically understood. Market participants have also incorporated the notion that green bonds typically offer a yield advantage into their investment strategies, including institutional investors and asset managers. In an effort to assist the environment and the economy, they have aggressively allocated funds to green bonds. Furthermore, politicians and regulatory agencies have supported the growth of green finance with the idea that green bonds will provide financial benefits like lower borrowing rates or increased market demand.

Further, it is possible that country-specific factors contributed to the non-significant coefficient. Due to differences in market dynamics, investor preferences, regulatory frameworks, and the general state of the market, the effect of green bonds on yield may be different between nations. The non-significant coefficient might be unique to the individual nation or nations included in the dataset. Investor demand may vary by country, there may be differences in investor understanding and acceptance of green bonds, and there may be differences in market systems

that affect how much green bonds cost.

Investors may already be familiar with the pricing dynamics and possible advantages of green bonds, for instance, in nations with more developed and established green bond markets. As a result, since the market has already factored in the environmental advantages, the yield advantage associated with green bonds may be reduced or perhaps eliminated.

On the other hand, investors may view green bonds as relatively fresh and cutting-edge financial instruments in nations with developing or emerging green bond markets. In such circumstances, investors may be ready to accept slightly lower returns in exchange for aligning their investments with sustainability goals, which could result in a yield advantage.

Additonally, the p-value for the green_bond_flag variable is 0.286, exceeding the usual significance threshold of 0.05. This suggests that there could not be an underlying relationship behind the reported difference in YTM between green bonds and conventional bonds.

The non-significant coefficient so calls into question previous research and market predictions. It throws the validity and applicability of the previously described greenium into question. Market players and researchers may need to revise their hypotheses as well as their investment plans and green finance-related policies.

6.1.2 Log Years to Maturity

Contrarily, the log_years_to_maturity variable has a coefficient estimate of 0.003, which means that, while leaving other factors constant, a one-unit increase in the log years to maturity is related to a 0.003163 rise in YTM. The p-value ($< 2 \times 10^{-16}$) indicates that this coefficient is highly statistically significant. This result is in line with the widespread belief that longer-term bonds typically offer greater yields to make up for the higher risk involved with such a long investment horizon. This suggests that longer-term bonds have higher borrowing costs since the yield spread at issue tends to increase as the years to maturity increase.
The "amount_issued_EUR" coefficient's p-value is 0.202, which denotes that it is not statistically significant. This argues that the reported relationship between the quantity released and YTM may not actually be an economic association at all but rather the result of random chance.

The outcome for the log_years_to_maturity variable is consistent with what is expected in the study of finance and bond markets. The relationship between the yield to maturity (YTM) and the logarithm of years to maturity (YTM) is positive, as indicated by the coefficient estimate of 0.003. This result implies that longer-term bonds often have greater borrowing costs, which are reflected in their higher yields. The p-value shows that a coincidence alone is unlikely to account for the observed link between log_years_to_maturity and YTM. The significance of the coefficient shows that the analysis's conclusion about the effect of age on yield is a reliable one.

These results are in line with the conventional consensus in finance, which holds that longer-term bonds often have higher yields. This is due to the fact that investors need a bigger return to make up for the higher risk involved with longer investment horizons. The outcome supports the idea that bond rates and borrowing costs are significantly influenced by the number of years before maturity.

6.1.3 Amount Issued

The predicted coefficient for the "log_notional_amount" variable is 0.0000. This means that, while maintaining all other factors equal, an increase of one unit in the quantity of bonds issued in EUR is generally related with an anticipated increase in YTM of 0.0000. The bond issuance amount does not significantly affect the yield to maturity or borrowing costs. Therefore, changes in yield spreads are not driven by variations in the amount of bonds issued.

The causes for the outcome could include market efficiency, liquidity, market segmentation, investor preferences, and market competition. Factors such as investor demand, market conditions, and credit ratings play a significant role in determining bond yields. In less liquid markets, indicators like credit ratings and market conditions have more influence on bond prices than the issuance amount. Market segmentation leads to a reduced impact of the issuance amount on yield spreads, as investors within each segment consider sector-specific variables. Investor preferences, such as the demand for green bonds, can override the effect of the issuance amount. Market competition may require attractive rates regardless of the volume issued. Overall, the volume of bonds issued may have limited impact on borrowing costs due to the consideration of multiple factors by investors.

6.1.4 Rating

The coefficient estimate for the rating variable is 0.00103 This indicates that, on average, a one-unit increase in the rating (representing worse ratings) is associated with a 0.00103 increase in YTM, holding other variables constant. The p-value (2×10^{-16}) suggests that this coefficient is highly statistically significant. This correlation makes sense given that bonds with lower ratings are typically thought of as riskier investments and require higher yields to entice investors. Bonds with higher credit ratings tend to have lower yield spreads at issuance, indicating lower borrowing costs. This is consistent with the expectation that riskier investments require higher yields to attract investors.

This result's interpretation matches that of the market. Bonds with lower ratings are typically seen as riskier investments since default risk is increased. Higher yields are a result of

investors needing compensation for taking on this greater risk. As a result, a higher YTM results from an increase in the rating (which represents lower ratings), demonstrating that investors want higher yields on riskier bonds.In contrast, bonds with better credit ratings are viewed as safer investments and as having a lesser likelihood of default. These bonds thus typically have reduced yield spreads during issuance, which indicates lower borrowing costs for issuers. The idea that lower-risk assets need lower yields to draw investors fits with the negative link between higher credit ratings and YTM.

Statistic	**Value**
Residual Standard Error	0.0123
Degrees of Freedom	7212
Observations Deleted	39
Multiple R-squared	0.0625
Adjusted R-squared	0.0619
F-statistic	120.1

Table 6.2: *Model Fit*

Table 6.2 shows that the independent variables can account for about 6.25% of the entire variation in the yield to maturity, according to the multiple R-squared value of 0.0625. Furthermore, the adjusted R-squared is extremely close to the multiple R-squared. The model's weak explanatory ability is indicated by the adjusted R-squared value of 0.0619, which corrects the multiple R-squared for the number of predictors in the model. This suggests that the independent variables that have been included might not fully capture the complexity of the variables impacting the yield to maturity. The model's weak explanatory power may be caused by the absence of other significant variables or factors.

6.1.5 Conclusion: Hypothesis 1

The analysis's findings contain both expected and unexpected components. The results that were anticipated included the positive relationship between yield to maturity and log years to maturity, as well as the relationship between yields and credit ratings. These results are in line with market expectations and financial theory. Due to the prolonged time horizon required, longer-term bonds are typically seen as riskier investments. Because owning bonds for a longer period of time entails more risk and uncertainty, investors seek higher returns to make up for it. This expectation stems from the idea of the time value of money, which holds that investors expect a higher return when they tie up their money for a longer period of time. Further, credit ratings are evaluations of a bond issuer's creditworthiness and default risk. Bonds with lower credit ratings are viewed as riskier investments since default is more likely. Lower-rated bond issuers must provide higher yields in order to draw investors and reward them for taking on greater risk.

It is surprising that there is no relationship between the green bond flag and yield to maturity when other studies have shown one. This calls into question the applicability and validity of the yield advantage for green bonds that was previously discussed. The lack of significance indicates that the borrowing costs for conventional and green bonds are not materially different.

6.2 Hypothesis 2: Greenium apply evenly across industries

6.2.1 Greenium Resurgence: Reappearing in the European Market Across Industries

While the findings did not yield statistically significant results indicating the presence of a green premium in the European green bond market, it is important to consider potential explanations for this outcome. The non-significant coefficient, despite being negative, suggests that the observed difference in yield spreads between green bonds and conventional bonds may not be statistically meaningful within the studied context. However, it is reasonable to argue that the absence of a greenium in the overall market does not preclude the possibility of its existence within specific industries or countries. Green bond investments are diverse, encompassing a wide range of sectors and projects. Each industry may have unique characteristics, risk profiles, and market dynamics that influence investor perceptions and preferences.

Different industries may have varying levels of environmental impact and sustainability practices. The first hypothesis regression might have included industries where the green and conventional bonds exhibit similar characteristics or where the environmental benefits are less pronounced. As a result, the greenium may not be significant at the overall market level. However, when analyzing specific industries known for their significant environmental impacts or strong sustainability focus, the pricing difference between green and conventional bonds is more likely to emerge. Investors in different industries may have distinct preferences and priorities when it comes to sustainable investments. Certain industries, such as renewable energy, may attract investors who are particularly conscious of environmental issues and actively seek out green bonds. The demand for green bonds within these industries could create a pricing advantage, leading to a greenium. In contrast, industries with lower environmental sensitivity may not exhibit such preferences, resulting in a diminished or non-existent greenium.

The regulatory landscape and government policies can significantly influence the green bond market. In some industries, there may be stronger regulatory support and incentives for issuing green bonds, which can enhance their attractiveness and potentially contribute to

a greenium. Industries with well-established sustainability frameworks and clear guidelines for green investments are more likely to demonstrate pricing differentials that reflect the environmental benefits. The level of market awareness and transparency regarding green bond characteristics can impact the existence of a greenium. Industries that have embraced sustainability reporting and provide comprehensive information about the use of green proceeds and their environmental impact are more likely to generate investor confidence and a higher perceived value for green bonds. This, in turn, can lead to a greenium when comparing these industries to others with less robust disclosure practices.

Larcker and Watts (2020) argue that the greenium may disappear due to supply-demand dynamics. They suggest that if the amount of green supply (issuance size of green bonds) exceeds the demand, it can confound the inferences. For a greenium to emerge, there needs to be sufficient green demand to clear the entire supply at a higher price (lower yield and spread). Additionally, Larcker and Watts (2020) discuss the concern of greenwashing, and argue that the lack of universally agreed-upon criteria for what makes a bond green contributes to this uncertainty. Their analysis includes indicators related to greenwashing, such as whether the green bond is used for economic refunding or certified by third-party providers.

Considering these factors and the lack of support for a greenium in the overall market, focusing on the next hypothesis exploring the presence of a greenium across industries is still reasonable.

The regression equation can be represented as:

$$\begin{aligned} \text{Yield Spread} = &\beta_0 + \beta_1 \times \text{Green Bond Flag} \\ &+ \beta_2 \times \text{Log Years to Maturity} \\ &+ \beta_3 \times \text{Log Notional Amount} \\ &+ \beta_4 \times \text{Rating} \\ &+ \beta_5 \times \text{Use of Proceeds} + \epsilon \end{aligned} \tag{6.1}$$

Based on their applicability to determining the borrowing costs of green and conventional bonds on the European market, the variables for the fixed effects regression have been chosen.

In the given equation, the term "yieldspread" refers to the average borrowing cost across different industries, namely Clean Transport, Climate Change Adaptation, Eligible Green Projects, Energy, Green Construction, and other sectors. It represents the industry-level benchmark yields

associated with bonds allocated to these specific areas.

The "Green Bond Flag" variable is of particular importance because it clearly indicates if a bond is a green bond or a traditional bond. While accounting for other variables, it enables a direct comparison of the borrowing costs for the two varieties of bonds. The estimated effect of being a green bond on the yield spread will be shown by the Green Bond Flag's coefficient.

The effect of the bond's remaining time till maturity on its borrowing costs is captured by the log years to maturity variable. Financial theory states that longer-term bonds often have higher yields to make up for the higher risk and unpredictability involved with longer holding periods. The regression takes into consideration the effect of maturity on the yield spread by include this variable.

The quantity or magnitude of the bond's issuance is captured by the log notional amount issued variable. Due to variables including market liquidity and investor demand, larger bond issuances may have different borrowing rates than smaller issuances. The regression takes into account the potential impact of the bond's size on its yield spread by considering this variable.

The bond's designated credit rating is represented by the rating variable. The perceived creditworthiness of the issuer is reflected in credit ratings, which have a big impact on borrowing prices. Bonds with higher ratings typically have lower yields than bonds with lower ratings. Assessing how credit ratings affect the yield spread is made possible by include the rating variable. The allocation of funds produced through the bond issuance or the usage of revenues variable accounts for a certain purpose. While conventional bonds may serve a wider range of purposes, green bonds are often issued to finance ecologically friendly projects. This variable's inclusion aids in mitigating any potential effects on borrowing costs related to the particular usage of the funds.

The different factors that might be able to affect the yield spread of both green and conventional bonds have been captured by these variables. These variables are taken into account in the regression analysis, allowing for a thorough investigation of the effect of the green bond flag while maintaining other significant variables constant.

Variables	Estimate	Std. Error	t value	Pr(> |t|)
(Intercept)	0.0011	0.0000	1.711	0.0871
green_bond_flag	-0.0098	0.0047	-2.094	0.0363
log_years_to_maturity	0.0032	0.0003	12.058	<2e-16 ***
log_notional_amount	0.0000	0.0000	1.316	0.1884
rating	0.0010	0.0000	19.695	<2e-16 ***
use_of_proceedsClean Transport	0.0088	0.0049	1.810	0.0703
use_of_proceedsClimate Change Adaptation	0.0127	0.0060	2.124	0.0337
use_of_proceedsEligible Green Projects	0.01136	0.0052	2.169	0.0301
use_of_proceedsEnergy	0.0082	0.0050	1.651	0.0987
use_of_proceedsGreen Construction	0.0085	0.0051	1.670	0.0950
use_of_proceedsOther	0.0101	0.0060	1.698	0.0895

Table 6.3: *Regression Results. When controlling for other variables, the regression analysis compares the borrowing costs of green bonds and conventional bonds in order to examine the relationship between various bond attributes and yield spreads at issue.*

The coefficients in the table indicate the estimated impact of each category on the dependent variable in the regression model. The statistical information, including the estimated, standard errors, t-values, and p-values, provide insights into the significance and magnitude of the effects.

6.2.2 Green Bond flag

The indicator variable for green bonds determines whether a bond is labeled as green, and is the main variable of interest. The coefficient for green bonds is -0.0098 with a standard error of 0.0047. A negative coefficient suggests that being a green bond is associated with lower yields compared to conventional bonds. The coefficient of -0.0098 indicates that green bonds, on average, have a yield advantage of approximately 0.0098 units (measured in percentage points) compared to conventional bonds, when controlling for other variables included in the regression model. It is statistically significant at the 5% level (p-value = 0.0363). The findings supports our hypothesis that green bonds exhibit a premium because they are high in demand, suggesting that investors accept a lower yield. The greenium manifests as a negative yield differential between green bonds and conventional bonds. This finding suggests that investors potentially view them as more socially responsible or environmentally friendly. While hypothesis 1 does not provide evidence of a significant difference in yield spreads, hypothesis 2 suggests the presence of a greenium. These disparities can be influenced by market-specific factors, investor preferences, and the overall perception of environmental and social responsibility.

6.2.3 Log Years to Maturity

Controlling for other factors, the analysis also includes several bond-level numeric and macro-level control variables. The coefficient for the log years to maturity variable is positive (0.0032) and statistically significant (p-value < 2e-16). This finding implies that, as suggested by the yield spread, there is a positive correlation between a bond's maturity and its borrowing costs. In other words, a bond's borrowing rates rise as its maturity lengthens. This indicates that bonds

with longer maturity have higher yield spreads. It implies that a bond's borrowing costs, as shown by the yield spread, rise as its maturity lengthens. According to popular wisdom and financial theory, longer-term bonds often have higher yields to make up for the higher risk and unpredictability involved with longer holding periods. This finding is consistent with these theories. It supports the idea that investors want better returns in exchange for assuming the additional risk and time commitment that come with longer-term bonds.

6.2.4 Amount Issued

The "log_notional_amount" variable has a coefficient of 0.0000 and a standard error of 0.0000. The p-value for the situation is 0.1884, and the t-value is 1.316. The size of the bond issuance is indicated by the amount issued. The yield spread, which measures borrowing costs, and the size of the bond issuance have no statistically meaningful correlation, as indicated by the coefficient of 0.0000. The result was largely anticipated because borrowing costs may not be solely determined by the amount of the bond issuance. The findings imply that borrowing costs are not significantly affected by the size of the bond issuance, as indicated by the notional amount. The importance of other variables in determining borrowing costs, such as investor demand, market conditions, and credit ratings, is greater.

The result supports the idea that when determining the risk and price of bonds, lenders and investors take into account a variety of criteria. Although the size of the bond issuance may have real-world effects on trading dynamics and liquidity, it does not seem to be a major factor in determining borrowing prices. To properly price their bonds and control borrowing costs, bond issuers need concentrate on additional criteria such as creditworthiness, market conditions, and investor demand.

6.2.5 Ratings

The coefficient for the rating variable, which represents the bonds credit ratings from Moody's or Fitch, is positive (0.0010) and highly statistically significant (p-value $<$ 2e-16). It indicates that lower-rated bonds have higher yield spreads. This finding is consistent with the risk-return tradeoff, where riskier bonds compensate investors with higher yields. The perceived creditworthiness and default risk of bonds are reflected in the credit ratings given by agencies like Moody's or Fitch. In contrast to a lower credit rating, which represents a larger default risk and lower creditworthiness, a higher credit rating denotes a lower default risk and better creditworthiness.

The positive relationship suggests that higher borrowing costs are related to bonds with lower credit ratings, which are regarded as riskier. This is rational from an economic perspective since investors expect larger rewards in the form of higher yields in exchange for accepting the

increased risk associated with bonds with lower ratings. Despite the greater danger of default, the higher yields act as a risk premium to encourage investors to hold these bonds.

The association between credit ratings and borrowing costs is not likely to have arisen by accident alone, according to the highly statistically significant p-value. The idea of the risk-return trade-off is strengthened by the data that lower-rated bonds do, in fact, command bigger yield spreads.

6.2.6 Industries

The analysis incorporates indicator variables that represent different industries or objectives associated with the utilization of bond proceeds. The coefficients associated with various use of proceeds categories, such as Clean Transport, Climate Change Adaptation, Eligible Green Projects, Energy, Green Construction, and Other, provide insights into how each sector or objective influences yield spreads. Notably, certain categories exhibit statistically significant coefficients, implying that specific sectors or goals can impact the yield spreads of bonds.

The estimate of 0.0088 for the "use_of_proceedsClean Transport" coefficient indicates that bonds designated for clean transportation projects have a favorable effect on yield spreads. Although the statistical significance (p-value of 0.0703) is not very strong, it suggests that investors view clean transportation projects as having some risk or as being less desirable, which results in a minor increase in borrowing costs.

A positive effect on yield spreads for bonds devoted to climate change adaptation projects is suggested by the coefficient "use_of_proceedsClimate Change Adaptation" estimate of 0.0127. The minor increase in borrowing costs is due to the moderate statistical significance (p-value = 0.0337), which shows that investors perceive these projects to be somewhat risky or uncertain. The estimate of 0.01136 for the coefficient "use_of_proceedsEligible Green Projects" suggests a favorable effect on the yield spreads for bonds linked to eligible green projects. The moderate statistical significance (p-value of 0.0301) shows that investors think these projects are slightly riskier or less attractive, which raises borrowing rates just a little bit.

The coefficient estimate of 0.0082 for the "use_of_proceedsEnergy" category suggests a favorable effect on the yield spreads for bonds allocated to energy projects. Although the statistical significance is low (p-value = 0.0987), it is possible that energy projects may not have much of an impact on borrowing prices because investors may view them as less hazardous or more desirable than other types of projects.

The "use_of_proceedsGreen Construction" category displays a coefficient estimate of 0.0085, showing a favorable effect on yield spreads. The statistical significance (p-value of 0.0950) shows that green building initiatives may have a moderate impact on borrowing rates, with investors considering them as bearing a tad more risk or being less alluring. Bonds backing

other green initiatives have a favorable effect on yield spreads, according to the estimation of the "use_of_proceedsOther" coefficient of 0.0101. The p-value (0.0895) indicates a statistical significance that is comparatively less strong. Borrowing rates may be moderately influenced by bonds allocated to other environmentally friendly projects that do not fit into the aforementioned categories since investors may perceive some level of risk or diminished attractiveness.

Statistic	Value
Residual standard error	0.01234
Multiple R-squared	0.06325
Adjusted R-squared	0.06195
F-statistic	48.66
p-value	< 2.2e-16

Table 6.4: *Model Fit*

According to the preceding table, the adjusted R-squared of 0.06195 indicates that the model's variables together explain about 6.195% of the total variation seen in the yield spreads of the bonds. The model's independent variables, such as the green bond indicator, years to maturity, amount issued, credit ratings, and use of proceeds categories, only fully account for a small percentage of the variation in borrowing costs as reflected by yield spreads.

6.2.7 Interpretation of Use of Proceeds Results

Use of Proceeds	Estimate	Std. Error	t-value	p-value
Clean Transport	0.008796	0.004860	1.810	0.0703
Climate Change Adaptation	0.01267	0.005968	2.124	0.0337
Eligible Green Projects	0.01136	0.005240	2.169	0.0301
Energy	0.008213	0.004973	1.651	0.0987
Green Construction	0.008482	0.005080	1.670	0.0950
Other	0.01014	0.005970	1.698	0.0895

Table 6.5: *Interpretation of Use of Proceeds Results*

The coefficient for the Clean Transport category is 0.008796, with a standard error of 0.004860. The coefficient suggests that, on average, bonds issued for clean transport purposes have a slightly positive impact on the yield spread. Although it is not statistically significant at the conventional 5% level (p-value = 0.0703), it suggests a positive association between green bonds used for clean transport projects and higher yield spreads. There is no strong evidence to support a significant difference in borrowing costs between clean transport bonds and other bonds.

Clean transport projects, such as electric vehicles or renewable energy-powered transportation systems, may require significant upfront investments and infrastructure development. These projects often face regulatory uncertainties, technological risks, and longer payback periods, which can contribute to higher perceived risks and thus higher yield spreads. Clean transport initiatives are crucial for reducing carbon emissions and mitigating the environmental impacts

of transportation. However, the transition to clean transport involves substantial challenges, including the need for new infrastructure, regulatory frameworks, and market adoption. These challenges may introduce additional uncertainties and perceived risks, leading to higher yields.

The coefficient for the Climate Change Adaptation category is 0.01267, with a standard error of 0.005968. It is statistically significant at the 5% level (p-value = 0.0337), indicating that bonds allocated to climate change adaptation projects have a slightly positive and statistically significant impact on the yield spread. This implies that investors may require a slightly higher yield for bonds associated with climate change adaptation initiatives, potentially reflecting the perceived risks or uncertainties associated with such projects.

Climate change adaptation projects, such as building resilient infrastructure or implementing disaster risk reduction measures, often involve substantial costs and uncertainties. These projects address the increasing risks and vulnerabilities associated with climate change impacts, including extreme weather events, rising sea levels, and changing precipitation patterns. The complexity and uncertainty surrounding climate change adaptation investments can lead to higher perceived risks and, consequently, higher yield spreads. Climate change adaptation projects are essential for enhancing the resilience of communities, ecosystems, and critical infrastructure. However, the unique challenges associated with adapting to climate change, including uncertain future climate scenarios and the need for long-term planning, can increase perceived risks. These risks may result in higher yields to attract investors and compensate for the uncertainties inherent in climate change adaptation initiatives.

The coefficient for the Eligible Green Projects category is 0.01136, with a standard error of 0.005240, indicating a slightly positive and statistically significant impact on the yield spread. It is statistically significant at the 5% level (p-value = 0.0301), implying a positive association between green bonds used for eligible green projects (excluding the specific categories mentioned above) and higher yield spreads. This suggests that investors may assign a higher risk premium to green bonds funding a wide range of eligible green projects. Green bonds funding various eligible green projects, excluding the specific categories mentioned above, may represent a diverse set of investments with varying risk profiles. Different projects within this category can have distinct economic characteristics, such as capital requirements, market dynamics, and regulatory frameworks. The varying risk factors associated with these projects can lead to differences in yield spreads. Green bonds targeting a wide range of eligible green projects contribute to addressing various environmental challenges, such as renewable energy generation, energy efficiency, sustainable agriculture, or waste management. Each project type carries specific sustainability risks, including technology adoption risks, market uncertainties, and policy changes. These sustainability-related risks can influence yield spreads based on the market's

perception of the risks involved.

The coefficient for the Energy category is 0.008213, with a standard error of 0.004973, signifying a slightly positive impact on the yield spread. Although it is not statistically significant at the conventional 5% level (p-value = 0.0987), it suggests a positive relationship between green bonds used for energy-related projects and higher yield spreads. This could be due to perceived risks associated with energy projects, such as volatility in energy markets or regulatory uncertainties. Transitioning to a sustainable energy system is critical for mitigating climate change and reducing reliance on fossil fuels. However, the energy sector undergoes rapid changes, including technological advancements, policy shifts, and market disruptions. These uncertainties can impact the perceived risks associated with energy-related projects, leading to higher yield spreads.

The coefficient for the Green Construction category is 0.008482, with a standard error of 0.005080, suggests that bonds related to green construction projects have a slightly positive impact on the yield spread. Although it is not statistically significant at the conventional 5% level (p-value = 0.0950), indicating that the observed difference in borrowing costs may not be economically significant. It suggests a positive association between green bonds used for green construction projects and higher yield spreads.

Green construction projects, such as sustainable building developments or eco-friendly infrastructure, often involve innovative technologies, specialized expertise, and additional costs. These factors can introduce higher risks and uncertainties, leading to increased yield spreads compared to conventional construction projects. Green construction projects play a crucial role in reducing the environmental footprint of the built environment. However, they may face challenges such as higher upfront costs, limited market demand, and potential delays associated with sustainable design, materials, and certification processes. These factors contribute to higher perceived risks and, consequently, higher yield spreads.

The coefficient for the Other category is 0.01014, with a standard error of 0.005970, indicating a slightly positive impact on the yield spread. Although it is not statistically significant at the conventional 5% level (p-value = 0.0895), it suggests that the observed difference in borrowing costs between bonds in the "other" category and other bonds may not be statistically reliable. There is a positive relationship between green bonds used for other unspecified categories of projects and higher yield spreads. The lack of specificity regarding the "Other" category limits the interpretation, as different projects within this category could have varying risk profiles and market perceptions.

6.2.8 Conclusion: Hypothesis 2

The analysis contains indicator variables for various sectors or purposes reflected by the usage of proceeds categories in order to assess the consistency of green bonds across diverse industries. The coefficients linked to these categories show how each sector or use affects yield spreads. It is possible that green bonds consistently apply to many businesses because some of these categories, such Clean Transport, Climate Change Adaptation, and Eligible Green Projects, have statistically significant coefficients (p-values 0.05).

The results indicate that, independent of the particular industry or goal associated with the bond issue, investors are willing to accept lower yields for green bonds, demonstrating that the green bond premium persists across industries. This indicates the widespread market acceptance of green bonds' sustainability and environmental advantages, expanding their influence beyond a particular industry.

In summary, the coefficients for the use of proceeds variables indicate that certain industry or project categories financed by green bonds may be associated with higher yield spreads. This suggests that investors perceive these categories as carrying higher risks, uncertainties, or potentially less well-defined returns. However, it's important to note that the statistical significance varies across categories, and further analysis considering the specific characteristics and market dynamics of each industry or project category would provide more comprehensive insights.

The regression supports the hypothesis that green bonds have a premium, as indicated by the negative coefficient for the green bond flag variable. Additionally, the findings suggest that green bonds consistently apply to different industries, with specific categories showing positive associations with higher yield spreads.

7 Conclusion

With the growth of the green bond market, there is an urgent need for greater transparency, consistent criteria for green project eligibility, third-party certification, and reporting. Many investors no longer trust green labels without further verification due to the growing skepticism surrounding green credentials and the actual environmental impact of bonds issued by certain corporations or nations. Although there is evidence that investors appreciate sustainability and are prepared to pay for non-financial aspects of investments, there are currently conflicting findings regarding the existence of a "Green bond premium.". To gain insights into the potential impact of green bonds on encouraging green investments, we conducted a comprehensive analysis on a European panel consisting of both conventional and green bonds. Our research focused on investigating two main hypotheses related to the European green bond market. The first hypothesis aimed to determine the presence of a premium for green bonds in the overall market, while the second hypothesis examined the uniformity of the greenium across various industries, taking into account the use of proceeds. By addressing these hypotheses, we aimed to shed light on the role and effectiveness of green bonds in promoting sustainable investments.

In our analysis of the first hypothesis, we investigated the presence of a green premium in the European bond market by examining the relationship between green bonds and yield spreads. Although the coefficient for the green bond flag variable indicated a negative relationship, it did not achieve statistical significance. As a result, our findings do not provide strong support for the existence of a significant greenium or premium for green bonds in the European market. Additional analysis is required to gain a more comprehensive understanding of the significance of the relationship between green bonds and yield spreads. However, it is worth considering other factors that could contribute to the absence of a significant greenium in the European market. The green bond market is complex and influenced by various elements, such as investor preferences, regulatory frameworks, and market dynamics. It is possible that the observed relationship between green bonds and yield spreads is influenced by these factors. For instance, the demand for green bonds may vary across different regions or industries, leading to variations in pricing. Furthermore, the lack of universally agreed-upon criteria for determining what qualifies as a green bond can introduce uncertainty and potentially impact the pricing dynamics. Considering these factors can provide a more nuanced understanding of the relationship between green bonds and yield spreads in the European market.

While the overall analysis did not reveal a statistically significant green premium in the European green bond market, it is important to acknowledge that the absence of such a premium at the market level does not discount the possibility of its reappearance within specific industries. Furthermore, regulatory support, government policies, market awareness, and

transparency regarding green bond characteristics can contribute to the emergence of a greenium. Supply-demand dynamics and concerns about greenwashing also play a role in shaping the presence or absence of a greenium (Larcker and Watts, 2020). Given these considerations, it is still relevant to explore the presence of a greenium across industries in the second hypothesis.

The coefficient for the green bond flag variable in the second hypothesis, which focused on the use of the greenium across industries, also demonstrated a negative association. Importantly, the p-value associated with this coefficient was statistically significant at a 5% level, providing strong evidence that the price gap between green and conventional bonds varies among industries. This suggests the potential presence of a greenium, highlighting the importance of examining industry-specific dynamics when assessing the impact of green bonds on yield spreads. There are a number of explanations for the two hypothesis' divergent results. First off, a greenium in particular industries does not necessarily follow from the absence of a major green premium in the market as a whole (first hypothesis). Investor opinions and inclinations regarding green bonds may be influenced by the particular traits, risk profiles, and market dynamics that are specific to each industry. Because of their strong sustainability emphasis or considerable environmental implications, some companies may see pricing benefits for green bonds even while the market as a whole may not show a greenium.

The size of the coefficients and the extent of the effect should also be taken into account. Although the second hypothesis's coefficient for the green flag variable is bigger in size than the first hypothesis', it is still quite modest (-0.0010). This implies that, if the greenium were to exist, its impact might be quite minimal and that it should be understood in the context of other variables affecting yield spreads.

The results show that, despite the absence of a sizable overall green premium in the market under investigation, there is evidence to imply that the existence of a greenium may differ across industries. Differences in the coefficients and p-values underscore the usefulness of taking into account industry-specific characteristics and the complex link between green bonds and yield spreads. It is crucial to understand the study's limitations as well as the complexity of the green bond market. The analysis of the use of proceeds primarily focused on examining the average yield rather than the yield for each individual industry. However, it would have been valuable to investigate the yield for each specific industry to determine if there were any variations or discrepancies in borrowing costs across sectors. By conducting an industry-specific analysis, a more detailed examination of the relationship between the use of proceeds and yield spreads could have been achieved, providing a deeper understanding of the influence of specific industries on bond yields.

8 References

Acharya, V. V., and Pedersen, L. H. (2005). Asset pricing with liquidity risk. *Journal of Financial Economics, 77(2)*, 375-410. https://doi.org/10.1016/j.jfineco.2004.06.007

Allman, E. and Lock, B. (2022). External Reviews and Green Bond Credibility. *SSRN*. http://dx.doi.org/10.2139/ssrn.4146237

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

Bahceli, Y. (2020, September 2). Calculating the 'greenium'? Germany may have an answer. *Reuters*. https://www.reuters.com/article/uk-bonds-green-germany-analysis-idUKKBN25T2ZS

Baker, M., Bergstresser, D., Serafeim, G., and Wurgler, J. (2022). The Pricing and Ownership of US Green Bonds. *Annual Review of Financial Economics, 14(1)*, 415-437. https://doi.org/10.1146/annurev-financial-111620-014802

Baker, M., Bergstresser, D., Serafeim, G., and Wurgler, J. (2018). Financing the Response to Climate change: The Pricing and Ownership of U.S. Green bonds (Working paper). *NBER Working Paper Series,* 25194. https://doi.org/10.3386/w25194

Bank of France. (2018). Green Bond Issues and Exchange-Traded Funds: Evidence from the Secondary Market. *Bank of France*. https://publications.banque-france.fr/sites/default/files/medias/documents/working-paper_706_2018.pdf.

Barbosa, D. M. C. (2018). Green Bond Issuance and Socioeconomic Factors: Do People Matter? (International Finance Discussion Paper No. 1346). *Board of Governors of the Federal Reserve System*. https://www.federalreserve.gov/econres/ifdp/files/ifdp1346.pdf

Bauer, R., Koedijk, K., and Otten, R. (2005). International evidence on ethical mutual fund performance and investment style. *Journal of Banking & Finance, 29(7),* 1751–1767. https://doi.org/10.1016/j.jbankfin.2004.06.035

Bloomberg NEF (2020). 1H 2020 Sustainable Finance Market Outlook. *Bloomberg NEF.*

Caramichael, J., and Rapp, A. (2022). The Green Corporate Bond Issuance Premium. *IDEAS Working Paper Series from RePEc.* https://doi.org/10.17016/IFDP.2022.1346

Climate Bonds Initiative. (2017a). *Bonds and climate change - the state of the market*. https://www.climatebonds.net/resources/reports/bonds-and-climate-change-

state-market-2017

Climate Bonds Initiative. (2017b). *Green Bonds Pricing in the Primary Market: January - June 2017 Update*. https://www.climatebonds.net/resources/reports/green-bonds-pricing-primary-market-january-june-2017-update.

Climate Bonds Initiative. (2020a). *Green bond pricing in the primary market: January - June 2020*. https://www.climatebonds.net/files/reports/cbi-pricing-h1-2020-21092020.pdf

Climate Bonds Initiative. (2020b). *Climate Bonds Initiative Green Bond Database Methodology*. https://www.climatebonds.net/market/green-bond-database-methodology

Climate Bonds Initiative. (2021a). *Explaining Green Bonds*. https://www.climatebonds.net/market/explaining-green-bonds

Climate Bonds Initiative. (2021b). *Green bond principles climate bonds standard*. https://www.climatebonds.net/market/best-practice-guidelines.

Climate Bonds Initiative. (2023). *Green and other Labelled Bonds Held Market Share in 2022 Amidst Fall of Global Fixed-Income.* https://www.climatebonds.net/resources/press-releases/2023/01/green-and-other-labelled-bonds-held-market-share-2022-amidst-fall

Climate Bond Initiative. (n.d.). *Interactive Data Platform.* https://www.climatebonds.net/market/data/

Duguid, K. (2022, July 18). Rising green bond issuance erodes premiums. *Financial Times.* https://www.ft.com/content/32dbf37c-8ff5-436b-88f3-9873fc864a7b

Ehlers, T. and Packer, F. (2017). Green Bond Finance and Certification. *BIS Quarterly Review September 2017.* https://www.bis.org/publ/qtrpdf/r_qt1709h.pdf

European Commission. (2019). *Green Bond Market Report.* https://finance.ec.europa.eu/system/files/2019-06/190618-sustainable-finance-teg-report-green-bond-standard_en.pdf

Fama, E. F. (1991). Efficient Capital Markets: II. *The Journal of Finance (New York), 46(5),* 1575–1617. https://doi.org/10.1111/j.1540-6261.1991.tb04636.x

Fatica, S., & Panzica, R. (2021). Green bonds as a tool against climate change? *Business Strategy and the Environment, 30(5)*, 2688–2701. https://doi.org/10.1002/bse.2771

Flammer, C. (2021). Corporate Green Bonds. *Journal of Financial Economics 142(2)*, 499–516, https://doi.org/10.1016/j.jfineco.2021.01.010

Gerard, B. (2019). ESG and Socially Responsible Investment: A Critical Review. *Beta (Oslo, Norway), 33(1)*, 61–83. https://doi.org/10.18261/issn.1504-3134-2019-01-05

Hachenberg, B. and Schiereck, D. (2018). Are green bonds priced differently from conventional bonds?. *Journal of Asset Management 19(6)*, 371–383. https://doi.org/10.1057/s41260-018-0088-5

Hartzmark, S., & Sussman, A. B. (2019). Do Investors Value Sustainability? A Natural Experiment Examining Ranking and Fund Flows. *The Journal of Finance (New York), 74(6)*, 2789–2837. https://doi.org/10.1111/jofi.12841

Helwege, J., Huang, J.-Z., Wang, Y. (2014). Liquidity effects in corporate bond spreads. *Journal of Banking Finance 45*, 105-116. https://doi.org/10.1016/j.jbankfin.2013.08.018

Hyun, S., Park, D., & Tian, S. (2022). The price of frequent issuance: the value of information in the green bond market. *Economic Change and Restructuring*, 1–23. https://doi.org/10.1007/s10644-022-09417-0

ICMA. (2018). *Green bond principles.* https://www.icmagroup.org/sustainable-finance/the-principles-guidelines-and-handbooks/green-bond-principles-gbp/

ICMA. (2021). *The green bond principles.* https://www.icmagroup.org/sustainable-finance/the-principles-guidelines-and-handbooks/green-bond-principles-gbp/

Karpf, A., and Mandel, A. (2018). The changing value of the 'green' label on the US municipal bond market. *Nature Climate Change, 8(2)*, 161–165. https://doi.org/10.1038/s41558-017-0062-0

Larcker, D. F, and Watts, E. M. (2020). Where's the greenium? J*ournal of Accounting and Economics 69(2-3)*, 101312. https://doi.org/10.1016/j.jacceco.2020.101312

Maltais, A. and Nykvist, B. (2020). Understanding the role of green bonds in advancing sustainability. *Journal of Sustainable Finance & Investment, 11(3),* 233–252. https://doi.org/10.1080/20430795.2020.1724864

Moody's. (2020). *Green Bonds - Europe: Yields on Green Bonds Issued by Governments are Slightly Higher than Those on Conventional Bonds.* https://www.moodys.com/researchdocumentcontentpage.aspx?docid=PBC_1221122

MSCI. (n.d.). F*oundations of ESG Investing in Corporate Bonds: How ESG Affects Corporate Credit Risk and Performance (002).* https://www.msci.com/documents/10199/19248715/Foundations-of-ESG-Investing-in-Corporate-Bonds-How-ESG-Affects-Corporate-Credit-Risk-and-Performance+(002).pdf

Murphy, C. J. (2002). The profitable correlation between environmental and financial performance: a review of the research. *Light Green Advisors,* 1–18.

NASA. (2021). *Responding to climate change.* https://climate.nasa.gov/solutions/adaptation-mitigation/

OECD. (2022). *OECD Business and Finance Policy Papers.* https://doi.org/10.1787/ 2c5b535c-en

Rehman, Z., Khan, A., and Rahman, A. (2020). Corporate social responsibility's influence on firm risk and firm performance: the mediating role of firm reputation. *Corporate Social-Responsibility and Environmental Management, 27(6)*, 2991–3005. https://doi.org/10.1002/csr.2018

Russo, M. V. and Fouts, P. A. (1997). A Resource-Based Perspective on Corporate Environmental Performance and Profitability. *Academy of Management Journal, 40(3),* 534–559. https://doi.org/10.2307/257052

Sangiorgi, I. and Schopohl, L. (2021). Why do institutional investors buy green bonds: Evidence from a survey of European asset managers. *International Review of Financial Analysis, 75*, 101738. https://doi.org/10.1016/j.irfa.2021.101738

Simeth, N. (2022). The value of external reviews in the secondary green bond market. *Finance Research Letters, 46*, 102306. https://doi.org/10.1016/j.frl.2021.102306

Stubbington, T. (2021). Squeeze on 'greenium' as ESG bond investors demand more value. *Financial Times*. https://www.ft.com/content/ecbed322-1709-4ed6-9f7f-d974f6e181da

The World Bank. (2021). *What You Need to Know About IFC's Green Bonds*. https://www.worldbank.org/en/news/feature/2021/12/08/what-you-need-to-know-about-ifc-s-green-bonds

U.S. Securities and Exchange Commission. (n.d.). *Bonds*. https://www.investor.gov/introduction- investing/investing-basics/investment-products/bonds-or-fixed-income-products/bonds

UNFCCC. (2015). Adoption of the Paris Agreement. *United Nations Framework Convention on Climate Change (UNFCCC)*. https://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf

United Nations. (2015). *Paris Agreement*. https://unfccc.int/sites/default/files/english_paris_agreement.pdf.

US SIF. (2018). *Report on US Sustainable, Responsible and Impact Investing Trends*. https://sustainableinvest.com/2018-ussif-report-shows-assets-reaching-12-trillion/

Verheyden, T. Eccles, R. G., and Feiner, A. (2016). ESG for All? The Impact of ESG Screening on Return, Risk, and Diversification. *Journal of Applied Corporate Finance, 28(2)*, 47–55. https://doi.org/10.1111/jacf.12174

Zerbib, O. D. (2019). The effect of pro-environmental preferences on bond prices: Evidence from green bonds. *Journal of Banking & Finance, 98,* 39–60. https://doi.org/10.1016/j.jbankfin.2018.10.012.

Appendix

A Sample of Bonds by currency

A.1 Green Bonds

Currency	**Amount Issued €**	***N***
Swiss Franc (CHF)	12 185 791 101	57
Swedish Krona (SEK)	394 710 801	7
Romanian Leu (RON)	101 280 662	1
Norwegian Krone (NOK)	153 346 254	2
Hungarian Forint (HUF)	394 662 369	4
Euro (EUR)	211 265 026 795	193
Danish Krone (DKK)	2 178 938 973	1
Australian Dollar (AUD)	42 635 209	1
Total	*226 716 392 164*	266

A.2 *Conventional Bonds*

Currency	**Amount Issued €**	***N***
Australian Dollar (AUD)	2 528 690 045	56
British Pound (GBP)	1 696 867 813 807	103
Bulgarian Lev (BGN)	2 677 147 556	8
Chinese Yuan (CNY)	966 021 723	25
Croatian Kuna (HRK)	397 838 553	1
Czech Koruna (CZK)	91 426 467 932	23
Danish Krone (DKK)	293 699 033 945	194
Dominican Peso (DOP)	4 860 323	1
Euro (EUR)	8 041 462 715 714	7 462
Hong Kong Dollar (HKD)	1 004 848 508	10
Hungarian Forint (HUF)	48 084 274 831	48
Icelandic Krona (ISK)	2 037 367 002	10
Japenese Yen (JPY)	2 484 385 578	20
New Zealand Dollar (NZD)	70 482 884	4
Norwegian Krone (NOK)	34 328 921 331	62
Polish Zloty (PLN)	132 635 834 748	23
Romanian Leu (RON)	60 052 271 947	33
South African Rand (ZAR)	20 419 215	3
Swedish Krona (SEK)	39 451 314 565	38
Swiss Franc (CHF)	383 926 931 811	1 119
US Dollar (USD)	24 829 431 350	75
Total	9 203 835 889 600	*8 264*

B Sample of Bonds by Ratings

B.1 *Green Bonds*

Moodys Rating	**Amount Issued €**	***N***
A1	1 267 176 324	4
A2	3 201 140 008	15
A3	20 007 303 872	38
Baa1	8 389 336 971	19
Baa2	40 421 138 304	13
NULL	83 866 997 251	63
Aa1	12 431 732 334	16
Aa2	25 658 174 425	29
Aa3	13 994 898 246	32
Aaa	17 478 494 429	37
Total	*226 716 392 164*	*266*

Fitch Rating	**Amount Issued €**	***N***
A	1 923 999 854	8
A-	14 950 858 295	26
A+	2 485 241 348	5
BBB	667 023 342	4
BBB+	5 475 607 620	6
NULL	84 331 107 519	156
AA	48 002 695 456	18
AA-	14 002 008 855	18
AA+	470 903 047	3
AAA	54 406 946 830	22
Total	*226 716 392 164*	*266*

B.1.1 Bond Ratings

Risk	Moody‘s	Fitch	Grade
Lowest Risk	Aaa	AAA	Investement Grade
Low Risk	Aa	AA	Investement Grade
Low Risk	A	A	Investement Grade
Medium Risk	Baa	BBB	Investment Grade
High Risk	Ba, B	BB/B	High Yield
Highest Risk	Caa/Ca/C	CCC/CC/C	High Yield
Defualt	C	D	High Yield

B.2 *Conventional bonds*

Moodys Rating	**Amount Issued €**	***N***
A1	172 385 445 149	182
A2	165 523 549 673	622
A3	113 935 896 563	566
B1	369 633 576	1
Baa1	622 697 922 528	303
Baa2	180 963 207 417	606
Baa3	712 675 265 874	77
NR	238 457 853 721	186
WR	44 660 934 045	131
Aa1	529 104 848 392	569
Aa2	1 092 716 008 840	714
Aa3	1 296 336 845 406	446
Aaa	1 849 705 107 094	1 890
Total	*9 203 835 889 600*	*8 264*

Fitch Rating	**Amount Issued €**	***N***
A	127 459 192 015	282
A-	504 410 056 285	404
A+	98 329 365 588	284
BB-	369 633 576	1
BBB-	66 528 209 105	82
BBB+	180 570 604 579	163
NR	25 948 669 510	51
NULL	2 166 690 555 548 9	4 172
WD	125 929 275 020	309
AA	1 675 468 047 152	667
AA-	1 741 281 801 848	604
AA+	151 867 934 129	46
AAA	1 892 276 092 966	1 081
Total	*9 203 835 889 600*	*8 264*

C Sample of Bonds by Sector

C.1 *Green Bonds*

Sector	**Amount Issued €**	***N***
Access to Essential Services	6 192 635 775	7
Acquisition	9 988 122	1
Aquatic Biodiversity Conservation	27 730 636 736	7
Circular Economy Adapted/Eco-efficient Products, Production Technologies/Processes	799 049 777	1
Clean Transport	112 676 803 308	94
Climate Change Adaptation	21 918 560 707	20
Eligible Green Projects	15 086 555 764	30
Energy Efficiency	21 823 308 348	55
Financing of Subordinated Loan	354 443 155	1
General Purpose	639 664 718	2
Green Construction/Buildings	14 309 992 441	37
Other Housing	1 429 207 481	4
Renewable Energy Projects	3 745 545 832	7
Total	*226 716 392 164*	*266*

C.1.1 Explanation of "Use of Proceeds" Categories

Proceeds Cluster	**Original Name**	**# Green bonds**
Biodiversity	Aquatic Biodiversity Conservation	7
Energy	Renewable Energy/ Energy Efficiency	62
Clean Transport	Clean Transport	94
Green Construction	Green Construction / Other housing	41
Climate Change Adaptation	Climate Change Adaptation	20
Eligible Green Projects	Eligible Green Projects	30
Other	General purpose/ Access to essential services/ Financing of subordinated/ Acquisition/ Circular Economy	12

Table C.1: *Proceeds Cluster and Number of Green Bonds*

- **Biodiversity:** Aquatic biodiversity conservation was funded by green bonds, which fall under the category of biodiversity. Seven green bonds were used for this purpose.
- **Energy:** Projects involving renewable energy and energy efficiency have been funded with the help of green bonds. For these uses, 62 green bonds in all were issued.
- **Clean Transport:** Projects relating to clean transportation were the focus of the green bonds in this category. For this aim, 94 green bonds were issued.
- **Green Construction:** This category includes green bonds that are used for environmentally friendly building activities, such as other housing programs. For these uses, a total of 41 green bonds were issued.
- **Climate Change Adaptation:** Projects in this category used green bonds to finance climate change adaptation. For this aim, 20 green bonds were issued.
- **Eligible Green Projects:** The green bonds assigned to eligible green projects fall under this category. For these uses, 30 green bonds in all were issued.
- **Other:** This category comprises green bonds that are used for a variety of things, including acquisitions, general spending, gaining access to basic services, financing subsidiary projects, and circular economy efforts. There were 12 green bonds included in this other category.

C.2 *Conventional bonds*

Sector	**Amount Issued €**	***N***
To reduce greenhouse gas emissions	4 99 406 111	1
Sustainable Management of Living Natural Resources	7 49 109 166	1
Sustainable Development Projects	2 247 327 499	3
Social Housing/Affordable Housing	741 064 594	3
Social -Workforce Empowerment	51 938 235	1
Social - Preventive health care	998 812 222	1
Repay Bank Loan or Bridge Financing	4 534 068 145	5
Renewable Energy Projects	49 940 611	1
Refinance/Financing expenses	5 734 619 638	21
Redevelop/Land Clearance	499 406 111	1
Recapitalization	64 922 794	2
Purchase of Funding Agreement	1 498 218 333	2
Purchase of Charged Assets	749 109 166	1
Pandemic	998 812 222	1
Other Housing	499 406 111	1
Other Health Care	5 293 704 776	2
Other Education	699 168 555	2
Other	699 168 555	1
New Public Housing	998 812 222	1
Lease financing	253 173 682	1
Guarantee	151 904 209	1
Green Construction/Buildings	499 406 111	1
General Purpose/Refinance	65 366 017 220	133
General Purpose/Acquisition	6 342 457 609	8
General Purpose	684 681 235 284	911
Funding new technologies to reduce GHS emissions	599 287 333	1

Financing of Subordinated Loan	4 994 061 110	4
Environmentally Sustainable Products	499 406 111	1
Environmental Protection Projects	5 014 037 354	7
Energy Efficiency	998 812 222	2
Eligible Social Expenditures	30 921 895 940	21
Eligible Green Projects	1 997 624 444	3
Economic Development	34 958 427	1
Compensatory education programs - Education Projects	499 406 111	1
Climate Change Adaptation	5 957 914 904	7
Clean Transport	2 399 925 833	5
Circular Economy Adapted/Eco-efficient Products, Production Technologies/Processes	1 348 396 500	2
Capital expenditure/Financing expenses	749 109 166	4
Budgetary Purpose	8 739 606 942	4
Bridges	2 916 531 688	3
Aquatic Biodiversity Conservation	4 841 342 721	4
Acquisition	1 206 904 169	4
Access to Essential Services	113 720 628 384	67
Not classified	8 231 494 831 058	7 017
Total	*9 203 835 889 600*	*8 264*