Copenhagen Business School
Copenhagen, Spring 2021

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HANDELSHØJSKOLEN

Green bond premium in the primary market

A comprehensive study of greenium and its determinants in the primary market

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Master's thesis

MSc in Economics and Business Administration - Finance and Investments

COPENHAGEN BUSINESS SCHOOL

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Date of submission: 16th May 2021

Number of pages: 111

Number of characters: 234 433

Abstract

The first green bond was issued in 2007 as a financial tool to address climate change. Since then, the green bond market has been growing exponentially, and in 2020, it reached 1 trillion USD in cumulative green issuance. There has been an ongoing debate on whether green bonds are priced differently from their conventional peers. The academic literature on this topic has not yet reached a consensus. This study provides a comprehensive analysis of green and conventional bond yield differences, referred to as the greenium, in the primary market.

The green bonds are matched with synthetic, conventional bonds in such a way so that the difference in yield can solely be attributed to the green label. The results indicate an insignificant green bond premium of -8 bps. Therefore, the conclusion is that there is no significant difference in pricing between green and conventional bonds in the primary market. However, the study also concludes that greenium is significant when separate market segments are considered. Then, eight cross-sectional OLS regressions are specified to analyze how the hypothesized bond-specific and issuer-specific characteristics affect the variation in greenium. The analysis shows that the greenium determinants which significantly affect the variation in greenium are the issue amount, country, currency, seniority & collateral, the use of proceeds, sector, ESG, "E," "S," and "G" scores. The "E" score was the most significant greenium determinant among all of the pillars. Moreover, the greenium was more negative for issuers with lower ESG scores. On the other hand, the third-party verification, maturity, issue year, issuer type, coupon type, or ESG combined score cannot explain the variation in greenium to a significant extent. This study concludes that the green bond premium is mainly a result of investors' non-pecuniary motives and is driven by their pro-environmental preferences and concerns. The discussion, which is built on the analysis, literature review, and both financial and non-financial theoretical frameworks, underlines the essential role that the greenium plays in developing the green bond market and suggests an action plan to establish and maintain greenium in the long term.

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1. Introduction

Climate change is affecting all of us. Experts in the field have set a limit on 2 tons of carbon dioxide per year for each person. With the current emissions, the global average is twice that size. In the developed world, the numbers are much higher, by 15-20 tons in the US and 6-9 tons in the UK (Pettinger, 2019; Union of Concerned Scientists, 2020; World Health Organization, 2008). According to the Paris Agreement, all countries which signed the document are legally committed to limit global warming below 2 degrees Celsius. However, preferably below 1,5 degrees Celsius compared to the average temperatures before the world's industrialization (United Nations, 2015b). Even with those limits not exceeded, environmental disasters and damages to the ecosystems are expected to be more common in the future due to the already increased temperature.

Several sources approximate that the global temperature already has increased by 1 degree Celsius (Masson-Delmotte et al., 2018; NASA, 2021), or even 1,2 degree Celsius (Millan Lombrana, 2020). Figure 1 below shows the average temperature since 1880. It appears with no doubt that the most recent years are the warmest. Due to the rapidly increasing temperature, acting urgently to beat climate change is one of the United Nations 17 sustainable development goals. Additionally, another seven of the 17 goals are directly connected to the environment, such as life on land and below water, responsible consumption and production, and sustainable cities (United Nations, 2015a). With the current ambitions and actions, the global average temperature might reach 3 degrees Celsius compared to pre-industrial levels within 100 years (Climate Action Tracker, 2021; OECD, 2017).

Figure 1 – Average Temperatures (NASA, 2021)

To increase the climate ambitions, the European Union recently launched the European Green Deal. In short, it is a decision to become the most climate-friendly region and be fully climate neutral by 2050. This goal will be reached through green technology, by creating a sustainable industry and transport, and by cutting pollution (European Commission, 2021). To finance those projects, the EU agrees to increase the budget for green investments, but they also conclude that private funding will be needed (European Commission, 2020). The need and demand for socially responsible investing, SRI, which focuses on both social and financial outcomes, can be considered higher than ever before (S&P Global, 2020).

The United Nations and OECD also admit that large-scale investments are required to reduce the emissions to the required extent (United Nations, n.d.). In a report from 2018, OECD estimates that 6,9 trillion USD each year until 2030 is required to reach the climate objectives (OECD et al., 2018). Therefore, the need for green funding is crucial. One way to finance green projects is through green bonds. They are similar to a conventional bond except that the proceeds should be used for environmentally-friendly purposes. The World Bank issued the first green bond in 2007. However, the market started to grow only in 2013 after the first corporate green bond was issued (Climate Bonds Initiative, 2020; The World Bank, 2019). Figure 2 below shows the growth in both the issued amount and the number of bonds. The values from year 2021 are lower since the data was collected from Eikon on 17 April 2021.

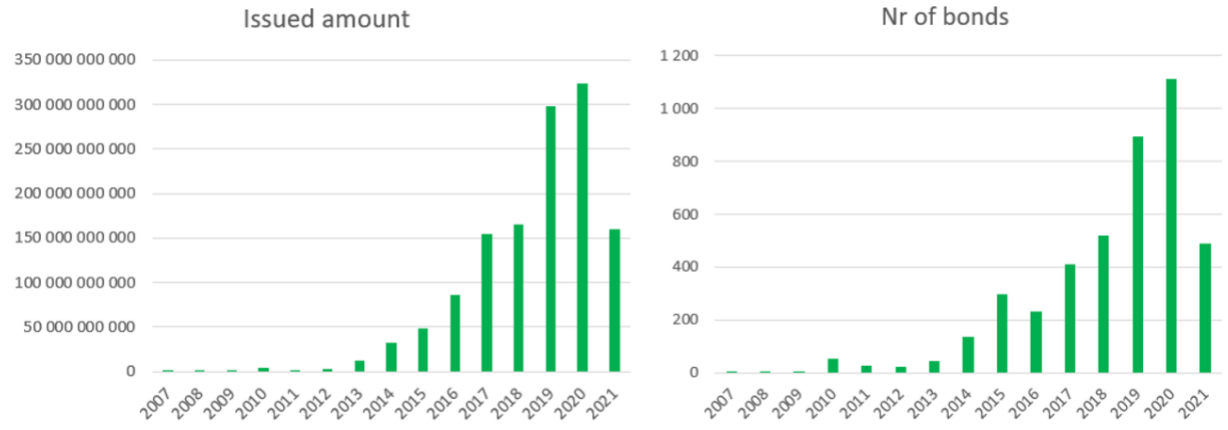

Figure 2 – Bond Market Development

Due to the fast growth in the green bond market, voluntary Green Bond Principles have been developed by the International Capital Markets Association, ICMA. These guidelines were intended to help increase the capital allocation to green projects by increasing transparency. The four core principles are 1. Use of proceeds, 2. Process for Project Evaluation, 3. Management of Proceeds, and 4. Reporting. The first two principles are about information that the issuer should provide to investors before investing in the bond. The use of proceeds is deemed the most fundamental since it refers to how the money will be allocated. The second principle explains how the projects are selected. The third principle implies that the issuer should separate the funds raised by the green bond from the general funds of the issuer. The fourth principle states that the issuer should provide yearly information about the proceeds until they are fully allocated. (ICMA, 2018).

In addition to this, a group of investors supported by the United Nations has developed six voluntary principles for responsible investments. The principles for the issuers are as follows: 1. We will incorporate ESG issues into investment analysis and decision-making processes, 2. We will be active owners and incorporate ESG issues into our ownership policies and practices, 3. We will seek appropriate disclosure on ESG issues by the entities in which we invest, 4. We will promote acceptance and implementation of the principles within the investment industry, 5. We will work together to enhance our effectiveness in implementing the principles, 6. We will each report on our activities and progress towards implementing the principles. The goal of the principles is to create an efficient and sustainable system that values the long-term perspective and responsible investments with benefits for the environment and the society. Since the start in 2006, the compliance to the principles has grown. In 2020, more than 80 trillion American dollars were managed according to the principles (Principles for Responsible Investment, 2020).

To further establish which kind of investments are to be considered green, in 2020, the European Union launched the EU Taxonomy. The taxonomy was launched as a tool to reach the objectives of the EU Green Deal. By introducing a common language with clear definitions of sustainability, the goal was to increase the investments into more sustainable projects. The purpose was to better clarify for investors what should be considered sustainable or green and decrease the potential greenwashing. This classification system consists of six objectives for classifying economic activities as either sustainable or not. The six objectives are 1. Climate change mitigation, 2.

Climate change adaption, 3. The sustainable use and protection of water and marine resources, 4. The transition to a circular economy, 5. Pollution prevention and control, and lastly, 6. The protection and restoration of biodiversity and ecosystems (EU TEG, 2020a; European Commission, n.d.). An activity or project will be considered sustainable according to the EU Taxonomy if it substantially contributes to or enables another activity to contribute to at least one of the six objectives. Another criterion is that it does not substantially harm any other criteria (Razauskaite & Edwards, 2020). By launching this taxonomy, the EU Commission hopes to standardize the market for green investments and make them more comparable (European Commission, n.d.). When implemented, this Taxonomy will become mandatory within the EU (EU TEG, 2020a; EY, 2020).

To fully implement this Taxonomy, the EU has also launched the EU Green Bond Standard consisting of four voluntary principles: a combination of the EU Taxonomy and the ICMA Green Bond Principles described above (EU TEG, 2020b; Razauskaite & Edwards, 2020). The four criteria of the EU Green Bond Standard are 1. The alignment of the use of proceeds with the EU Taxonomy, 2. The content of a Green Bond Framework to be produced by the issuer, 3. The required Allocation and Impact Reporting, and 4. The requirements for external verification by an approved verifier (EU TEG, 2020b).

When the issuer provides the voluntary information discussed in the previous sections, there might exist a degree of information asymmetry between the issuer and the investor. To prevent this, a method with fixed standards and third-party verifications has been established. One such verification is the Climate Bonds Standard developed by the Climate Bonds Initiative. Usually, a green bond can be certified according to the Climate Bonds Standard before issuance, and due to this, the issuer can use the verification to attract investors (Climate Bonds Initiative, 2021). If a green bond is verified according to the standard, it means that the bond is 1. Fully aligned with the Green Bond Principles and/or the Green Loan Principles, 2. Using best practices for internal controls, tracking, reporting, and verification, and 3. Financing assets consistent with achieving the goals of the Paris Climate Agreement (Climate Bonds Initiative, 2019). Therefore, this certification can be used as a tool to increase transparency further and reduce information asymmetry.

Another way to increase transparency is to follow the Task Force's guidelines on Climate-Related Financial Disclosures, TCFD, launched by the Financial Stability Board, FSB. The TCFD is a framework for providing reliable information on climate-related risks and opportunities that is supposed to help stakeholders make more well-informed decisions (TCFD, 2021). The FSB launched the framework due to the need to value and incorporate climate-associated risks in a transparent and standardized way. The consequences of underestimated climate risks are mispriced assets or misallocation of assets. The framework focuses on four primary areas. They include 1. Disclosing the organization's governance around climate-related risks and opportunities, 2. Disclosing the actual and potential impacts of climate-related risks and opportunities on the organization's businesses, strategy, and financial planning where such information is material, 3. Disclosing how the organization identifies, assesses, and manages climate-related risks, and lastly, 4. Disclosing the metrics and targets used to assess and manage relevant climate-related risks and opportunities where such information is material (TCFD, 2017). If this information is available to investors, they are expected to understand the entire risk of the issuer better.

1.1. Theoretical connection

Recent studies on green bonds have shown that green bonds might be priced differently than their conventional counterparts. If the green bonds are priced with a yield lower than the yield for comparable bonds, it is called a greenium. The opposite, higher yields for green bonds, is referred to as a green bond discount. However, it has not been concluded yet if there is a significant difference in pricing. Previous literature on the subject separates between the primary and the secondary market. Around 70% of the studies on the secondary market concluded that there is a greenium. In most cases, the greenium was within -1 and -9 basis points. However, the results from the primary market are much less consistent. Only 56% of the studies concluded that there was a greenium. According to those studies, the greenium in the primary market ranges from -85 to +213 basis points (MacAskill et al., 2021).

According to traditional theories within finance, the price of bonds should entirely depend on their fundamental risk factors and expected cash flow. The most relevant aspects of bond pricing are

the interest rate and the default risk (Berk & DeMarzo, 2017). However, the model does not consider if the bond is green or not. When pricing irregularities arise in the financial markets, they are later considered as an arbitrage opportunity, which is expected to disappear. When it exists for a longer time, it might also be considered an anomaly. Anomalies can persist if trading barriers make it hard to trade and thereby fix the arbitrage (Zaremba & Szczygielski, 2019). One perspective to look at would be to consider greenium as a pricing irregularity or a financial anomaly. If a green bond is issued at a lower yield than a similar conventional bond, any rational investor should invest in the latter. Suppose the green bond yield is higher than the yield of a conventional counterpart. In that case, a rational issuer should issue a conventional bond instead of the green bond and use the proceeds from a conventional bond for green purposes. This logic, therefore, suggests that there should not be any differences in yields between green and conventional bonds.

A concern that has been raised since the green bond market started to take off is additionality. It is hard for an investor to measure if the green bond label brings any additional value. If a green project could have been financed with a conventional bond and could have existed without the green bond, there is no additionality in labeling the bond as green. In this case, the green bond might just be a cheaper way to finance green projects if there is a greenium.

1.2. Purpose and research question

The purpose of this study is to conclude whether there exist significant differences in pricing between green and conventional bonds. As a second step, the determinants of these potential differences will be analyzed. Since the most ambiguous greenium values have been previously observed in the primary market, further research there is needed. The yield in the primary market is also more directly related to the issuers' cost of capital than the secondary market, which means that it directly affects the attractiveness of green projects. Therefore, the focus of this study will be on the primary green bond market. The research question that will guide the analysis of this study is the following:

Is there a greenium, and how can it be explained?

Three hypotheses have been developed to help answer this question. The first hypothesis aims to answer the first part of the question and conclude whether the greenium exists. The second and third hypotheses were developed to answer the second part of the research question and show which factors can explain the potential greenium. The exact formulation of the hypotheses is provided in the literature review.

This study does not find any significant differences in yield between green and conventional bonds in the primary market. However, it shows that there is a significant greenium in some market segments and some specific categories of issuers. It does also show that both issuer-specific and bond-specific characteristics can explain the variation in greenium. The results are based on the matching and synthesizing approach where green bonds are matched with two conventional counterparts, which are similar in all fundamental characteristics except for the green label. This method is similar to how Zerbib (2019) estimated greenium in the secondary market. The two conventional bonds are used to construct a synthetic, conventional bond with the same maturity as the green bond by interpolation and extrapolation of yields. A sample of 63 greenium values is estimated by the difference in green and synthetic conventional bond yields. The Wilcoxon rank-sum test is used to evaluate if the mean value is significantly different from 0. The total sample was divided into several subsamples based on different bonds' characteristics to test the first hypothesis. A cross-sectional OLS regression was further used to estimate the potential factors that might determine the size of greenium.

2. Systematic literature review

This literature presents the current knowledge and literature related to the field of greenium and its determinants. The structure will handle four different segments. At first, the increased awareness of climate change among people is described. Secondly comes a section describing how this leads to increased pressure on corporations and governments regarding demands for sustainable investments in the form of, for example, green bonds. The following section will discuss information asymmetry related to green bonds and their implications on the market. This section also presents solutions for how the asymmetry can be decreased. Next, the current knowledge about green bond premium based on previous studies from the primary and secondary markets is discussed separately. The last part of this review is focused on the factors that might determine the magnitude and direction of greenium. This section will discuss factors previous research has found significant and not significant and which implications this might have on the market. At last, we summarize the current knowledge to show how this study will contribute to the literature.

A systematic approach to the literature review was chosen for the "Information Asymmetry," "Greenium," and "Greenium determinants" sections to ensure the robustness of results and to avoid any potential bias. The search criteria were not limited to any specific time due to the relative scarcity of the existing literature on this topic. The search criteria were primarily limited to the following broad keywords: "Green," "Bond," "Premium," "Greenwashing." These keywords were preferred over more specific options, such as "Greenium," "Factors," "Determinants," etc., as they allowed us to reach the broadest scope of the literature. This approach was expected to decrease the risk of overlooking papers which are not using this specific terminology, e.g., the "Greenium" term to describe the "Green Bond Premium." The scholarly databases used are Scopus and Web of Science. The search results are limited to academic articles in the English language.

2.1. Global warming

2.1.1. Raising awareness

Almost all researchers today agree that climate change is caused by humankind and that if we do not change our way of living, the effects will be devastating. The emission of greenhouse gases into the atmosphere increases the temperature and causes global warming, followed by climate changes and natural disasters worldwide (Joubert & Köhler, 1996; Orru et al., 2019; Touma et al., 2021). Raising awareness among the public is crucial to stop climate change (Yilmaz & Can, 2020). Other research concludes that one efficient way to increase awareness and affect public behavior is through media. Studies show that the number of articles in media is more critical than well-developed campaigns or big climate meetings. One reason for this is said to be due to the audience. Those who participate in the meetings or fully engage in the campaigns are already well-informed about climate change. Therefore, the articles in media are a better way to reach out a broader audience (Ricci & Banterle, 2020).

The number of news articles on the subject has faced a drastic increase. Schmidt et al. (2013) conclude that 0,20% of the news articles in 1997-2000 covered the subject. Ten years later, that number was 1,26%. The sample of their study included 27 countries from both developed and emerging markets. The same article concludes that the coverage did not seem to be cyclical. The trend was steadily increasing during the years (Schmidt et al., 2013). This view is further supported by an article in YALE Climate Connections proving that the media coverage on climate change strengthens the number of articles and their quality in the years building up to 2019 (Svoboda, 2020). Based on these articles, it is no surprise that the awareness of climate change has increased among the public. Between 2011 and 2018, the number of Americans that were very worried about global warming tripled (Leiserowitz et al., 2019). In a European context, a survey from 2019 concluded that 93% of the Europeans see climate change as a serious problem and have changed their behavior in at least one way to help stop climate change (European Commission, 2019).

2.1.2. Investor preferences and power

Prior research shows that some investors have what Fama & French (2007) define as a taste for more sustainable investments and companies who participate in CSR activities. This leads to differences in how investors value the same company (Fama & French, 2007). According to more traditionally economic models, the market value of a company is generated by its cash flow. With a discounted cash flow model, DCF, the market value is derived from the net present value of the future cash flow without considering how the cash flow is generated. This is no longer the entire truth. Some investors today pay more attention to what happens around the company and their impact on their surroundings. How much attention and which value it has is dependent on the individual investor's preferences. Some investors only value the cash flow while others pay equal attention to nonfinancial activities. Investors might reach widely different conclusions regarding the market value of a company (Friedman & Heinle, 2016).

This view is further supported by other research by Martin & Moser (2016), who saw that investors tend to react positively to green activities even if they decrease the cash flow. They concluded that investors reward managers for taking green initiatives. They also evaluated the investors' reaction to manager's disclosures regarding green investments. Their findings were that investors as a group reacted positively to disclosures on green investments. Also, announcements on green investments which aimed to increase the cash flow were followed by large reactions. They found that the reactions were larger than motivated only by the change in expected cash flow, which led them to conclude that investors also include other valuation aspects besides the net present value of cash flow (Martin & Moser, 2016). An earlier study also concluded that the disclosure itself might have an impact on the company's earnings. A company with CSR performance better than the peers in the sector can lower their cost of equity only by initiating separate disclosure for their CSR activities instead of having it together with their financial reports (Dhaliwal et al., 2011). Therefore, the managers have incentives from two directions to engage in sustainable activities and show them to the world.

It is not only the cost of capital that can be affected by investor's preferences. Also, the composition of a company can, in some cases, be affected. The taste and preferences in the investor base might

have an impact on spin-offs from a company. A company active within different sectors or segments, where one division is not as sustainable as the others, might divide and make that division a separate company to please the ethically oriented investors. A division that the investors do not prefer might generate a discount and lower the market value on the entire company. On the other hand, if the division gets separated from the rest of the company, the discount might go away. This is since the ethically oriented investor type can now choose to only invest in the parts they prefer, and other investors can invest in the spin-off. The summarized market value of the two new units might therefore be higher than the old value. This is one way for investors to have an impact on the company's sustainability. Another solution for the company could be to close down the division. This could also lead to greater sustainability credibility among the investors (Friedman & Heinle, 2016).

In contrast, Heinkel et al. (2001) studied the effects of changing preferences among investors to see what happened when ethical investors left a company that no longer lived up to their high standards. They concluded that the share price declined in those situations due to the changed risk for remaining investors. Without ethical investors, the neutral had to carry the entire risk (Heinkel et al., 2001). According to the theory of supply and demand, a decline in the price is also what we should expect.

Other studies on the same theme conclude that companies with better CSR performance also have a wider breadth in ownership. Kim et al. (2018) conducted a study in which they subsampled firms depending on their CSR performance into high-CSR or low-CSR based on the KLD database. They concluded that those in the high-CSR group, on average, had more investors, both institutional and private. The engagement in ethical activities also seemed to have a positive effect on the firm's equity. Companies engaged in CSR activities had higher stock liquidity, faced lower equity costs, and had more expansive access to external capital regarding debt and equity (Kim et al., 2018). Those additional consequences are in line with our intuition. When the base of potential investors gets wider, economic theories on demand and supply suggest that the cost of capital should decrease and that the traded volume should increase. These findings suggest that it can be more profitable for shareholders when managers invest in sustainable projects even when other projects might be better for the cash flow. This view has further support in a study suggesting that

if manager's goal is to maximize the value for shareholders, they should strive to increase the number of investors (Heinkel et al., 2001).

A goal for some investors is to make their individual social responsibility become the corporate social responsibility which is assumed to have a larger impact (Friedman & Heinle, 2016). The findings above also indicate that some investors have high demands on the companies they invest in. To gain access to capital, managers must become more sustainable to live up to those demands. It does also show that investors as a group can affect companies in the way they want. This view is further supported by Chen & Harrison (2020), who concluded that companies now are more influenced by the preferences of their investors.

Ethical investors are not a homogenous group, and companies that are acceptable to invest in differ. Some investors might only invest in pro-environmental initiatives such as water management or renewable energy. In contrast, others could accept a manufacturer of hybrid cars since they are better than fossil cars. According to Heinkel et al. (2001), this heterogeneity can reduce the impact of ethical investors. If they instead would have acted as a uniform group, their impact could have been even more remarkable. Despite this, the impact is still high within the areas where most ethical investors agree and push in the same direction (Heinkel et al., 2001).

A study on Swedish pension funds conducted by Hamilton & Eriksson (2011) concluded that one strong motivation to engage in sustainability is reputational risk. In their view, they must engage and make sure their investments are sustainable not to lose investors. They need to build a green image with high standards (Hamilton & Eriksson, 2011). This is well in line with the previous sections concluding that the influence and impact from investors are strong. Previous research seems to agree that ethically oriented investors can push the companies into a more sustainable direction. One way to do so is through green bonds. Green bonds can help build such an image for both the investor as well as the issuer. A green bond is like any other conventional bond except that the proceeds, or a part of the proceeds, must be invested in green projects. Green bonds have become a popular instrument since they allow investors to finance green projects and help stop climate changes (Piñeiro-Chousa et al., 2021). From the company's perspective, they contribute to financing new projects and creating a better image. As discussed before, since companies engaged

in CSR activities can attract a broader investor base, the issuance of green bonds can help managers increase the market value of their companies.

A great boost to the green bond market comes from the Copenhagen Accord, where several economies decided that large investments were needed to fight the climate changes and that the best way to finance those was with green bonds. Moreover, the characteristics of being a fixed income asset and also being attractive to a wide range of investors increased the status of green bonds (Piñeiro-Chousa et al., 2021).

2.2. Information asymmetry

In general, information asymmetries play an essential role in developing the corporate information environment (Beyer et al., 2010). The three main dimensions that determine the corporation information environment are (1) managers' voluntary disclosure decisions, (2) disclosures mandated by regulators, and (3) reporting decisions by analysts. (ibid). The authors also point at the importance of analyzing potential interrelations between all three information sources and their challenges. One such interrelation was analyzed by Mark & Russell (1993). He explained that analysts tend to follow more firms that exhibit a higher level of voluntary informative disclosures as it decreases the cost of obtaining information. Under this framework, the green bond information environment can be split into (1) voluntary green bond disclosures such as impact reporting, summarized under the Green Bond Principles, (2) mandatory reporting required by e.g., SEC, as well as upcoming mandatory climate risk disclosures in line with e.g., Task Force on Climate-related Financial Disclosures, and (3) analysts review, second-party opinions and third-party verifications. Next, we will review the literature on these disclosure types and analyze their interrelations.

2.2.1. Greenwashing

Greenwashing serves as evidence of information asymmetry, which persists in the green bond market. Due to this information asymmetry, stakeholders are required to rely on companies'

signals to understand their current environmental quality and future commitments to the environment (Berrone et al., 2017). The concept has been defined by Lyon & Maxwell (2011, p.9) as "selective disclosure of positive information about a company's environmental or social performance without full disclosure of negative information on these dimensions, to create an overly positive corporate image." There have been a number of cases of companies involved in opportunistic behavior, such as signaling their environmental responsibility to relevant stakeholders, while actually following their own agenda. Greenwashing can take many forms, such as selective disclosures, ambiguous labels and visuals, and misguiding anecdotes (Lyon & Montgomery, 2015). These methods are much more appealing to corporations willing to engage in greenwashing as greenwashing through the actual green bond issuance is more complex and costly (Flammer, 2019).

Drawing from institutional theory, Delmas & Burbano (2011) have created a framework in which they classified the drivers of greenwashing into four distinct categories: organizational, psychological, market external, and nonmarket external drivers of greenwashing. Market external drivers include consumer, investor, and competitors' demands. Organizational drivers are organizational attributes such as structure and culture, while physiological drivers include various cognitive biases. Nonmarket external drivers are the basis of this framework and consist of the uncertain regulatory environment often blamed in the literature for fostering greenwashing. Similarly, Park (2018) names the lack of centralized public governance of the green bond market as one reason for greenwashing. Private governance regimes, such as standards, certifications, ratings, and third-party assessments, tend to be easier in implementation and more flexible in adapting to market needs than public regulation. However, it is inherently less legitimate, accountable, and consistent, therefore creating a favorable environment for greenwashing (S. K. Park, 2018).

Laufer (2003) argues that greenwashing mainly operates on three dimensions of deception: confusion, fronting, and posturing. In his work, Laufer (2003) explains how oil corporations create confusion by complex corporate forms and decentralized decision-making. They engage in fronting by casting doubts on the severity of danger and making exaggerated claims and deceptively posture the firm's objectives and commitments to ethics by employing "front groups."

Even though many companies find it lucrative to engage in greenwashing, market participants tend to punish such engagements once revealed severely. In their analysis of market reactions, Nyilasy et al. (2014) have shown that green advertising efforts can severely backfire if there is a discrepancy between companies' announcements and their actual environmental performance. Moreover, they conclude that besides ethical consequences, greenwashing has a significant impact on stakeholders' attitudes towards the company, leading to financial consequences.

2.2.2. Regulatory policies

As the green bond market evolves, it gradually moves towards a higher regulated information environment due to the increasing demand. Various mechanisms, e.g., principles, standards, third-party verifications, have been developed by policymakers to regulate the green bond market, reduce information asymmetry, eliminate the opportunity for greenwashing and provide ethical assurance. Research has been investigating the usefulness of these tools and their effect on the green bond market. For instance, Parguel et al. (2011) have studied the capacity of independent companies' sustainability ratings to limit the potential for greenwashing. They have revealed the asymmetric nature of the impact that poor and good sustainability ratings might have on a company's CSR communication. It was argued that a good sustainability rating has a limited effect on a company's perception by the public compared to a neutral rating. In contrast, a bad rating can have a detrimental effect. Therefore, it might be more beneficial for companies to stay "neutral" rather than trying to enhance their sustainability image at all costs.

Another famous mechanism that regulates the green bond market is third-party verifications. In their study of the discrepancy between environmental policy statement commitment and actual policy implementation, Ramus & Montiel (2005) have concluded that third-party audits and verifications are probably the only methods to assure that public environmental commitments indeed transform into action. Another interesting conclusion is that corporations are not evil. They make environmental policy statements because it is easy, and stakeholders demand it. However, without a proper mechanism that would enforce commitment to sub-policies necessary for implementing the central policy, their sustainability goals will remain illusory.

Berrone et al. (2017) have investigated the conditions under which greenwashing can backfire. They have found the presence of critical NGOs to be essential for revealing inconsistencies between companies' environmental claims and their actual action. They further claimed that the presence of environmental NGOs is crucial for green credentials to lead to environmental legitimacy. It also serves as a mechanism to reduce the incentives for companies to engage in greenwashing significantly. However, they have not found any significant positive effect of environmental NGOs on relatively sustainable companies, meaning that the mechanism is limited in its usefulness. It does not motivate companies to enhance their environmental performance after some point further. Therefore, environmental NGOs' influence on companies' environmental performance can be compared to independent companies' sustainability ratings. Both mechanisms have a greater potential to impact less sustainable companies positively and have a relatively limited impact on more sustainable ones. Like Parguel et al. (2011), Berrone et al. (2017) have argued that it may be safer for companies with a higher than average carbon footprint that functions in environmentally sensitive sectors to stay quiet than trying to look green.

Lyon & Maxwell (2011) have addressed information asymmetry by constructing the first economic model of "greenwash." As discussed in other papers, the unequal impact of various regulating mechanisms on companies with different characteristics can make it optimal for some to remain silent on their environmental performance. In other words, rather than becoming more transparent, some companies feel discouraged to disclose out of fear of public backlash. The authors have discovered that such a response is more likely for companies that are not fully informed about their positive environmental impact. The "greenwash" model addresses this issue by proposing an equilibrium under which a company discloses information on its environmental performance to activists who punish companies for greenwashing rather than poor environmental performance. Under this model, companies with bad environmental performance are more inclined to disclose information, which, in theory, can solve the issue of companies restraining from environmental disclosures. In contrast, firms with relatively good environmental performance are more likely to choose the strategy of withholding information, which may arguably sound counterintuitive. Their results represent a theoretical framework, the real-world applicability, which is to be tested.

In general, researchers agree on the role of private regulatory mechanisms, such as standards, certifications, ratings, third-party assessments, and acknowledge their limited positive effect on reducing information asymmetry and the opportunities for greenwashing. Some also point at the importance of their interrelations. However, little is said about how private regulatory mechanisms function in combination with public governance. Park (2018) has addressed this issue by proposing a hybrid framework to achieve a synergy between private and public regulations. He draws on the concept of hybridity to suggest how the green bond market may benefit from collaboration between market-based and public governance structures to keep its flexibility and innovative dimension and acquire transparency and legitimacy, necessary for overcoming public skepticism. He argues that hybridization can address legitimacy deficits of private mechanisms in 3 main ways. The hybridization strategy consists of (1) improving the use of second-party opinions as external assurance that has not yet become a standard in the green bond market by implementing a default penalty for its absence. In addition to this, hybridization can (2) support the signaling effect of certification if government labeling schemes incorporate private certifications, such as CBI, or explicitly mutually recognize them. Finally, hybridization strategy is supposed to (3) induce participation in private governance regimes if public regulators provide monetary incentives for stakeholders to engage in private governance decision-making and consultations.

2.3. Greenium

Green bonds are a critical tool to finance sustainable projects (Kapraun & Scheins, 2019). Between 2015 and 2019, the issuance of green bonds on the global market faced a fivefold increase. Both the issuers and the investors are said to have a clear momentum towards environmentally sustainable investments. They also conclude that there is still a need for more green bonds in the market. Most of the issued green bonds are oversubscribed, meaning that there are more buyers than bonds to buy. Some research shows that the market sentiment towards green bonds is emerging to the extent that a green bond premium, a greenium, has been established (MacAskill et al., 2021). If this is true, traditional economic theories of no-arbitrage can be questioned. According to traditional theories, an investor who faces two financially similar assets where one

is sustainable should be indifferent between them (Larcker & Watts, 2020). This phenomenon will be discussed more in detail in the following theoretical framework.

We will, in this thesis, use the same definition of greenium as Kapraun & Scheins (2019), who defines it as the difference in yield between a green bond and a conventional bond with the same fundamental characteristics shown in Equation 1. A green bond premium of -10 basis points does, despite the negative sign, indicate a greenium. The negative sign implies that there is a negative difference compared to a corresponding conventional bond. On the other hand, if the difference is positive, it is referred to as a green bond discount.

$$Y_{GB} - Y_{CB} = Greenium \qquad \textit{Equation 1}$$

MacAskill et al. (2021) explain that the greenium is represented by a higher price on the green bond than its conventional counterpart. The higher price implies a lower yield which means that the investor gives up some return for non-financial purposes (MacAskill et al., 2021). Several studies have tried to find evidence of greenium on the primary and the secondary market. We will in this section provide an overview of their widely different findings.

2.3.1. Primary market

MacAskill et al. (2021) found ambiguous results regarding the greenium in the primary market in their systematic literature review. The studies they analyzed found evidence of a greenium in the broad spectrum -85 to +213 basis points. Since zero is inside the boundaries, the review did not find definite evidence in favor of a greenium. They also showed that 44% of the studies did not find any greenium compared to 56% who found it (MacAskill et al., 2021). These contradictory findings raise the need for further research within the field.

Kapraun & Scheins (2019) conducted a study in which they estimated the greenium by matching and comparing green bonds with their conventional counterparts. Their criteria were that the bond should have the same issuer, rating, seniority, currency, and type of bond. In addition, the issue

size and maturity had to be as close as possible but without a definite limit. This approach gave them around 1 500 green and 200 000 conventional bonds to analyze. The green bonds were then matched into pairs with the conventional bonds. After this, they applied a regression model to calculate any differences in the yield. They found that the green bonds, on average, had a lower yield of 15 basis points at issue. They concluded that there was a greenium in the primary market (Kapraun & Scheins, 2019).

A minor study by Ehlers & Packer (2017) that reached a similar result has studied differences in credit spread. They compared the credit spread of a green bond with the credit spread of a conventional bond. Their sample consisted of 21 bonds of each kind issued between 2014 and 2017. The bonds were matched such that the issuer and the seniority were the same. They also kept the maturities as close as possible and only included bonds issued in USD and Euro. Their findings were close to Kapraun & Scheins (2019) and indicated an average greenium of -18 basis points in the primary market. They could thereby conclude that the issuers of green bonds have had access to cheaper funding for their projects. Despite this, there were differences among their sample. Five of the 21 bonds indicated a green bond discount, i.e., a negative greenium (Ehlers & Packer, 2017). This finding and the fact that their sample only consists of 21 green bonds makes their results less reliable. At the same time, their findings and conclusions regarding the existence of an average greenium are the same as in the previously described study with 1 500 bonds.

Another study by Gianfrate & Peri (2019) used a score matching technique to match green bonds with conventional counterparts. Their sample consisted of 121 green bonds issued between 2013 and 2017. They estimated a propensity score to predict the greenness of a bond. This score was used to match a green bond with its nearest neighbor among the conventional bonds to estimate the green effect. They allowed the conventional bonds to be matched with more than one green bond. Also, with this method, the findings support the existence of a green bond premium in the primary market. Their study concludes that green bonds can be an essential tool against climate change since it provides cheaper funding for green projects. They help green the economy without financially punishing those who make an effort for the climate (Gianfrate & Peri, 2019). Due to the different methods, this study strengthens the support for those who claim there is a greenium.

In contrast to this, Larcker & Watts (2020) did not find any evidence of an economically significant greenium. They used self-labeled green bonds and conventional bonds issued by municipals during 2013-2018. The green bonds were matched with an almost identical conventional bond. The issuer, rating, and call date were the same, and the allowance for maturity differences was set to one year. This method left them with 640 matched pairs from 30 different issuers. After this, they simply calculate the difference between the two bonds in each pair. Their findings were that the difference is exactly or close to zero in 85% of the pairs. Among the remaining 15%, 40% implied a greenium, and 60% indicated a green bond discount. On average, they found a green bond discount of 0,45 basis points, but they considered it to be economically insignificant due to its small size. Their conclusion was, therefore, that there was no greenium in the municipal bonds primary market. In contrast to other studies, this implies that the investors are unwilling to sacrifice their financial returns in favor of environmentally sustainable projects (Larcker & Watts, 2020).

Another paper by Deng et al. (2020) has studied the effects of green bond announcements on stock returns to evaluate if the incumbent equity holders benefit from green bond issuance. The authors did it by analyzing if green bond issuance led to a lower cost of debt. They created a sample with bonds issued between 2007-2017. Publicly traded companies issued all bonds in their sample. Since not all of the companies had issued both green and conventional bonds similar enough to be compared, they matched bonds from different issuers. Criterions for this matching was that the firms should be of similar size, market to book ratio, and have similar stock liquidity. They evaluated the yield spread to check for differences between green and conventional bonds. Using this method, they could not find any statistically significant greenium. Therefore, they concluded that any change in returns related to green bond announcements could not be caused by lower debt costs (Deng et al., 2020).

2.3.2. Secondary market

In the secondary market, the view on greenium is more uniform. MacAskill et al. (2021) report an average greenium of -1 to -9 basis points. This view is further supported by other studies that report a greenium of around -2 basis points (Meyer & Henide, 2020; Zerbib, 2019) and (Bakshi &

Preclaw, 2015). In addition to this, some studies even find evidence of a greenium as big as -17 and -63 basis points (Bakshi & Preclaw, 2015; Nanayakkara & Colombage, 2019). On the other hand, all these studies are contradicted by a study by Hachenberg & Schiereck (2018), who found no evidence for a greenium in the secondary market, and by Kapraun & Scheins (2019), who finds evidence of a green bond discount as big as ten basis points.

One study by Nanayakkara & Colombage (2019) used the credit spread to estimate if green corporate bonds are traded at a premium in relation to their conventional counterparts in the secondary market. They used the option-adjusted spread since it is assumed to be a better approximation for corporate bonds credit spread. In the study, they used daily data from 125 different bonds issued 2016-2017. Further, they estimated a regression with bond type, currency, market risk, US 10-year treasury rate, GDP, CPI, firm-specific effects, and unobserved fixed effects as variables. The findings of their study were that green bonds were traded at a 63 basis point tighter spread. These results indicate that there is a substantial greenium in the secondary market. As an explanation to these findings, the authors discuss the premium from both the investor and the issuer perspective. According to them, a green bond premium is a good deal for both parties. The investor can invest in an asset associated with lower risk since ESG related concerns are lower for companies that engage in ESG activities. The benefit for issuers was said to be is the decreased cost of capital (Nanayakkara & Colombage, 2019).

Another study by Zerbib (2019) focused on the pro-environmental preferences of investors to see if they were willing to pay a premium for green bonds. The sample consisted of 110 green bonds trading in the secondary market from 2013-2017. The study was global and included both corporate and government-issued bonds. A matching method was used in the study based on some essential criteria. The two bonds had the same issuer, maturity, currency, rating, bond structure, seniority, collateral, and coupon type. In addition to this, they had a similar issue date and issue size. A limit on the maturity was also set to two years prior and two years after. Each green bond is matched with two conventional counterparts. The two conventional bonds are used to construct a synthetic bond with the same maturity as the green bond to eliminate the maturity bias. This process is done with linear interpolation or extrapolation. The greenium is later estimated as the simple difference between the yield from the green bond and the synthetic, conventional bond

yield. The author found evidence of a small but statistically significant average greenium of almost -2 basis points. Due to the small size, the economic effect of such a greenium is questionable. The article also includes a discussion of the different factors determining the size of the greenium. The conclusion is that the size of the greenium varies widely across different sectors and ratings. Another conclusion is that due to the small observed greenium, environmentally friendly investors are not said to influence the price of green bonds in any dramatic way in the secondary market (Zerbib, 2019).

Another study evaluated the greenium among bonds trading on the secondary market in autumn 2015. With an ordinary least square regression, they concluded a greenium of -17 basis points. They measured this with a tighter credit spread over the option-adjusted spread. An interesting thing with their study is that they had performed similar studies quarterly since the beginning of 2014. Due to this, they can show how the greenium changed during this time. The first study indicated a slightly positive difference, a green bond discount. Since then, the greenium increased steadily between each measure. They discussed that the demand for green investments might cause the increased greenium to have faster growth than the supply. Their view on the coming years was that the growth in greenium probably would not continue forever. When more issuers see the opportunity for cheaper funding, the supply will increase, which is assumed to create a new balance. At the same time, they report that several institutional investors only have a green bias as long as the risk-adjusted return is equivalent to conventional bonds (Bakshi & Preclaw, 2015). With this view, greenium is not sustainable in the long run. It should instead be seen as arbitrage and something that the market is going to correct.

A study contradicting the existence of greenium was conducted by (Hachenberg & Schiereck, 2018). Instead of using the option-adjusted spread as Nanayakkara & Colombage (2019), they use the i-spread, calculated with a risk-free swap rate. According to the authors, the benefit of this approach is that the i-spread separates the credit and the interest rate part of the yield allowing them only to study the credit part. The i-spread is found by subtracting the interpolated swap rate with the same maturity as the green bond. Their goal was to compare the yield for green-labeled bonds and non-green labeled bonds. To make sure the bonds were similar, they only included plain vanilla bonds and dropped all structured bonds from their initial sample. The sample consisted of

global bonds issued by supranational organizations, development banks, financials, corporates, and real-estate firms. Each green bond was matched with two similar conventional bonds where one had a shorter maturity and the other had a longer maturity. The matching was made with the following criteria. The three bonds had the same issuer, ranking, currency, type regarding fixed or floating, type regarding secured or unsecured. In addition to this, only bonds with an issue size above 150 million USD were included. Their final sample consisted of 63 green, and 126 conventional bonds were issued between 2015 and 2016. It also gave them around 21 000 daily observations. With linear interpolation, they aligned the i-spread of the two conventional bonds with the green bond. In the analysis, the authors divide the bonds into groups depending on the rating. This shows that only A-rated bonds trade at tighter yields of less than four basis points. AA and BBB also seem to trade at tighter yields, but it is so tiny that it is not statistically significant. Overall, they do not find evidence that green bonds trade at tighter yields. Since green bonds tend to be associated with higher issuing costs for certifications etc., these results indicate that it might be a bad solution to issue green bonds (Hachenberg & Schiereck, 2018).

The article by Kapraun & Scheins (2019) found higher yields for green bonds in the secondary market. Green corporate bonds in their sample were traded at an average green bond discount of 33 basis points. On the other hand, for government-issued green bonds, there was a greenium of -3 basis points leading to an average green bond discount of 10 basis points over the whole sample. Their results are important because their sample for the secondary market consists of 769 matched pairs with green bonds and conventional bonds with the same or similar characteristics in all relevant factors. The length of their sample also ranges from 2009 to 2018 (Kapraun & Scheins, 2019). They find results that contradict all the other studies we have reviewed so far. It is easy to conclude that this study is much larger than the others, both in the number of bonds and the timeframe studied. Due to this, their results are still reliable. Kapraun & Scheins (2019) concludes that the demand for green bonds might be lower on the secondary market or that the investors in the secondary market might have higher demands on the issuers. Another explanation might be that those bonds with high green credibility are not traded as much in the secondary market. It might be the case that those bonds are fully subscribed in the primary market, and those investors

hold on to their investments until maturity. Therefore, the study results are dominated by bonds with lower ESG ratings, for which the greenium is expected to be closer to zero.

2.3.3. Concluding remarks

Author	Market	Greenium?
Kapraun & Scheins 2019	Primary and secondary	Yes, -15 bps in the primary market. No, 10 bps discount in the secondary market
Ehlers & Packar 2017	Primary	Yes, -18 bps
Gianfrate & Peri 2019	Primary	Yes -18,5 bps
Larcker & Watts 2020	Primary	No, 0,45 bps discount
Deng et al. 2020	Primary	No
Nanayakkara & Colombage 2019	Secondary	Yes, -63 bps
Zerbib	Secondary	Yes, -2 bps
Bakshi & Preclaw 2015	Secondary	Yes, -17 bps
Hachenberg & Schiereck 2018	Secondary	No

Table 1 – Literature Review

The literature review on greenium presented above reaches the same conclusion as earlier reviews, such as MacAskill et al. (2021). Some studies conclude a greenium that is both economically and statistically significant, while others conclude its absence. Two articles find evidence of green bond discount, one in the primary market and one in the secondary market. However, the overall findings in the primary market are much more inconsistent than in the secondary market. The average greenium in the secondary market tends to lie within -1 and -9 bps limits, while in the primary market, it lies within -85 and +213 bps limits (MacAskill et al., 2021). These findings support the need for further research within the area with a focus on the primary market. Therefore, the following hypothesis has been developed:

Hypothesis 1:

H0: The green bond premium is insignificant in the primary green bond market

H1: The green bond premium is significant in the primary green bond market

H2: The green bond premium is significant in some market segments of the primary green bond market

2.4. Greenium determinants

The literature review about the green bond premium shows that researchers have not reached a consensus about the existence of greenium. Different sample selections, periods, methodologies, and the characteristics of issuing entities are among the potential reasons studies show conflicting results (Liaw, 2020). However, some of the researchers who were able to spot greenium took it one step further and tried to explain its essence by looking for factors that might affect its magnitude and direction. In the following section, we would like to provide an overview of these factors and compare and contrast the diverging views on their meaning and role.

MacAskill et al. (2021) have conducted a systematic literature review of 15 studies to provide a comprehensive overview of greenium's drivers discovered in these studies. Moreover, they have built a ranking of the green bond characteristics based on how frequently they are associated with the green bond premium. This was done by analyzing the strength of correlation between the found determinants and the green bond premium. The correlation analysis shows that bond governance characteristics such as Climate Bond Certification, Green Bond Principles, and Third-party assessment have the most decisive influence on the green bond premium. The authors suggest that it implies that investors are willing to pay for the reduction in information asymmetry provided by the proper green bond governance. Besides the governance structure, the bond credit rating was found to be predictive of greenium existence, although to a lesser extent.

Conversely, the issuer type and study time frame had a much lower correlation with the green bond premium, therefore, the weakest determinants. They conclude that most of the time, greenium has been found by other researchers in the secondary market, especially for investment-grade

government-issued bonds with a CBI certification label. All in all, the authors provide a structured overview of the potential green bond premium determinants. However, it is based on a very limited amount of scientific and industry studies due to the screening criteria used, limiting its usefulness in drawing reliable conclusions on the effect of the listed factors on green bond pricing. Furthermore, it is not possible to infer any cause-and-effect relationships between green determinants and green premium because correlation does not imply causation.

Moreover, there is also a statistical bias in the way the ranking was constructed. The ranking combines the results of various studies to draw conclusions about which characteristics have the greatest impact on greenium evidence. However, the underlying studies analyze some green bond premium determinants in isolation of the others, which are also included in the ranking. In reality, there may exist unknown significant interrelations between the green bond premium determinants analyzed in two different studies. This implies that if the underlying studies had analyzed all the determinants simultaneously, that might have altered the ranking results. Finally, the ranking considers a limited number of possible determinants and does not take into account such potential determinants as a market sector, currency, and geographical location. Therefore, the following section will focus on the studies that were not included in the ranking mentioned above to provide a contrasting view.

In their analysis of the green bond premium determinants, Sheng et al. (2021) have focused on the role of the type of ownership. They classified the issuer types into four categories: state-owned financial and corporate enterprises and non-state-owned financial and corporate enterprises. In contrast to MacAskill et al. (2021), the issuer type was a statistically significant determinant of greenium. Particularly, the greenium was higher for green bonds issued by SOEs than for those issued by non-SOEs. Moreover, both SOE and non-SOE financial institutions issued the green bonds had a higher greenium than corporate green bonds.

Additionally, SOEs were then split into central and local SOEs. The results suggest that central SOEs have more influence on greenium than local SOEs. Sheng et al. (2021) have also documented a positive impact of third-party verifications on greenium, especially in non-SOEs corporate bonds, which supports the conclusions reached by (MacAskill et al., 2021). This result implies a

larger positive influence of third-party verifications on reducing information asymmetry where the lack of legitimacy is the most pronounced. It is important to note that the study was limited to Chinese green bonds. Therefore, it is impossible to entirely extrapolate these results to other markets due to the Chinese government's peculiar role in developing the Chinese green bond market.

Wang et al. (2019) have also found greenium in the Chinese green bond market and analyzed its factors. The study comprehensively considers the main greenium determinants and splits the factors into three main categories, which are (1) macro-influence factors, (2) micro-influence factors, and (3) green attribute factors. Like MacAskill et al. (2021), the authors have found the third-party green assessment certification to be the main green attribute responsible for reducing financing costs for the issuer. Wang et al. (2019) also acknowledge the comparatively loose requirements of Chinese regulations for third-party certifications, which tend to be more encouraging than enforcing nature. Moreover, they highlight the inconsistency, irregularity, and inadequate comparability of evaluation procedures and standards that persist in the Chinese green assessment certification market.

Nevertheless, despite its questionable value, third-party certifications remain the most significant green bond attribute, affecting greenium in the Chinese green bond market. However, contrary to Sheng et al. (2021), the authors have found that third-party certifications have a higher potential in reducing financing costs for green bonds with a higher credit rating, unlike green bonds, which initially lack the necessary legitimacy. This study has likewise found that state-owned financial enterprises benefit from the reduced financial costs more than non-SOEs. Additionally, the authors explain it with higher environmental risk management and control, project management capabilities, better information disclosures, and implicit government guarantees inherent to Chinese SOEs. Finally, the study results have shown a positive influence of the issuance size and the time horizon on greenium. The explanation is that a higher issuance size provides greater liquidity, and a longer time to maturity signals issuers' confidence in their ability to satisfy their long-term commitments. (Wang et al., 2019)

Similar to Sheng et al. (2021) but in contrast to MacAskill et al. (2021), Kapraun & Scheins (2019) did show a significant difference in yield based on the type of issuer. In the secondary market, green bonds issued by governments were trading at a greenium of -3 basis points. On the other hand, green bonds issued by corporations were traded at a green bond discount of 33 basis points. Therefore, the issuer type is considered to be highly significant. The same study also concluded that the trading place is a relevant factor. When a green bond was trading at an exchange with an explicit green segment, the yield was on average 7 basis points lower. They conclude that this is due to the increased visibility and transparency on such markets. Based on the previous conclusions by MacAskill et al. (2021), Sheng et al. (2021), and Wang et al. (2019) about the effect of third-party certification, it seems intuitive that bonds traded at a specific green exchange should be less connected to greenwashing which in turn implies a more negative greenium.

Kapraun & Scheins (2019) also concluded that the country in which the bond is issued affects the yield. In their study, they look at the effect of environmental sentiment. They show that an increase in the Environmental Performance Index, EPI, with 1, tends to decrease the greenium by 6 basis points. This effect is also intuitive. It shows that when more people in a country start favoring green investments, the demand for such investments increases which further affects the greenium. What is interesting is the size of the effect. Since the EPI varies widely across different countries, the effect on the greenium is also large. As a last factor, the authors evaluate the issuer's sustainability reputation. They divided the bonds into three groups depending on their Sustainalytics ESG score, with the top 30% as high, middle 40% as middle, and bottom 30% as low. The 30% highest-ranked bonds faced, on average, 15 basis points lower yield than those in the middle group. Their suggested reason for this is that many investors apply a top-down approach for their investments. With this approach, the investor's first step is to filter out low performers only to consider top performers. When this happens, the demand for those bonds will be higher than those outside the scope (Kapraun & Scheins, 2019).

Multiple research has shown that investors value the greenness of bonds and are ready to accept a lower yield., i.e., pay a significant greenium, especially if a third party sufficiently backs up this greenness. Immel et al. (2020) have decided to take it one step further and see if investors also differentiate between shades of green by examining the effect of companies' ESG ratings on the

greenium of their bonds. Their first hypothesis was that a green bond with an ESG rating should experience a higher greenium than a green bond without the rating. In other words, the issuer should expect to seize the same benefits from having an ESG rating, such as the reduced financing costs, which any other third-party label would provide. However, the essential difference of any rating is that it is quantifiable. Therefore, it allows determining if issuers' position in the ESG ratings, which is a direct result of their "greenness," significantly affects the size of greenium. Given investor's preferences for green products and willingness to pay for green legitimacy, one would expect a positive relationship between the issuer's ESG rating and the greenium investors are willing to pay. Finally, since the "greenness" of green bonds is their only difference from their brown peers, one would also expect the "E" dimension of the ESG rating to have the strongest influence on greenium. As expected, the authors have found a positive relationship between the mere existence of an ESG rating and greenium, which implies that it serves a similar function as any other green label in reducing information asymmetry and providing the necessary assurance.

Moreover, the greenness of a green bond measured by the issuer's ESG rating indeed was found to have a positive magnitude effect on greenium. However, contrary to prior intuition, the issuers' E-score was insignificant in determining the size of greenium. The authors concluded that the "G"-score, represented by the issuer's governance structure, is the only driver behind greenium when the rating is decomposed. That means that the trustworthiness defined by the issuer's "G"-score is more valuable for investors than the environmental friendliness of the issuer defined by the issuer's "E"-score. In other words, investors emphasize the assurance that the proceeds will be allocated as promised, rather than the environmental performance of the issuer, and presumably the environmental benefits of the green bond itself.

The results of the previous study provide some important implications for further research. If investors are willing to pay a premium for acquiring green assets, why aren't they taking the issuer's greenness into account? If the initial driver for paying extra for green products is the sentiment towards the environment, the environmental performance of the issuer should presumably be the primary concern of investors.

This literature review has found some contradicting evidence regarding greenium. Some studies find strong evidence in favor of greenium, where others do not. Some studies even find evidence in favor of green bond discount. By intuition, such a discount is hard to explain with the given ESG sentiment in mind. Suppose pro-environmental investors are driven by non-pecuniary motives and prefer ESG-related assets, such as green bonds. In that case, it is counter-intuitive why these products can be traded at a discount. Therefore, it is both exciting and necessary to further evaluate the determinants behind greenium. Our literature review on the greenium determinants concludes that the most relevant determinant is the third-party green certification. This is well in line with the section discussing information asymmetry and the problems associated with it. Despite this, there are still some discrepancies regarding the greenium determinants. While one article concludes that the issuer type is not a significant factor, two other articles conclude it is. Other interesting conclusions were that the "G" factor significantly affects the greenium size while the effect from "E" is insignificant.

As shown in this literature review, there is no consensus on which factors determine the size of a potential greenium. Factors that are considered relevant by one study might be insignificant and irrelevant in other studies. This study aims to contribute to the field and analyze factors that are considered potential determinants by the literature review and the theories. The evaluated factors are grouped into bond-specific and issuer-specific categories. The intention with this grouping is to understand better if it is the issuer or the bond characteristics, or both of them, that are relevant to the size of greenium. Therefore, the following hypotheses have been developed:

Hypothesis 2:

H0: Bond-specific characteristics cannot explain the green bond premium

H1: Bond-specific characteristics can explain the green bond premium

Hypothesis 3:

H0: Issuer-specific characteristics cannot explain the green bond premium

H1: Issuer-specific characteristics can explain the green bond premium

3. Theoretical framework

This section will describe the theoretical framework which in this study is used to understand greenium better. The theories used are a mix of traditional financial theories such as the Bond pricing theory, Arbitrage, Anomalies, and non-financial theories such as Information asymmetry, Signaling, Halo-effect, and Additionality. Within each section, the basics of the theory and the implications and relevance to this thesis will be described.

3.1. Financial theories

3.1.1. Bond pricing theory

According to traditional economic theory, the price of an asset shall reflect the present value of the future cash flow (Hull, 2015). Different types of bonds, such as zero-coupon bonds and bullet bonds, are, in theory, also priced this way. In practice, the formulas for calculating the prices differ due to the bond's different characteristics. For a zero-coupon bond, there is only one payment that comes at maturity. The formula to get the price is, therefore, relatively simple, according to Munk (2015):

$$Z_{0,n} = F_0(1+r)^{-n} \qquad \textit{Equation 2}$$

Where $Z_{0,n}$ is the price, F_0 is the face value, r is the periodical interest rate, and n is the number of periods to maturity. When r is greater than 0, the bond is trading at a discount compared to the face value, which for a zero-coupon bond means that the bondholder is receiving a larger amount in the future than he invests today. The formula above is the same as usually used when discounting a future value back to today. Bullets bonds are slightly more complex. They usually pay interest once or twice a year and pay the total face value at once when the bond matures. Most corporate bonds and government bonds are bullet bonds. The following formula generates the price of a bullet bond according to Munk (2015):

$$B_0 = F_0\left(\frac{q}{r} + \left(1 - \frac{q}{r}\right)(1+r)^{-n}\right)$$ *Equation 3*

In this formula, the price is represented by B_0, while F_0, r and n still represent the same as in the previous formula. In addition to this, q represents the coupon rate. Due to construction, if q = r, the formula becomes the same as for a zero-coupon bond (Munk, 2015). Both of the two formulas above imply that only financial aspects should affect the theoretical price. No component in the formula considers how the future cash flow is generated or how the proceeds are used.

Another relevant term for bonds is yield-to-maturity or simply the yield. The yield is the discount rate at which the discounted value of all future cash flows, both interest and face value, equals the price today (Hull, 2015). For an investor who holds the bond until maturity, the yield is the same thing as for other investments referred to as the internal rate of return, IRR (Berk & DeMarzo, 2017). For a zero-coupon bond, the yield is found by the following formula:

$$YTM_i = \left(\frac{F_0}{Z_{0,n}}\right)^{1/n}$$ *Equation 4*

In the formula, F_0 is the face value, $Z_{0,n}$ represents the current price, and n is the number of periods until maturity. For coupon bonds, on the other hand, where the yield incorporates different types of cash flow occurring at different times, the calculation is more complicated. There is no simple formula to calculate the yield. The easiest way to find it is instead with a trial-and-error approach using the following formula inspired by Berk & DeMarzo, (2017):

$$B_0 = CPN * \frac{1}{y}\left(1 - \frac{1}{(1+y)^n}\right) + \frac{F_0}{(1+y)^n}$$ *Equation 5*

In the formula, B_0 is the price at time 0, CPN is the coupon, y is the yield to maturity that will be found, n is the number of periods to maturity, and lastly, F_0 represents the face value (Berk &

DeMarzo, 2017). As long as the yield, coupon, and the numbers of periods are quoted with the same frequency and the coupons are paid regularly, the formula is applicable for all different frequencies such as annual, semi-annual, or monthly coupons. According to the formula presented above, neither the yield should be affected by the non-financial characteristics of bonds. If they are green or not is not something that should be reflected in the yield to maturity. As shown this far, this is a fact for all traditional theories presented in this theoretical framework.

3.1.2. Bond risk factors

The pricing theory above does only hold for risk-free bonds. Today, it is almost only bonds issued by the US government that is fully considered risk-free. All other bonds, issued either by corporations or by any other nation, are considered risky assets. In order to value this kind of bond, their riskiness is included in the formula. The two primary things to include are the probability of default and the loss given default. With these two values, it is possible to calculate the expected values to include in the previously discussed formulas. Based on the loss given default, it is possible to calculate how much of the promised payments in the form of principal and coupons will be repaid in case of default. The probability of default gives the likelihood of ending up in this stage (Berk & DeMarzo, 2017). According to traditional theories, the three external factors most relevant to bond yields are the interest rates, the probability of default, and the loss given default (Liu et al., 2009; Merton, 1974).

For example, assume a zero-coupon bond has a principal of 1000 USD, the risk-free rate is 2%, the investors demand a risk premium of 1%, and there is 1 year to maturity. The cost of debt capital is then 3% for the issuer. For a risk-free bond, the yield would equal the debt cost of capital. For this discussion, the loss given default and the probability of default must also be included. In this example, the loss given default is set to be 100 USD with a probability of default of 25%. Therefore, the potential outcomes are 1000 with 75% probability and 900 USD with a probability of 25%. The expected value if therefore:

$$0{,}75 * 1000 + 0{,}25 * 900 = 975$$

With Equation 2 from above, the price of the bond is:

$$Z_{0,n} = 975(1 + 3\%)^{-1} = 946{,}6$$

The corresponding yield calculated with Equation 4 is:

$$YTM_i = \left(\frac{1000}{946{,}6}\right)^{1/1} = 5{,}64\%$$

The promised yield to maturity does therefore deviate from the expected return to the investor. With this method, the issuer's credit risk is included in the price and yield of the bond. The probability of default can be found from rating agencies such as Standard and Poor or Moody's to simplify for investors. The highest-ranked categories are often referred to as investment-grade bonds, while the lower-rated are called high-yield bonds or even junk bonds (Berk & DeMarzo, 2017). Based on the seniority and collateral, the same rating agencies also provide statistics on the recovery rate and loss given default (Hull, 2015). With these risk factors included, the calculated yield will better reflect the reality for most risky bonds.

3.1.3. Bond yield curve

The yield curve shows the relationship between bond yield and the time to maturity. The curve is often concave and upward sloping, which implies that bonds with longer maturities generally have higher yields. For shorter maturities, the curve is relatively steep compared to longer maturities (Munk, 2015). This pattern can be observed in the graph below with yield curves for US treasury zero-coupon bonds. With only two exceptions, the yield curves have followed this pattern.

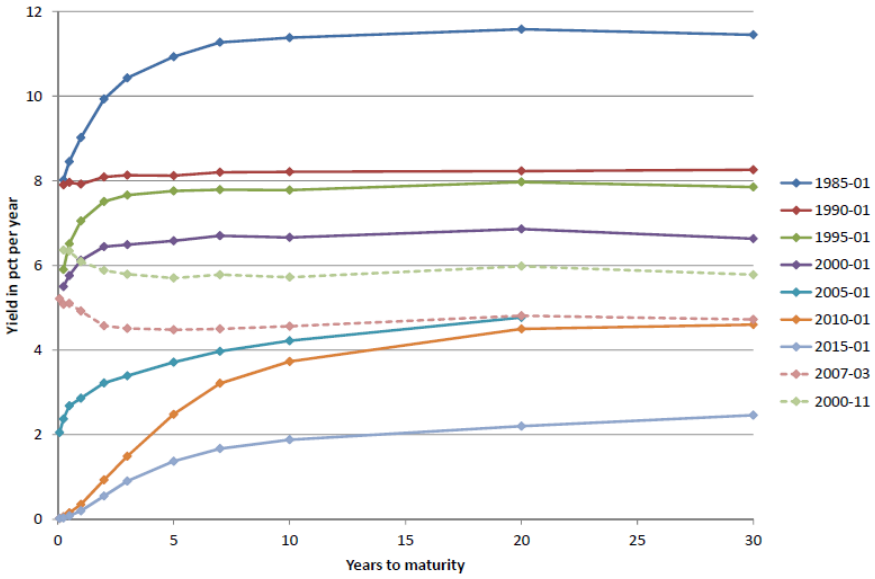

Figure 3 – Bond Yield Curves (Munk, 2015)

The expectation theory gives a common and straightforward explanation to the curve. According to it, the long-term interest rates are given by the expectations of the future short-term rate. The long-term yield curve for a given future period is expected to reflect that period's short-term interest rate (Hull, 2015). The difference between the yield curve for risk-free bonds and corporate bonds is the credit spread (Berk & DeMarzo, 2017).

3.1.4. Arbitrage

According to a logic referred to as the law of one price, the price of an asset shall be the same even if it is trading in two or more different exchanges. In practice, assets in different locations might sometimes trade at slightly different prices (Durbin, 2010). For example, gold can have one price in Europe and another in America. Another example is dual-listed stocks that can be trading in several different markets at as many different prices. When one price is higher than another, a fast investor can make a risk-free profit higher than the risk-free rate. The investor does buy the asset at a low price and simultaneously sells at a higher price. Since the asset is the same, the profit is risk-free. Such a possibility is referred to as an arbitrage opportunity (Berk & DeMarzo, 2017). When investors identify arbitrage opportunities and start to act on them, the prices will adjust. The

increased demand for the low-priced assets will make the price increase, and the increased supply of the asset priced high will pressure the price. Eventually, the prices will adjust into a new equilibrium without any arbitrage opportunity (Hull, 2015).

To price an asset without arbitrage, the price must equal the present value of all future cash flow. If the price deviates from this, there is usually an arbitrage opportunity (Durbin, 2010). If the price of a zero-coupon bond is less than the present value of the principal, an investor can borrow the present value of the principal at the bank until the bond matures and buy the bond. This will make him earn the difference immediately while the sum of the two cash-flows will equal zero at maturity. If the price, on the other hand, is higher than the present value of the principal, he should, in theory, sell the bond and lend the present value of the principal to the bank for the same period (Berk & DeMarzo, 2017). A similar procedure can also be done with various combinations of options, borrowing, and lending at the risk-free rate and the underlying asset (Hull, 2015). There are some limits to where arbitrage opportunities can arise. The first limit is due to fundamental risk. If the assets are not exactly the same or risk-free assets, no pure arbitrage can exist (Ghadhab & Hellara, 2015). On the other hand, assets with the same risk classification and the same future cash flow should still be priced equally. Schultz & Shive (2010) have shown that no-arbitrage arguments tend to hold also for assets that are not the same in all ways.

According to the theory presented above, green and conventional bonds with the same fundamental characteristics must have the same price. If this is not true, it is an arbitrage opportunity that fast investors should trade on. Assuming that the price is higher and the yield is lower on green bonds, investors should, in theory, sell the green bonds and buy the conventional counterparts. Due to the decreased demand for green bonds, the yields should become equal, and the greenium should disappear. We found and presented more studies implying that there was a greenium than the opposite. An implication which arbitrage opportunities in the bond market are that under normal circumstances is not possible for investors to take the short position in green bonds directly (Callum, 2020; Smith, n.d.). A pure arbitrage is therefore not possible.

On the other hand, with the logic from no-arbitrage and Ross (1977), investors should not enter the long position. This would make the demand and price for such investments fall and the yield

increase. If the demand for fixed income assets is kept the same, the demand on conventional bonds should, in contrast, increase their price, moving the bond market into equilibrium. The yield on green and conventional bonds should then be the same, and no greenium driven by non-financial factors would exist.

3.1.5. Anomalies

In some cases, arbitrage opportunities last for a long time. Such investor irrationality is referred to as anomalies. They can arise when there are some limits to arbitrage, making them hard for investors to reach and fix (Zaremba & Szczygielski, 2019). A well-known anomaly from the equities market is the momentum effect. It says that a stock that has performed high returns previously is more likely to generate high returns also in the near future compared to those with low past returns (Chu et al., 2020; Fama & French, 2008). Jostova et al. (2013) has further concluded that this anomaly also is present in the secondary market for corporate bonds. Since the phenomenon is inconsistent with theory and has lasted for a long time, it is considered an anomaly. Another study by Crawford et al. (2019) has found evidence of 17 other anomalies in the bond market. The anomalies are related to value, accruals, profitability, investments, financing, and financial reporting quality, indicating that anomalies are not a limited phenomenon. Instead, it seems to be related to a wide range of aspects.

A study by Guerard & Markowitz (2018) has tried to understand how anomalies can exist in the long run. They concluded that many of the anomalies identified already in the 1970s and 1980s were still statistically significant as late as 2017. This strengthens the assumption that even though some arbitrage opportunities are identified, they cannot easily be traded on. Other times, financial anomalies last for a while before they end drastically. This kind of situation is often referred to as financial bubbles (Lee & Phillips, 2016). A bubble can be defined as when the asset price deviates far from what can be considered the fundamental value. The price continues to rise because many investors speculate that other investors will pay even more for the assets soon (Campbell et al., 1997). Two well-known bubbles that burst near in time are the dot-com bubble described by

Anderson et al. (2010) and the housing bubble before the last financial crisis covered in Acharya et al. (2009).

As we saw in the literature review, the studies analyzing greenium have done so over several years. Since it is neither something that would exist according to the traditional financial theories, it can be considered an anomaly. A study by Crawford et al. (2019) argues that anomalies tend to exist due to limits in the possibility to trade on arbitrage opportunities. Although it is possible to short bonds, the costs are usually higher, which has made it less common than shorting stocks. Since this is the case, arbitrage opportunities arising in the bond market might be hard to trade on. As a consequence, they might be anomalies instead (Crawford et al., 2019).

Recently, voices have been raised arguing that ESG and the green sentiment have come to look like a bubble. According to Dillan (2020), valuations on ESG related assets are a self-fulfilling prophecy. People invest in the assets since the price rises and the price rises since people invest in them. The increased demand for such assets is increasing at such a high speed that supply cannot follow. When the market stabilizes, the yield difference might go away (Dillan, 2020). There is still no research concluding whether ESG and greenium is a long-lasting anomaly or a bubble that suddenly will explode. If it is a bubble, we will probably not know it until it bursts. In such a case, the vanished ESG sentiment would make the greenium disappear. There would then be no difference in yields between green and conventional bonds. If this happens, it might have consequences on the number of new green projects expected to stagnate due to the increased cost of capital.

3.2. Non-financial theories

3.2.1. Information asymmetry

In its early development stage, the green bond market can be characterized as having a relatively high degree of information asymmetry. This provides particular challenges for the evolution of the green bond market and, consequently, calls for action. The “lemon problem” described by Akerlof (1970) explains the concept of information asymmetry as different levels of knowledge about the

actual value of a product that buying and selling parties possess. Akerlof's (1970) original example is about the purchase of a used car. A critical aspect of the lemon problem is that information asymmetry arises when buyers do not easily comprehend the used car's actual value. In this case, buyers would only be willing to pay an average price to minimize the chances of overpaying for a lemon. At first glance, it looks like a fair deal, and on average, buyers should receive what they are paying for. However, Akerlof, (1970) explained that the information asymmetry serves some sellers who can sell lemons for the average price and punishes the sellers of good cars. That, in turn, drives sellers of good cars out of the market, increasing the proportion of sellers who sell lemons. This is a classic illustrative example of how information asymmetry can affect pricing and the average product quality on the market. In the green bond market, brown bonds would be lemons and green bonds would be good cars where the value difference between the two would lie in the level of their greenness. Therefore, it can be a useful exercise to frame information asymmetry in the green bond market as a "lemon problem" to discuss green bond pricing and the quality of greenness.

Akerlof (1970) has proposed guarantees as a solution to overcome information asymmetries. Guarantees are meant to protect buyers from buying a lemon. In the green bond market, green certifications serve as a guarantee from a third party that a given green bond is not a lemon. Therefore, green certifications play such an essential role in eliminating asymmetrical information in the green bond market and enhancing issuers' trustworthiness.

3.2.2. Signaling

Another concept that has evolved in the information asymmetry theory alongside the lemon problem is "Signaling." Spence (1973) explains that parties can use signaling to decrease the information gap by transferring relevant information. In the original job-market example, an employee is signaling about their level of employability by providing the employer with information about their education in the attempt to sell their services for a higher wage. The employer would receive, interpret, and act on the signal by adjusting their "purchasing behavior," i.e., offering a higher wage, if they believe in the correlation between education and employability.

Signaling theory can serve as a helpful tool to understand the information flow in the green bond market. Issuers are essentially sending signals about the greenness of bonds' underlying projects in the attempt to affect the purchasing behavior of investors who value green products and increase the value of the green bond accordingly. Therefore, both parties benefit from the signal as long as it reveals a valuable factor.

Interestingly, one of Spence's conclusions was that even in the absence of a direct effect of education on employability, the signal may still be valuable for both parties under certain circumstances. These circumstances include the presence of an appropriate cost/benefit structure. Good employees are investing in their education to signal to the employer that they deserve higher wages. In Spence's model, the assumption that good employees can obtain an education at a lower cost, not necessarily monetary, makes the signal valuable. Such a cost/benefit structure should prevent bad employees from reaching the same level of education at the same cost, making the signal costly for them. In the green bond market, that would have an important implication. The "green" signal can carry value if "green" issuers can issue green bonds at a lower cost than their less sustainable peers. In other words, for the signal to be valuable for both investors and issuers, there should be a cost/benefit structure that would prevent less sustainable issuers from obtaining "green" credentials at the same cost that more sustainable issuers are incurring. Another interpretation of this example extrapolated to the green bond market is that for the "green" signal to carry real value, it should be more difficult for brown bonds to appear green.

Researchers have also raised questions about the cost of the signal to the sending party. In other words, how much resources should the sender spend on sending the signal? Connelly et al. (2011) argue that signal cost is one of the essential characteristics of an efficacious signal. There exists a separate line of research discussing the "theory of costly signaling". The authors explain that there should be an appropriate cost structure that would prevent some senders from sending out false signals.

Their original example of ISO9000 certification can be directly extrapolated to the green bond market. As we know from the literature review, there is a cost of obtaining green certification, which is why some issuers are hesitant to obtain it. This cost makes it difficult, if not impossible,

for issuers in some countries to fake the "green" signal by engaging in greenwashing. At the same time, more sustainable issuers can obtain green certifications easier than less sustainable ones because they are in better shape to absorb the costs associated with it. This cost should not only be interpreted as the actual fees but also as costs of implementing the necessary changes to satisfy the requirements of the regulating party.

For example, as discussed earlier, the Chinese green certification market does not hold the desired characteristics to provide a reliable context under which the signal would function efficiently. According to the theory, under such circumstances, a signaler which does not possess the required quality associated with the "green" signal and who also believes that the benefits of signaling are higher than the costs of producing it will be motivated to engage in false signaling, e.g., greenwashing. Moreover, such deceptive "green" signals will prosper until receivers learn to disregard them. Therefore, the cost structure of the green certification market in China should be structured in such a way that misleading signals would no longer pay off.

Another important question raised by the research in this area is, "How can the receiving party trust the signal?" This question is partially addressed by the concept of penalty costs in signaling theory. Feedback is the final stage of the signaling process, and it occurs when the receiving party sends a countersignal back to the signaler about the effectiveness of the initial signal (Connelly et al., 2011). Penalty costs represent negative feedback that the receiver sends back to the sender. Penalty costs play an essential role in determining the signal cost structure. Moreover, some penalty types have different levels of effectiveness. Therefore, they might affect the signaling process differently (ibid.). For instance, in the green bond market, a public backlash that leads to real financial consequences for the company represents a penalty cost for sending a fake signal. Furthermore, this penalty cost might affect the sender's future actions to a larger extent than, for example, a temporary loss of trust.

3.2.3. Halo-effect

The first empirical evidence of the halo effect was provided by Thorndike (1920). He concluded that the halo effect is a cognitive bias that leads to an inability of people to analyze different traits, e.g., of the other person, and rate each trait independently of the other traits. In the original example, Thorndike (1920, p. 25) names it a *"constant error towards suffusing ratings of special features with a halo belonging to the individual as a whole."* In other words, people's evaluation of individual features is affected by the tendency to think of an object in general as rather superior or inferior and to alter the judgments of individual features based on the general perception of an object. The phenomenon also takes place when the impression of an object in one area influences the observer's opinion about the object in other areas.

Later on, the halo effect was extrapolated to the organizational theory to explain how people perceive organizations. Particularly, researchers have analyzed the halo effect in companies' CSR activities and sustainability performance to understand how it affects the public perception of these companies. The halo effect suggests that a firm can attain social recognition of being green simply because the audience tends to associate factors poorly related to the actual environmental performance with the overall company's sustainability performance (S. Park et al., 2020). In the absence of objective information and inherent cognitive limits, and high search costs, decision-makers are prone to using uncertainty-reducing decision heuristics by relying on the second-best information, which may not indicate companies' actual sustainability performance (ibid.).

Recently, researchers and industry practitioners have been trying to explain the rising popularity of the green bond market with the halo effect. For instance, Krebbers (2019) has argued that there might be a green halo effect. His interpretation is that a mere green bond issuance leads to increased attention from a broader range of sustainability-focused investors towards the company's debt as a whole. Therefore, the increased attractiveness helps companies enrich their investor base and puts downward pressure on their entire yield curve. In other words, when a company issues a green bond, it affects investors' perception of companies' non-green bonds in a positive way leading to an increased demand for the latter driven by sustainability considerations. Krebbers (2019) has further suggested that the green halo effect goes beyond companies' debt and can also explain the

positive effect of green bond issuance on companies' share price and other externalities. Contrary to Krebbers (2019), Hale (2018) has shown skepticism about the green halo effect. He argued against the green halo effect and questioned the validity of the methodology later used by Krebbers (2019) to arrive at the positive spillover effect of green bond issuance and conclude the existence of the green halo effect.

Like Hale (2018), other researchers have raised concerns about the potential of the green halo effect to have a real influence on market valuations of debt and equity. Park et al. (2020) have argued that the halo effect can only influence uninformed audiences and should have a limited effect on investors' perception of the company as a whole. The reason for it is that a critical condition of the halo effect is the limited access to objective information. Therefore, the impact of the halo effect is limited by the audience's capabilities to access and retrieve information necessary to make rational judgments. Field experts, such as corporate social responsibility professionals, academics, environmental experts, and industry analysts, are expected to have the capacity to access the data required to overcome this heuristic (ibid.). Therefore, as long as this condition holds, field experts should not be prone to the halo effect to a visible extent. For the green bond market, it means that the green bond issuance should only lead to spillover effects if it implies a real increase in economic value that investors are aware of.

3.2.4. Additionality

Since the green bond market started to expand, additionality has always been a topic of concern, usually discussed alongside greenwashing. Additionality can be defined as “enabling capital to flow to green assets and projects that would not otherwise get financed” (Kidney, 2018). Researchers and industry practitioners are constantly questioning the additionality dimension of the green bond market. There is an ongoing debate if the raised funds represent any “new” money used for green projects that would not have taken place otherwise (Grene, 2015). It is a valid argument that for most of the green bonds, the environmental impact can be measured. However, it is highly uncertain if the growing amount of green bonds increases the proportionate growth in

green projects on a macroscale (Gyura, 2020). Therefore, the concept of additionality represents a relevant lens through which the green bond market can be analyzed.

The debate about additionality is natural given that green bonds are mostly structured as regular investment-grade government or corporate bonds. One of the main distinctions is the "use of proceeds" attribute of green bonds, which does not imply that without a green label, capital would have been allocated differently (Maltais & Nykvist, 2020). Green bonds are blamed for giving the impression that they deliver a greater impact than they are due to the way they are advertised. For example, Swedish issuers tend to market green bonds by emphasizing the underlying projects and their environmental impact in generating renewable energy, avoiding emissions, or managing waste. Such things may create an impression that green bonds are redirecting capital to some groundbreaking investments. In contrast, in practice, similar projects had been funded before with non-green financial instruments. Moreover, at the same time, Swedish issuers themselves do not believe that green bonds can play a significant role in shifting capital from unsustainable to more sustainable investments. This perspective on green bond's additionality implies that they are anything, but an innovative financial tool and that green bonds do not seem to provide any new source of capital for green investments or make them more financially attractive than they would have been otherwise (ibid.).

The second reason why green bonds are criticized for the lack of additionality is that the green bond market is mainly dominated by government and corporate issuers, which usually do not experience any difficulties raising funds regardless of the label. Therefore, it can be argued that green bonds are simply repackaging traditional non-green financial instruments (Jones et al., 2020). In other words, the green industry had existed long before the first green bond was issued. Projects like the ones funded with green bonds had been or could have been funded before by the same issuers with conventional bonds, even before the emergence of the green bonds market.

Another reason why green bond's additionality remains a concern is that most of the green bonds are refinancing projects which are already complete. Furthermore, the freed-up capital from existing assets remains at the green bond issuer's discretion. This means that the green label on bonds intended to refinance existing green projects does not oblige the issuers to reinvest their

original capital into new green assets. The capital can easily be redirected to brown assets if the issuers find it more attractive (Kidney, 2018). Furthermore, some investors even classify refinancing as greenwashing (Veltmeijer, 2019).

In addition to the concerns raised by investors about the added value of green bonds, some studies show that issuers themselves have doubts about the additionality of green bonds. Gyura (2020) has conducted a worldwide survey of green bond issuers to determine if the raised funds played a significant role in realizing the issuers' green agenda. Most respondents admitted that the green bonds were primarily issued for reputational reasons and that the green projects would have been undertaken regardless of whether they had been awarded the green label or not. Therefore, the result of this survey is raising serious doubts about whether green bonds contribute to a larger capital flow to environmental projects.

All in all, various studies concluded that there has only been marginal proof of the additionality of green bonds (Schneeweiss, 2019). However, researchers have pointed out how additionality can be ensured. It includes state regulations that would require proof of additionality from issuers in the form of a change in their general investment strategies (ibid.). Moreover, unique tax treatments and the cultivation of an investment culture that would encourage paying greenium are required to ensure additionality (Jones et al., 2020; Kidney, 2018).

The other side of this ongoing debate around additionality seems to acknowledge the validity of the concerns mentioned above. However, some green finance practitioners argue that the additionality concept should not be used to judge the development and legitimacy of the green bond market (Cripps, 2018a). Many of the green bonds are indeed used for refinancing existing loans, and their primary financial purpose is to obtain better loan terms. However, due to its narrowness, the additionality lens is simply not applicable to the green bond market (Kidney, 2018). Green bonds provide other externalities in cultural change and new industry standards and practices (Cripps, 2018b). Therefore, green bonds should not be assessed based on their ability to bring about an immediate, direct, short-term change but should be seen as a tool for creating a larger long-term systematic change that is difficult to measure (Kidney, 2018).

One of the main arguments about the lack of additionality was that many green bonds do not directly link to specific projects or impacts, making it almost impossible to track and measure additionality. In other words, when green bonds are issued under a common framework, it is difficult to check if projects they end up funding would not have taken place outside of the framework. However, green industry practitioners argue that the unsecured format of the green bond market provides companies with the necessary degree of flexibility in allocating funds. Moreover, it allows investors to rely on company-wide credit characteristics instead of solely considering individual project risks (Michaelsen, 2018).

Conventional bonds can indeed fund the same and even a larger spectrum of projects. Moreover, it is also true that many issuers could have raised funds for the same projects outside of the green bond market. However, the difference between issuing a conventional and green bond also lies in issuers' commitments which usually accompany the issuance. For instance, when issuing a green bond, national and local governments tend to introduce various policies to control and stimulate the capital flow towards green investments (Kidney, 2018). In addition to that, the green bond issuance is accompanied by establishing relevant guidelines that are crucial for setting market standards and expectations from the green industry. Moreover, the rapid growth of the green bond market has brought the conversation on green finance to an entirely new level. Over the last few years, more than 50 countries have launched Green Finance Study and Working Groups responsible for greening the financial system (ibid.). Therefore, it shows that rather than solely focusing on the additionality dimension, the comparison of conventional and green bonds should instead be conducted on multiple dimensions, which include broader implications of the latter.

Concerning refinancing, it should be noted that green bonds are not meant to expose investors to project risks. The refinancing nature of green bonds offer investors low-risk and long-term interest payments from green projects that have already been completed and de-risked. This, in turn, indirectly contributes to new green projects because refinancing allows the party which initially bore all project-related development and construction risks to free up capital from completed projects and redirect it towards new projects. Therefore, refinancing existing projects is essentially speeding up and facilitating new green undertakings as well (Kidney, 2018).

There is still a risk that these new undertakings will not be green because the issuers are free to decide what to do with the original capital. Nevertheless, investors should be confident in green bond issuer's goodwill, as nowadays, green bond issuance is a form of official public commitment towards green investments. Therefore, issuers' good intentions on the whole subject of refinancing are backed up by their public reputation (Kidney, 2018). Instead of solely relying on the issuers' goodwill, another solution to ensure that the freed-up capital is allocated to new green projects could include special covenants for green bonds. These could require issuers to reallocate capital to green investments and to report on the reallocated capital in the same way they report on the use of proceeds. This would end any debate around the additionality of refinancing (Cripps, 2018b).

4. Research Method

4.1. Methodology

4.1.1. Research design

According to Bryman & Bell (2011), two different approaches can be used when conducting a research study. These are the inductive and deductive approaches. Within the inductive approach, the research starts in the field. The first step of the study is that the researcher collects data and identifies relevant patterns in it. These patterns are in the next step used to form generalized theories. When this method is used, the researcher is usually freer and less tied to previous expectations. This procedure is sometimes also referred to as bottom-up since it starts in the field or bottom without a theory (Bryman, 2008; Lundahl & Skärvad, 1999). On the other hand, within the deductive approach, the starting point is the current knowledge and theory. Based on the theory, one or more hypotheses are developed. First, in this stage, when the researcher is clear of how the current knowledge is, the data collection starts. The next step is to analyze the data and extract relevant findings. When this step is done, the researcher returns to the hypothesis or hypotheses to either reject or accept them. Based on the previous decision, the conclusions are used to revise the existing theory. Therefore, it is often referred to as top-down (Bryman & Bell, 2011; Lundahl & Skärvad, 1999).

As already shown with the hypotheses stated in the literature review, the deductive approach is used in this study. The reasons for this are twofold. At first, it is a more appropriate method for studies with quantitative data (Bryman, 2008). Secondly, this thesis aims to test if the traditional theories taught in finance courses are still accurate and applicable to the green bond market. This would not have been possible with an inductive approach since theory, in this case, is an outcome of the data. Previous research has already suggested a few potential outcomes for the studied phenomenon. Therefore, a deductive approach with hypotheses testing is the most appropriate.

4.1.2. Epistemological considerations

In general, epistemology is about which methods can be used to generate new science. The dominant concerns within the field are if social science should be studied in the same way as natural science or if other approaches are required. Two opposite views dominate the field of epistemology, namely positivism and interpretivism. Within positivism, tools and natural science tools are considered the only way to generate new science-based theory. The approach implies that science must be objective and not affected by the valuations from the researcher. A study influenced by valuations cannot be used for scientific purposes. Another important criterion is that it separates the theory and the data. The data is used to test the theories and contribute to their development (Bryman & Bell, 2011). In contrast, interpretivism is, as the name suggests, based on interpretations. It relies on the assumption that the study object within social and natural science differs to the extent that they must be studied with different methods. The tools from natural science are not considered helpful to capture the true meaning of social life. When humans are studied, a positivistic approach cannot capture the interaction and communication between the participants (Bryman, 2008).

Von Wright made a classic separation between positivism and interpretivism. According to him, the underlying purpose of the study shall determine which approach to use. If the purpose is to *explain* a phenomenon, a positivistic approach shall be used. On the other hand, if the purpose is to contribute to a deeper *understanding* of something, an interpretive approach is more beneficial (von Wright, 1971). This study aims to estimate any potential greenium and explain the factors behind it, rather than generate an understanding of why these factors are relevant. A positivistic approach was therefore selected. The chosen approach is expected to answer better the research question whose purpose is to explain a phenomenon. The positivistic view is also more compatible with the method described in further sections.

4.1.3. Ontological considerations

Ontological considerations refer to the philosophical construction of contexts. The basic concept refers to what existence is and how things are created. What does the world consist of, and how

are these parts connected? The dominant discussion within the field is about how social entities can be objective and free of influence from the participants. Within the logic referred to as objectivism, social contexts are independent of the individual participants. Everything that happens in a social context is determined by an external logic beyond the reach of the actors inside. They are just performing according to this predetermined logic (Bryman & Bell, 2011). Bryman (2008) exemplifies ontology with an organization. According to the objective perspective, it is the rules and the hierarchy that determine the actions. New participants learn the rules and culture and act according to them (Bryman, 2008). The contrasting view is referred to as constructionism. Everything that happens in a social context does so due to the actions of the individuals. The participants create the context together by interacting with each other. No actions were predetermined, and everything is revised and changed due to the occurred interactions (Bryman & Bell, 2011). Regarding the example with an organization, the performed actions are more based on negotiations between the participants than direct orders. The relation between culture and actors also goes both ways, and new actors will change the culture instead of just adapting to it (Bryman, 2008).

The central aspect of this thesis is greenium and the determinants as phenomena. No focus will be directed towards the individual market participants and their individual motives. Although market participants as a collective create the market and environment, they as individuals are out of scope for this study. The dominant logic is therefore objectivistic. This is also how most financial studies focused on a general understanding of the market are designed (Rao, 2018). The research question is also targeting an objective phenomenon that further credits the chosen approach.

4.1.4. Research strategy

Scientific research can be divided into two primary groups. These are quantitative and qualitative research. Generalized, the main difference between them is whether the empirical data is expressed in numbers or words. Which data is required is therefore dependent on whether it shall be used to calculate statistical properties or not. Quantitative data can help measure, quantify, or statistically describe a phenomenon. On the other hand, qualitative data is helpful for understanding behavior

such as motives based on the participants (Skärvad & Lundahl, 2016). This discipline is also primarily connected to research design, epistemology, and ontology (Bryman & Bell, 2011). Since this study aims to explain greenium and the factors determining it, a quantitative approach is appropriate.

On the other hand, it would be possible to conduct a similar study with a qualitative approach. Such a strategy could be to interview market participants, both issuers and investors, to understand which factors they consider relevant for the bond yield and why. A study with that approach could generate exciting insights based on their different views. On the other hand, that kind of study would not be a generalizable and objective description of reality. Even with a large number of interviews, it would still be the subjective view of the respondents and not the objective reality in focus. Therefore, the decision was instead to use a quantitative approach and draw conclusions based on numerical calculations from market data.

As previously discussed, this study used a deductive approach, a positivistic epistemology, and an objective ontology. This combination finds support in Bryman & Bell (2011), who argue that it is the best combination for quantitative data. The objective approach and the distinction between theory and data follow through the three approaches (Bryman & Bell, 2011). To the best of our knowledge, this combination is the most appropriate to answer the research question. Therefore, the statistical results are expected to be objective and reliable.

4.2. Method

4.2.1. Primary market

The existing studies on greenium can be split into the ones examining the primary market data and the ones focusing on the secondary market data. As described in the literature review, contradictory findings are present in both markets. However, as MacAskill et al. (2021) shown in the secondary market, the average greenium tends to lie within -1 and -9 bps limits. Moreover, 70% of the studies on the secondary market agree on a statistically significant greenium, as opposed to only 56% of the studies conducted on the primary market. Furthermore, the consensus on the magnitude of

greenium in the primary market is much less pronounced. The average greenium found in the primary market lies within -85 to +213 bps limits. Therefore, the primary market represents a highly unexplored and contradictory environment, where according to various findings, the greenium ranges from being strongly negative to a green bond discount. It also seems counter-intuitive that a green bond can be sold at a discount in the primary market and then traded at a premium in the secondary market. This would represent an arbitrage for investors who would exploit it by buying green bonds in the primary market and selling them in the secondary market. This pronounced discrepancy in the previous findings implies an urgent need further to investigate the green bond premium in the primary market. Therefore, this study was conducted on the primary market data.

Our decision to focus on the primary market was also motivated by the additionality theory and our understanding of the holistic role of the green bond market. The main purpose of green bonds is to shift capital towards environmental projects and enable green investments that would not have occurred otherwise. The green bond issuers raise funds for such environmental projects in the primary market and are usually not involved in the secondary market transactions. Therefore, it is the primary market where the real change occurs.

It is true, however, that the secondary market's role should not be undermined. The secondary market stimulates the development of the primary market by providing the necessary liquidity. In the absence of secondary market liquidity for green bonds, investors would need to hold the bonds to maturity, which would indisputably decrease the demand for such investments and prevent the primary market from further growth. In other words, the expected secondary market liquidity does affect the yields in the primary market. Therefore, the secondary market plays an essential role in supporting the development of the primary market. However, it is explained later in the methods section that the liquidity differences between green and similar non-green bonds in the secondary market are insignificant. It implies that even though the expected liquidity in the secondary market affects the total yield size in the primary market, it cannot explain the greenium.

As discussed earlier under the additionality theory, it is the primary market yields that determine the issuers' cost of capital and, therefore, directly define the attractiveness of the environmental

projects which are to be undertaken. In other words, the green bond premium in the primary market has an immediate effect on project costs. It thus is responsible for the real growth in the volume of environmental projects by making them either more or less attractive compared to non-green undertakings. Even though the secondary market plays a supporting role in developing the primary market by providing the necessary degree of liquidity, the green bonds on the secondary market do not directly improve any environmental outcomes. It is the primary market where the fundamental transformation occurs.

Multiple sources have pointed towards the existence of ESG sentiment, which is one of the drivers behind the rapid market expansion (Piñeiro-Chousa et al., 2021). We assume that if investors' demand for green bonds is indeed at least partially driven by their environmental concerns, they would want their investments to achieve the highest degree of additionality in terms of positive environmental impact. Therefore, this type of investor should prioritize investing in the newly issued green bonds. On the other hand, the green bonds in the secondary market, to a greater extent, resemble conventional bonds, as the proceeds from their sale belong to the counterparty instead of the issuer and do not have a direct impact on the environment. Following this logic, there should be more casual investors in the secondary market than in the primary market, who are less concerned about the impact of their investments and perceive green bonds more as regular financial instruments. Therefore, after considering the additionality dimension and the ultimate purpose of green bonds, this study was focused on the primary market.

4.2.2. Data collection

Thomson Reuters Eikon database was chosen for collecting the information on bonds. As the first step, all bonds issued after 01/01/2007, labeled as "Bond," were considered. However, the vast majority of the green bonds were issued only after 01/01/2013 since this was when the green bond market started taking off. There were only 2 green bonds found in the Eikon database issued before 01/01/2013, which means that Eikon uses the same cut-off point to define the green bond market. It was necessary to obtain the data on conventional bonds issued before 01/01/2013 and increase the available pool of conventional bonds used for the subsequent comparison. In

addition, the filters were set only to include the bonds for which the data on bond grade was available. After applying the necessary filters, a total of 259 green bonds and 15,741 conventional bonds issued before 01/03/2021 were included in the final sample. Information on the following variables was retrieved for both green and conventional bonds: issuer, issuer type, country of issue, issue price, currency, bond grade, bond structure, seniority, collateral, coupon type, coupon rate, coupon currency, and coupon frequency, issue size both in local currency and USD, issue date, maturity date, sector, and the use of proceeds. Previous research on this topic has revealed the importance of conducting a study on a larger sample size without imposing further limitations on the currency, issuer type, or market. Therefore, it was decided not to impose any additional restrictions on the initial sample.

As discussed earlier, there is no single definition of what a green bond is. Therefore, various data providers use different ways to classify bonds as either green or not. For example, Bloomberg is labeling a bond as green if it satisfies the "Use of Proceeds" principle of the Green Bond Principles defined by ICMA. Since the data was obtained from Thomson Reuters Eikon, we were supposed to rely on Eikon's "green bond" definition. Unfortunately, Eikon does not openly elaborate on its criteria for labeling bonds as green or not. Therefore, as a safety check, it was decided to run all 259 green bonds obtained from Eikon against Bloomberg's criteria by looking them up in Bloomberg to define how many of them are considered green by Bloomberg. As a result, 239 bonds out of 259 were considered "green" by Bloomberg, which constitutes more than 92% of the total sample size. This implies that even though the green bond eligibility criteria of Eikon remained unknown, it is not considerably different from Bloomberg's definition of "green bond."

Another essential parameter for the subsequent analysis is the issue yield, which can also be defined as the yield to maturity at the date of issuance in the primary market. Unfortunately, Eikon does not provide the issue yield explicitly as a separate variable. However, it provides all of the information which is necessary for its calculation, such as the (1) issue price, (2) bond face value, (3) annual coupon rate, and (4) coupon frequency. The number of years to maturity was calculated by subtracting the issue date from the maturity date. It should also be noted that for the bonds which were issued at par, the issue yield, by definition, equals their coupon rate. Therefore, there was a need to calculate the issue yield only for the bonds issued at a price different from their par

value. We used the following formula presented in the theory section to calculate the yields of such bonds:

$$B_0 = CPN * \frac{1}{y}\left(1 - \frac{1}{(1+y)^n}\right) + \frac{F_0}{(1+y)^n} \qquad \textit{Equation 6}$$

In the formula, B_0 is the price at time 0, CPN is the coupon, y is the issue yield, n is the number of periods to maturity, and lastly, F_0 represents the face value (Berk & DeMarzo, 2017).

As was concluded by the literature review, one of the most critical factors expected to determine the size of the green bond premium is the verification provided by a third party. Unfortunately, Eikon does not provide any information about certifications, second-party opinions, or any other kind of third-party approvals. Therefore, this information was retrieved from Bloomberg, where it is referred to as the ESG Assurance Provider. Suppose the issuer's Environmental Social Governance Framework or other types of the documentation contains a statement that includes the name and type of Assurance Provider for the issuer's ESG framework. In that case, Bloomberg considers it as "reviewed." Therefore, the information on ESG Assurance Provider was also added to the final sample of 259 green bonds.

It was shown in the literature review that the academic literature is split into the studies which analyze if greenium exists and studies that take it one step further and analyze the factors determining it. Our research question puts us in the second category of studies. However, in order to explain greenium existence, it should first be shown. Therefore, the first step was to estimate the greenium and analyze its significance in the main sample and the subsamples. After the presence of a significant greenium was proven, the next step was to analyze the factors that might influence its size and explain it.

Bachelet et al. (2019) argue that the best way to estimate a greenium would be to compare each green bond with a conventional counterpart with precisely the same characteristics in all means except from the fact that one of them is green and the other one is conventional. This method would give an exact and indisputable answer to the existence and size of a greenium.

Unfortunately, such a sample would be minimal since not many issuers issue both types of bonds simultaneously (Bachelet et al., 2019). Instead, we have in this thesis used one of the second-best approaches. The approach used was to compare each green bond with a synthesized conventional bond. Each green bond was matched with two conventional bonds with the same characteristics to construct the synthetic conventional bond. Just as Larcker & Watts (2020), we allowed the conventional bonds to be matched several times as long as the pairs met the predefined matching criteria. After that, we obtained triplets of bonds consisting of one green bond and two conventional bonds similar to the green bond based on the matching criteria. Using these triplets, we synthesized conventional bonds that would become identical to the given green bonds on all parameters besides their greenness. This way, we could construct a data set of matched pairs of green and synthetic conventional bonds. Any difference in yield could be attributed to the characteristic of interest, namely the green label. Zerbib (2019) inspired this method, who has conducted a similar study with a focus on the secondary market.

An alternative approach would be to follow Larcker & Watts (2020) or Bachelet et al. (2019), who, instead of constructing a synthetic bond, compares the green bond with the closest conventional counterpart. Although this approach credits in the way that the compared bond is real and existing, the results might be biased. The first critique is that matching bonds with almost identical maturities does not generate a big enough sample to draw reliable conclusions. If the maturities, on the other hand, differs more, the results are not reliable. It would not be possible to determine which fraction of the difference is due to the green label. Therefore, the second problem with selecting from the existing pool of conventional bonds is that it might suffer from the maturity bias (Zerbib, 2019).

Another common method used in other studies is to run a regression directly on the total sample (Baker et al., 2018). In this method, both conventional and green bond yields are regressed on various bond characteristics expected to affect the yield size. In this regression, the green label is represented with a dummy variable. The coefficient estimate of the dummy can then be interpreted as the green bond premium. One of the critiques of this method is that the model might suffer from the omitted variable bias. The reason is that such models need to account for every potential risk factor which might affect the yield by including them as variables. If many factors are included,

this may lead to multicollinearity due to high correlation. On the other hand, if only a selected number of risk proxies is included in the model, there is a high risk of omitting a relevant variable that would have altered the model's estimates if it had been included. Therefore, depending on their specifications, such models are usually criticized for leading to biased greenium estimates.

The benefit of the model-free approach is that it circumvents all of the drawbacks associated with competing approaches, such as the maturity bias, sample representativeness, and the omitted-variable bias. Moreover, it was argued that the lack of academic consensus on the existence of greenium is caused by the difference in methodological approaches used by various studies (Liaw, 2020). To the best of our knowledge, no academic study has implemented the matching and synthesizing approach to analyze green bonds premium in the primary market. Therefore, this paper is expected to contribute to the academic literature significantly.

4.2.3. Matching

The matching criteria for conventional bonds to be included in the triplet with green bonds were that they must have the same issuer, currency, bond grade, bond structure, seniority, collateral, and coupon type as the green bonds. In addition, the restrictions on the issue size and date were imposed to control for any potential liquidity differences in the secondary market. This was deemed necessary because large differences in the secondary market liquidity can also affect the yield size in the primary market. Therefore, to account for any potential secondary market liquidity mismatches, the conventional bonds sample was restricted to conventional bonds (i) with an issue amount of fewer than four times and greater than one-quarter of the green bond's issue amount, and (ii) with an issue date of not more than six years earlier or later than the corresponding green bonds' issue date. These criteria are based on the previous studies discussed in the literature review. By including them in the matching process, we can isolate the green label more efficiently. In addition to this, the maturity needed to be as similar as possible. A too narrow limit in maturity would significantly decrease the available pool of conventional bonds to choose from and negatively affect the sample size. On the other hand, loose restrictions in maturity would undermine the applicability of linear interpolation and extrapolation techniques in estimating the

synthetic, conventional bond yields. Therefore, the applied criterion was that the maturities should not differ by more than two years. This length seems reasonable in those concerns and is also the limit used by previous studies (Zerbib, 2019). Larcker & Watts (2020) used a limit of one year instead of two, but their matching was, on the other hand, without synthesizing and does therefore require a narrower limit.

Bond Characteristics	Criteria
Issuer	Same
Currency	Same
Bond grade	Same
Bond structure	Same
Seniority	Same
Collateral	Same
Coupon type	Same
Issue date	+/- 6 years
Issue size	+/- 400%
Maturity	+/- 2 years

Table 2 – Matching Criterions

When more than two conventional bonds satisfied all of the criteria, the conventional bonds with maturities closer to the green bond's maturity were chosen to increase the reliability of the subsequent synthesizing. In a few cases where the maturities were precisely equal, the issue date closest to the green bond's issue date was then used to determine which conventional bond to include each triplet. The issue date was chosen as the second dominant criterion to minimize the bias in interpolation or extrapolation of the yield curve. The yield curves tend to change shape over time. When it was impossible to find two conventional bonds that would satisfy all the requirements, the green bond was excluded from the sample. Before the matching process, the sample consisted of 259 green and 15,741 conventional bonds. For 183 of the green bonds, it was only possible to find one conventional counterpart, or it could not be matched at all. As a result, 76 triplets which consisted of 1 green and 2 conventional bonds which satisfied the criteria mentioned above, were obtained.

4.2.4. Synthesizing

The purpose of synthesizing conventional bonds was to create a synthetic, conventional bond with exactly the same maturity as the green bond in each triplet. Linear interpolation of the conventional bond yields was used to find the yield of the conventional synthetic bond that would have the same maturity as the green bond. Extrapolation was used in those cases when both conventional bonds had either longer or shorter maturity than the green bond. In contrast to Zerbib (2019), who studied the secondary market and used the ask-yield, we used the yield at issue calculated before. This is also the yield Kapraun & Scheins (2019) used to analyze the primary market. When calculating the yield for the synthetic bonds, the following formula inspired by Zerbib (2019) was used:

$$\tilde{y}_{CB} = y_{CB\_short} + \frac{y_{CB\_long} - y_{CB\_short}}{X_{CB\_long} - X_{CB\_short}} * \left(X_{GB} - X_{CB\_short}\right) \qquad \textit{Equation 7}$$

$\tilde{y}_{CB}$ is the estimated issue yield of a conventional synthetic bond with the same maturity as the green bond. y_{CB_short} and y_{CB_long} are the observed issue yields of the conventional bonds with the shortest and longest maturity, respectively. X_{CB_long} and X_{CB_short} represent the maturities of the conventional bonds with the longest and shortest maturity, respectively. Lastly, X_{GB} is the maturity of the green bond. In this way, we synthesized conventional bonds identical to the green bonds on every parameter, including the maturity, but apart from the green label.

As the formula suggests, two conventional bonds with the exact same maturity could not be used simultaneously since the denominator would be zero. Therefore, in such cases, one of the conventional bonds was substituted by another conventional bond with a slightly different maturity that still satisfied all of the criteria. As described above, the issue date was used as a second dominant criterion to decide which bonds to include each triplet if two candidates that satisfied all of the criteria also had equal maturities. Therefore, the issue date was also used as a criterion for substituting one of the conventional bonds with exactly the same maturities. For 8 of the 76 triplets, no substitutable bond was found. Therefore, the sample of 76 triplets was decreased to 68 triplets, which after synthesizing was transformed into 68 pairs of green and synthetic conventional bonds.

Of the resulting 68 pairs, 6 implied synthetical conventional bond yields and the corresponding greeniums of more than 10%. One of them even indicated a synthetic yield of 318%. These abnormal yields resulted from extrapolation for pairs with minimal differences in maturity but large differences in yield. According to the sample, the actual yields of the conventional bonds were of sizes that were considered normal. However, due to the nature of extrapolation, small differences in maturity and large differences in yields resulted in an extremely steep yield curve slope. They, therefore, indicated extreme values for the synthetic, conventional bond yields. It was concluded that the bias in the chosen method caused the outliers. To overcome this issue, it was decided to substitute one conventional bond with another match, which satisfied all of the criteria. In one case, it was possible to find a conventional bond with a maturity difference slightly above the bond used in the first attempt. For the other five pairs, this was not possible with the given criteria. Therefore, 5 outliers were eliminated from the final sample, resulting in 63 pairs of matched green and synthetic conventional bonds. Each of these 63 green bonds was, according to Eikon, graded as investment grade. Due to this, we had to exclude it as a potential factor in the following OLS regression.

4.2.5. Collecting additional data

In order to test the second hypothesis, it was necessary to collect the data on issuers' ESG performance. Therefore, the ESG Combined score, ESG score, Environmental pillar score, Social pillar score, and Governance pillar score were also retrieved from the Eikon database. The ESG score is an overall company score based on the self-reported information in all three pillars. On the other hand, the ESG combined score results from combining the ESG score with the ESG controversies score. The latter measures the issuers' exposure to environmental, social, and governance controversies and negative events reflected in global media. The ESG combined score is deemed a more comprehensive and objective assessment of an issuer's ESG performance. It combines both the information disclosed by the issuer and negative ESG-related events captured by the media. For instance, scandals, lawsuits, ongoing legislation disputes, and fines are among such events. As a result, ESG combined score is the ESG score discounted for ESG controversies that materially impact the company. All of the ESG combined scores collected were lower than

the corresponding ESG scores, which shows a bias in the latter. On average, ESG scores were 19.47% higher than the corresponding ESG combined scores in the whole sample. Eikon reports the issuers' ESG assessments on an annual basis. Therefore, the issuers' ESG and ESG combined scores were retrieved in such a way as to match the ESG assessment year with the bond issue date as close as possible. If the ESG score was not available for the year when the green bond was issued, the ESG assessment from the nearest year was taken. When the issuer was a subsidiary, the ESG score of the parent company was taken as a proxy. For example, the ESG scores of Toyota Finance Corp, Hyundai Capital Services Inc, and Honda Finance Co Ltd were proxied by the ESG scores of Toyota Motor Corp, Hyundai Motor Co, and Honda Motor Co Ltd accordingly. It is important to note that Eikon does not provide ESG scores for Agencies, Governments and Supranational, Central Banks, and Municipalities which considerably decreased the total sample for the subsequent ESG score analysis. Moreover, the ESG assessment on 4 of the corporate issuers was also missing in Eikon. Therefore, out of 63 green bonds, it was only possible to retrieve the ESG scores for 34 of them.

4.2.6. Estimating the greenium

To arrive at the green bond premium, Zerbib (2019) performed a fixed-effects panel regression as the final step of the process. The greenium was the unobserved specific effect of the regression of the difference in yields between the green and conventional synthetic bonds on the difference in their liquidity. The bonds' bid-ask spreads were used as a proxy for liquidity to account for any residual liquidity mismatches between green and conventional bonds in the secondary market.

$$\Delta\tilde{y}_{i,t} = p_i + \beta\Delta\widetilde{BA}_{i,t} + \varepsilon_{i,t} \qquad \textit{Equation 8}$$

$\Delta\tilde{y}_{i,t}$ is the yield differential and the p_i the variable is the green bond premium. The ΔBA variable represents the difference between the green bonds' bid-ask spreads and the conventional bonds' distance-weighted average bid-ask spreads during the time period under analysis. At this stage, the difference between the green bond yields and the synthetic, conventional bond yields can solely

be attributed to the liquidity differential and the green bond premium, as bonds are exactly equal on all of the remaining parameters. This liquidity control is usually used in addition to other liquidity controls, such as the restrictions on the issue amount and the issue date used in this study. It is desirable to use the bid-ask spreads of green and conventional bonds as a 3rd liquidity control to analyze the secondary market data. Since this study was conducted on the primary market, it was not feasible to use this additional liquidity control.

We acknowledge that the liquidity of bonds in the secondary market may affect their yields in the primary market. However, as suggested by Febi et al. (2018), the impact of liquidity risk on the yield spread of green bonds is negligible. Moreover, Zerbib (2019) mentioned that the issue size and the issue date liquidity controls provided acceptable results. The reason was that the average difference between bid-ask spreads of green and conventional bonds was around 0, with a low standard deviation. This implies that any residual liquidity differences in the secondary market have a limited effect on the green bond premium. Therefore, it was assumed that the restrictions on the issue size and the issue date are sufficient to control for any potential secondary market liquidity mismatches.

Having the necessary liquidity controls in place, the only difference between the green bond yields and the equivalent synthetic, conventional bond yields was the green bond premium. The estimated greenium of the green bond *i* is therefore given by the following formula:

$$\hat{g}_i = y_i^{GB} - \tilde{y}_i^{CB} \qquad \textit{Equation 9}$$

where the issue yield of the green bond *i* is represented by $y_i^{GB}$and the issue yield of the conventional synthetic bond *i* is represented by $\tilde{y}_i^{CB}$. The average greenium in the market was then calculated by taking the simple average of all estimated $\hat{g}_i$. The sample was then split into various subsamples, and the average greenium was calculated within each of the subsamples. The subsamples were constructed to consist of at least five greenium estimates to allow for the subsequent significance testing. According to Lind et al. (2018), five observations are usually enough to perform parametric and non-parametric tests. In order to test for greenium significance

in the main sample and the subsamples, either parametric or non-parametric tests could be used. First, the Shapiro-Wilk's normality test was run to check if the data were normally distributed or not. Shapiro-Wilk's test is based on the correlation between the data and the corresponding scores and was preferred over other normality tests since it usually provides a higher power (Mohd Razali & Bee Wah, 2011). Shapiro-Wilk's normality test showed that the main sample and most of the subsamples violated the normality assumption. Therefore, a non-parametric test should be used to check for greenium significance. Finally, a non-parametric Wilcoxon signed-rank test was run to analyze if the average greenium found in the main sample and all subsamples are statistically different from zero.

4.2.7. Estimating greenium determinants

When the tests on greenium significance were performed, the next step in our analysis was to estimate the determinants of greenium. Similar to Zerbib (2019), a cross-sectional OLS regression was used, which according to Wooldridge (2013), in general, can be expressed as:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \cdots + \beta_k x_k + \epsilon \qquad \textit{Equation 10}$$

Where β_0 is the intercept, β_1 is the coefficient for the first independent variable x_1 and so on up to β_k and x_k for the last variable included in the regression. In the OLS regressions, 63 bond-specific greenium estimates were regressed on potential greenium determinants to see if they can explain greenium size to a significant extent. The independent variables included in the regression were those discussed in the literature review and theory chapters, namely, whether the green bond had been certified by a third party, issuer type, country, currency, coupon type, the natural logarithm of the amount issued, seniority, sector, maturity, and lastly, the use of proceeds. It is necessary to use the logarithm of the amount issued to linearize the values and obtain a relative change in the greenium.

As can be seen, most of these variables are qualitative. It is therefore not possible to simply form a standard OLS regression. Instead, dummy variables were used for those factors. In the case with third-party certification, a single binary dummy variable where "1" equaled "yes" and "0" equaled "no" were included. For the other factors such as issuer type, country, coupon type, seniority, and use of proceeds, more than two outcomes were possible. Therefore, several dummy variables for each category were included. A variable with five possible outcomes in our sample got four dummy variables. The case where all four got a value of "0" indicated that the bond possessed the fifth alternative referred to as the reference value. Instead, using an equal amount of factors and dummy variables was not possible to the dummy variable trap, which means that one variable can be predicted from the others (Wooldridge, 2013). In such a case, the regression would suffer from multicollinearity.

In all cases except for one, the variable with the most observations was used as a reference value. In the case of the issue date, which is an ordinal variable, the earliest date was used as a reference value. To avoid biased results with high R^2, we wanted to make sure each category had a sufficient amount of bonds. We, therefore, followed the logic by Zerbib, (2019) and made sure each category captured at least three observations. Cases with less than three observations were combined into a new variable named "others." Due to the variability among the green bonds, each category had a variable for others. The following shows the most general formula, including all of the variables used.

General formula: $y = \beta_0 + \beta_1 \ln(Issued\ Amount_i) + \beta_2\ Maturity_i + \beta_3 Verified_i + \sum_{j=1}^{N_{Issue\ Year}-1} \beta_4\ Issue\ Year_i + \sum_{j=1}^{N_{Country}-1} \beta_5\ Country_i + \sum_{j=1}^{N_{Currency}-1} \beta_6\ Currency_i + \beta_7 Coupon\ type_i + \sum_{j=1}^{N_{Seniority}-1} \beta_8\ Seniority_i + \sum_{j=1}^{N_{Sector}-1} \beta_9\ Sector_i + \sum_{j=1}^{N_{Use\ of\ proceeds}-1} \beta_{10}\ Use\ of\ proceeds_i + \varepsilon_i$

When specifying the OLS model, we followed the logic of Zerbib (2019), who at first formulated a general model, which he later specified in line with General-to-Specific, GETS. According to

Clarke (2014), the GETS procedure is well suited for regression with cross-sectional data. We started by forming one large regression with all of the variables we earlier had concluded to be potential determinants. When the general model was specified, we noticed that the two variables, country, and currency were not possible to combine in the same model due to multicollinearity. According to Wooldridge (2013), the problem with multicollinearity is that when two or more variables are too correlated, an OLS regression cannot determine which of them impacts the dependent variable, making the model biased. Therefore, county and currency were separated into two different models. It was also concluded that the variable sector made several models suffer from multicollinearity. The decision was therefore made to study the variable in a single variable regression instead. Concerning the other variables, they were all in both models, one with country and one with currency, to still keep the models general.

The GETS procedure, further described by Campos et al. (2005), builds on the method that all potentially relevant factors are included from the beginning. Those are then excluded one by one according to a predetermined logic. In line with Clarke (2014), we followed the logic to exclude variables due to their significance level, here their p-values, in the regression. When one variable was excluded, we reran the regression to control for any drastic changes in either the coefficient estimates, the p-values, or the adjusted R-squared. Within each step, tests for heteroskedasticity, multicollinearity, and normality among the residuals were performed. If any of the assumptions were violated according to the tests, the procedure of excluding variables stopped, and the last excluded variable was added back to the model. If the adjusted R-squared dropped by more the 2%, the last excluded variable was added back to the model, and no further variables were excluded. Campos et al. (2005) argue that the GETS procedure is the best to decrease the risk of the omitted variable bias. We did treat our two models individually, following the GETS procedure. In the end, we had two general and two specific models. In addition, we also had the regression only including sector.

Next, the analysis of the 34 bonds for which various ESG scores were available was performed. When the number of observations decreases, the likelihood of finding rare and extreme numbers increases. This can bias the regressions since those relations do not exist in reality. There is also an increased risk that existing relations are found insignificant by the regression. Therefore, the

decision was made to perform five different single variable regressions, one for each ESG variable. By doing so, the risk of the omitted variable bias is higher. On the other hand, when all of the variables were included in the same model, the model suffered from significant multicollinearity. The decision was, therefore, to use single variable regressions for the ESG scores.

4.2.8. Model fit

When the models were estimated, several tests were performed to check how well fitted they were. A model is considered adequate if OLS standard errors are unbiased, which means that the residuals are independently distributed. The tests selected in this study followed the recommendation from Lind et al. (2018) and aimed at concluding whether the residuals were homoscedastic and normally distributed and that the model did not suffer from multicollinearity. Homoscedasticity means that the residuals have equal variance over the whole sample. If there exist differences in residuals' variance, the model suffers from heteroskedasticity. If that is the case, the model is not well-specified and might, for example, only work for a specific range of the dependent variable (Lind et al., 2018). To ensure this is not a problem, the Breusch-Pagan test for heteroskedasticity was performed on all of our specified models. The test has the null hypothesis that there is no heteroskedasticity. Suppose the residuals are normally distributed around a mean of zero. In that case, the model is said to incorporate a sample large enough and not be affected by skewness or outliers (Lind et al., 2018). To test whether the residuals were normally distributed or not, two different methods were used. For the general and the specific models, the residuals were first plotted as a histogram together with the actual normal distribution. With this, it was possible to evaluate the distribution graphically. As a second step, the Shapiro-Wilk test was further performed. In all cases, the p-value was above the level of significance at 0,05, which meant that the residuals were approximately normally distributed.

Lastly, we also tested for multicollinearity, leading to biased and misleading coefficients (Wooldridge, 2013). Multicollinearity can be a problem if the correlation between two or more independent variables is too high. If that is the case, an OLS regression including both factors can show that one of them is positive and the other one is negative even if both are of the same sign

with similar size. This is because the regression cannot determine precisely which effect is due to which variable. A rule of thumb is that the correlation is no problem within the interval from -0,7 to 0,7. A reliable way to test for multicollinearity is the Variance Inflation Factor, VIF. The test measures to which extent the independent variables can explain the variation in the other independent variables. A score below 10 indicates that there usually is no problem (Lind et al., 2018; Wooldridge, 2013). To test for multicollinearity, the VIF was calculated in each step.

4.2.9. Limitations

As discussed earlier, if a large enough sample of identical green and non-green bonds had existed, that would have resolved all of the debates around the existence of greenium. After analyzing the whole sample of 15,741 conventional bonds, no single conventional counterpart was found to represent an ideal match. Therefore, it is practically impossible to conduct a perfect comparison as such twin bonds simply do not exist. The approach chosen in this study was considered as the most optimal for conducting academic research as it circumvents most of the problems related to the competing approaches. However, it also has some drawbacks, which are usually overlooked when its benefits are discussed.

First of all, the real-life applicability of the model-free approach is limited because neither of the synthesized bonds exists in reality. As the name suggests, the pool of synthesized bonds represents a hypothetical pool of conventional counterparts if it had existed in reality and if the issuers had decided to price it similarly to the green bonds. The second limitation refers to the shape of the yield curve. As explained earlier, linear interpolation and extrapolation of the conventional bond yields were used to estimate the yields of the conventional synthetic bonds with the same maturity as the corresponding green bonds' maturity. However, in reality, yield curves are rarely linear. Therefore, one can argue that even though this issue is addressed through strict limitations on maturity for conventional bonds which were used for synthesizing, the actual shape of the yield curve for each of the triplets remains unknown. Therefore there may exist moderate approximation errors. It implies that the validity of the synthesized yields is limited depending on the actual shape of the yield curve and the maturity differences between green and conventional bonds in each

triplet. Another limitation of the interpolation and extrapolation method is that if one of the conventional bonds has precisely the same maturity as the green bond, then the synthetic, conventional bond yield is by definition equal to the yield of that conventional bond. Therefore, the yield of the second conventional bond in that triplet will not affect the resulting synthetic yield in any way. The method is biased because, during the matching process, some of the green bonds were excluded from the sample due to the lack of a second conventional counterpart satisfying all of the criteria. However, in such cases where it was only possible to form a pair, if the maturity of the conventional counterpart was precisely equal to the green bond maturity, the second conventional counterpart, even if it was available for forming a triplet, would not affect the subsequent synthesizing results. Nevertheless, the method implied eliminating green bonds, for which it was not possible to form a triplet.

Another limitation is that the green bond sample used for analysis is essentially not random but somewhat based on a predefined criterion. That means that one can argue that the results of this and similar studies cannot be generalized to the whole green bond market and are only applicable to the green bonds for which there existed at least two close enough conventional bonds. In other words, one can argue that the 177 green bonds, which were excluded from the analysis due to the lack of a suitable match, may, in reality, enjoy a different greenium or even a green bond discount. These concerns seem exceptionally reasonable if, in reality, the existence of the green bond premium to any extent depends on the availability of a conventional counterpart. However, as was discussed earlier, the variety of methods used for analyzing the green bond market is probably one reason for the diverging results.

5. Results and Analysis

In the following section, the results of the empirical analysis are presented. First, the descriptive statistics of the sample under analysis are provided. It is followed by the analysis of greenium significance in the main sample and the subsamples. Next, the significance of greenium determinants is analyzed through OLS based on their ability to explain variations in greenium. Lastly, a similar analysis is conducted on issuers' sustainability performance proxied by their ESG scores.

5.1. Descriptive statistics

In Table 3, the number of pairs, the average values for the green bond yield, issue amount, and maturity are reported for the main sample, and the subsamples used in the subsequent analysis. The issued amount is denominated in USD and shown in millions, and maturity is expressed in years. Categories with less than 5 observations are not shown in the table.

Category	Subcategory	# pairs	y_{GB}	Issue amount	Maturity
Main sample		63	1,53%	688,17	13,23
Issuer type	Agency	7	0,88%	870,80	8,35
	Corporate	40	1,83%	593,47	15,19
	Other Gov/Supra	13	1,21%	547,81	9,02
Sector	Utility	17	3,51%	588,24	24,40
	Supranational	5	1,85%	633,99	6,26
	Oil and Gas	5	1,04%	821,10	9,69
	Official and Muni	10	0,89%	440,03	13,14
	Financial - Other	5	0,22%	347,94	4,60
	Banking	9	0,32%	652,68	6,72
	Agency	7	0,88%	870,80	8,35
Currency	Euro	22	0,95%	1042,60	9,44
	Japanese Yen	7	0,25%	282,00	9,71
	Swiss Franc	10	0,30%	265,05	9,25
	US Dollar	18	3,37%	583,33	23,60
Verification	No	13	3,12%	527,17	22,14
	Yes	50	1,12%	730,03	10,91
Country	France	17	1,05%	785,75	10,02
	Japan	7	0,25%	282,00	9,71
	Switzerland	10	0,30%	265,05	9,25
	United States	19	3,26%	573,85	22,62
Use of Proceeds	Clean Transport	5	1,10%	282,68	5,01
	Eligible Green Proje	30	1,85%	647,30	15,52
	Energy Efficiency	17	1,64%	548,24	15,08
Issue date	Before 2017	5	1,90%	397,66	9,71
	2017	6	0,66%	567,94	8,57
	2018	6	3,51%	528,33	20,10
	2019	25	1,69%	685,98	15,15
	2020 & 2021	21	0,95%	839,97	11,15

Table 3 – Descriptive Statistics

The mains sample consists of 63 green bonds from 38 unique issuers, of which Engie SA and the European Investment Bank are the most frequent issuers with 5 issues each. The biggest issue in the sample belongs to the Federal Republic of Germany. It equals 5950 million USD, which is greater than the aggregated issue amount of either Engie SA or the European Investment Bank. The smallest issue in the sample equals 40 million USD and belongs to the European Investment Bank, while the total sample of green bonds amounts to 43355 million USD. The majority of the green bonds in this sample were issued after 2019 by corporate issuers in the utility sector,

denominated in EUR, and under a verified ESG framework. The most popular category for the use of proceeds is "Eligible Green Projects." Therefore, the sample is representative because Euro bonds issued by corporate issuers dominate the green bond market. The most popular category for the use of proceeds is "Eligible Green Projects," closely followed by "Clean Transportation." The sample is also representative because most of the green bonds on the market are fixed coupon, bullet, senior unsecured bonds. The sample consists of 58, 35, and 31 green bonds of each category, respectively, which constitute most of the sample in each category.

The average green bond yield is 1.53%, the issue amount is 688 million USD, and the average maturity is 13.23 years in the main sample. The highest average maturity was found in the utility sector. It can be explained by the nature of the projects which are undertaken in the utility industry. The utility industry also represents the highest yield environment among all. The highest average issue amount was found in the Oil and Gas and Agency sectors. On the other hand, the Financial sector represents a low yield environment with the shortest maturities and the smallest average issue amount. The green bonds denominated in USD are issued at the highest yields and the longest maturities. It makes sense since most of the green bonds denominated in USD are issued in the utility sector. However, the sample is dominated by EUR denominated bonds, and their average issue size is also considerably larger than the average issue size of bonds denominated in other currencies. The green bonds issued in Japanese Yen and Swiss franc have the smallest average issue size and the lowest average yield at issue. On average, bonds issued under unverified ESG frameworks face a comparatively high yield environment and have longer maturities. The reason is that most of the green bonds without a third-party verification were issued in the US, are denominated in USD, and USD denominated bonds show the same pattern. The use of proceeds category, "Clean Transport," has the lowest average yield, issue size, and the shortest average maturity. Consistently, most of the green bonds issued for this purpose are denominated in either Swiss franc or Japanese Yen.

It is also essential for the subsequent analysis to note that some of the subsamples are entirely overlapping. For instance, all of the green bonds denominated in Swiss Franc and Japanese Yen were issued in Switzerland and Japan. Hence, the average green bond yield, issue amount, and maturity values are the same for those categories. Another strong pattern can be observed in the

"Issue date" subsample. The average issue amount is steadily increasing over time. This serves as an indication that not only the increase in the number of green bonds but also the increase in their average size contributes to market expansion.

5.2. Greenium in the main sample and subsamples

The charts below represent the distribution of greenium estimates in the main sample. The range is 9.13%, with the minimum greenium value being -4.59% and the maximum value being 4.54%. Out of 63 observations, 32 are negative, and 31 are positive values. The mean equals -0.08%, the median is -0.02%, and the mode is -1.15%. As can be inferred from the plots, the distribution is unimodal and is skewed to the left with one positive outlier.

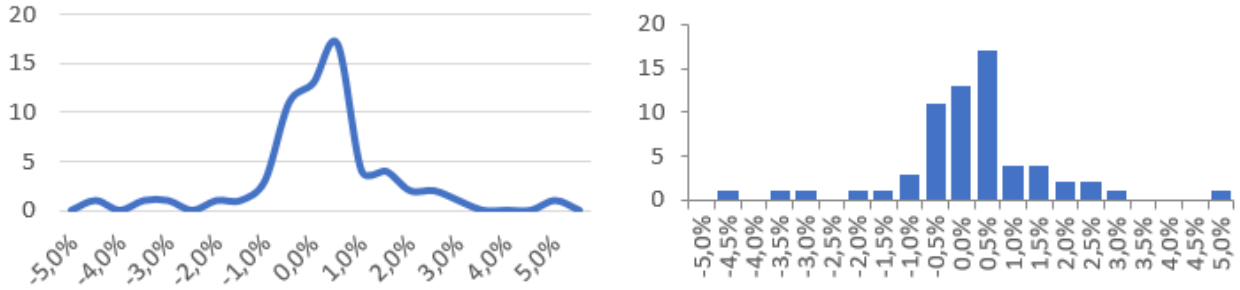

Figure 4 – Greenium Distribution

As described earlier in the methodology section, Shapiro–Wilk test for normality indicated that in the main sample and most subsamples, the data violated the normal distribution assumption. Shapiro–Wilk test conducted on the main sample indicated a p-value of 0,0002. Therefore, after considering the data distribution and relatively small sample size in many sub-samples, the Wilcoxon Signed-Rank test was conducted to analyze the significance of greenium in the main sample and all of the subsamples. Table 4 summarizes the results. It provides the number of greenium estimates in each category used for the analysis, means, medians, and the one-tail and two-tail p-values for the Wilcoxon Signed-Rank test. It also shows the levels of significance at which the H0: $\hat{g}_i = 0$ is rejected.

Category	Subcategory	# pairs	mean	median	p-value 1-tail	p-value 2-tail
Main sample		63	-0,08%	-0,02%	0,2623	0,5247
Issuer type	Agency	7	-1,06%	-0,39%	0,1484	0,2968
	Corporate	40	0,11%	0,02%	0,2258	0,4517
	Other Gov/Supra	13	0,27%	-0,27%	0,4196	0,8393
Sector	Utility	17	0,14%	0,16%	0,2019	0,4038
	Supranational	5	0,93%	0,36%	0,3125	0,6250
	Oil and Gas	5	0,57%	0,01%	0,3125	0,6250
	Official and Muni	10	-0,22%	-0,34%	0,0527*	0,1055
	Financial - Other	5	0,01%	0,04%	0,3125	0,6250
	Banking	9	-0,16%	-0,14%	0,2480	0,4961
	Agency	7	-1,06%	-0,39%	0,1484	0,2969
Currency	Euro	22	-0,07%	-0,17%	0,3631	0,7262
	Japanese Yen	7	-0,11%	-0,02%	0,2891	0,5781
	Swiss Franc	10	-0,20%	-0,16%	0,0966*	0,1934
	US Dollar	18	-0,06%	0,13%	0,3509	0,7019
Verification	No	13	0,02%	0,27%	0,2939	0,5879
	Yes	50	-0,11%	-0,06%	0,1206	0,2412
Issue amount	0 - 353m	16	0,29%	0,03%	0,3718	0,7436
	353m - 595m	18	-0,40%	-0,46%	0,0448**	0,0897*
	595m - 841m	13	0,13%	0,09%	0,3934	0,7869
	841m +	16	-0,26%	-0,07%	0,3529	0,7057
Seniority & Collateral	Senior Secured	18	0,13%	0,13%	0,2086	0,4171
	Senior Unsecured	31	-0,07%	-0,25%	0,1636	0,3271
Coupon type	Fixed then Floating	5	0,26%	0,27%	0,0937*	0,1875
	Plain Vanilla Fixed Coupo	58	-0,11%	-0,06%	0,1901	0,3802
Maturity	Short ≤5	12	-0,20%	-0,03%	0,2349	0,4697
	5 < Intermediate ≤ 12	33	-0,03%	0,01%	0,4439	0,8879
	12 < Long	18	-0,09%	-0,17%	0,3830	0,7660
ESG score	25 < C ≤ 50	5	-0,71%	0,01%	0,4063	0,8125
	50 < B ≤ 75	10	0,15%	0,07%	0,2158	0,4316
	75 < A ≤ 100	19	0,43%	0,27%	0,0399**	0,0799
ESG combined	25 < C ≤ 50	7	0,70%	0,04%	0,0781*	0,1563
	50 < B ≤ 75	13	0,04%	0,04%	0,2487	0,4973
	75 < A ≤ 100	10	0,44%	0,62%	0,0966*	0,1934
Country	France	17	0,30%	0,01%	0,2585	0,5171
	Japan	7	-0,11%	-0,02%	0,2891	0,5781
	Switzerland	10	-0,20%	-0,16%	0,0966*	0,1934
	United States	19	-0,11%	0,09%	0,4453	0,8906
Use of Proceeds	Clean Transport	5	0,93%	0,04%	0,0625*	0,1250
	Eligible Green Projects	30	-0,24%	-0,21%	0,1854	0,3707
	Energy Efficiency	17	0,08%	0,02%	0,3910	0,7819
Issue date	Before 2017	5	-0,02%	-0,36%	0,4063	0,8125
	2017	6	-0,34%	-0,48%	0,1094	0,2188
	2018	6	0,15%	0,53%	0,4219	0,8438
	2019	25	-0,11%	0,02%	0,5000	1,0000
	2020 & 2021	21	-0,05%	-0,14%	0,2584	0,5168

*p < 0.1; **p < 0.05; ***p<0.01

Table 4 – Greenium

As can be inferred from the table, the average green bond premium in the main sample is -8 bps, which aligns with the expectations and indicates the overall greenium presence in the market. However, the value is not significant under any significance level. Therefore, we fail to reject the first null hypothesis about the overall greenium existence in favor of the alternative hypothesis H1 and conclude that the average green bond premium is not significantly different from zero in the main sample.

The greenium of -8 bps is a simple average of 63 greenium estimates. Another way to look at it is to calculate the average greenium based on what portion of the market the corresponding green bonds represent. It was decided to measure green bonds' representativeness by their issue size. In other words, the greenium of two different bonds does not influence the market in the same way if these bonds are of considerably different sizes. The issue size weighted average is expected to reflect the relative economic significance of each greenium estimate to a better extent and is, therefore, more descriptive than a simple average. The issue size weighted greenium was found to be -67 bps which is considerably lower than when all greenium estimates are weighted equally. This means that green bonds of larger than average size, which consequently constitute a larger portion of the market, pull the average greenium down to more negative, and therefore more significantly different from zero, values. On the other hand, it also means that the average greenium is pulled closer to zero by multiple issuers of smaller size.

To investigate the alternative hypothesis H2, it was necessary to split the greenium into various subsamples to check if a significant greenium is present in either of them. As a first step, greenium estimates were grouped based on the issuer type. Neither of the issuer groups exhibited a significant greenium. However, a negative greenium of 106 bps was found among the Agency issuers. On the other hand, an insignificant green bond discount of 11 bps and 27 bps was found among the Corporate and Other Governmental and Supranational issuers, respectively. The corporate issuers largely dominate both the sample under analysis as well as the overall green bond market. Since neither of the issuer groups on average can issue green bonds at a significant greenium, "Issuer type" is not expected to represent a relevant greenium factor.

The second subsample categorizing greeniums based on the sector indicates a significantly negative green bond premium in the Official and Municipal sector at a 10% significance level. Negative, yet insignificant, greeniums were also found in Banking and Agency sectors. On the other hand, Utility, Oil and Gas, Supranational sectors exhibit an insignificant green bond discount of 14 bps, 57 bps, and 93 bps, respectively. A significantly negative greenium was found in one of the sectors indicates that "Sector" may be one of the relevant greenium determinants. The next category consists of currency types, and the green bond premium was found to be negative at a 10% level of significance for the green bonds issued in Swiss Franc. The rest of the currencies also point towards the existence of the green bond premium but not significantly. The second-lowest green bond premium was found in bonds issued in Japanese Yen. It should be noted that bonds issued in Japanese Yen and Swiss Franc are represented by a relatively homogeneous pool of issuers, compared to bonds issued in Euro or USD. This implies that "Currency" can also be a potential greenium determinant but to a lesser extent as it is highly correlated with the Country factor for both Japanese Yen and Swiss Franc. Therefore, it is difficult to conclude whether the greenium is caused by the currency or country effect.

Contrary to the expectations defined by the literature review and the theory section, the third-party verification does not seem to explain the existence of greenium. Nevertheless, the sign of the average greenium found in both subsamples is according to the expectations. The average green bond premium for the green bonds with an ESG assurance provider was found to be -11 bps compared to +2 bps for the green bonds, which lack an ESG assurance provider. This implies that investors, on average, are willing to accept lower yields provided by the green bonds issued under the ESG framework, which had previously been examined by a third party, which is in line with expectations. It can also be noted that, on average, investors are ready to acquire green bonds without such assurance only at a discount. It implies that the issuers who issue green bonds under the uncertified ESG framework may decrease the cost of capital by funding the same green projects with conventional bonds until they obtain the necessary verifications for their ESG framework. All in all, the third-party guarantees do not seem to be a relevant greenium determinant and can only provide indications as to how the market is evolving.

In order to analyze greenium for bonds with different issue sizes, the issue amount was subsampled based on quartiles. The Q1, Q2, and Q3 were 353, 595 841 million USD, respectively. A negative greenium significant at a 5% level was found in the second quarter, i.e., green bonds with an issue amount below the average. A negative, though insignificant, a green bond premium was also found for the green bonds with the largest issue amount. The green bonds in the first and third quarters were, on average, sold at an insignificant discount. This fact limits economic interpretations about the potential influence of the issue size on the green bond premium. However, it should also be noted that since a significantly negative greenium was found in this category, "Issue size" may be a potential factor affecting the size of the green bond premium. Next, the greenium was categorized based on the "Seniority and Collateral." It should be noted that most of the Seniority and Collateral subcategories, such as "Subordinated Unsecured," were not possible to analyze due to the small sample size. Therefore, the only difference between the two subcategories is whether green bonds are collateralized. Even though the green bonds premium is not significantly different from zero in both groups, it is still helpful to analyze the pattern, which is somewhat contradictory. On average, investors are willing to pay a -7 bps green bond premium for senior unsecured bonds and require an average discount of +13 bps for the senior secured bonds. Therefore, it makes it difficult to draw any meaningful conclusions before running the OLS. However, judging by the greenium significance, "Seniority and Collateral" is not expected to represent a relevant greenium determinant.

The next category classifies greeniums based on the coupon type. A green bond discount of +26 bps significant at the 10% level was found for the green bonds with a fixed then floating coupon type. On the other hand, plain vanilla fixed coupon green bonds exhibit an insignificant green bond premium of -11 bps. Even though a significantly high green bond discount found in the former serves as an indication that "Coupon type" may be a relevant greenium factor, the sample consists of only 5 greeniums which was deemed sufficient to analyze within-the-sample significance but is admittedly not enough to call it representative. Moreover, the overall green bond market is dominated mainly by fixed coupon green bonds, further limiting the usefulness of this finding. Next, the greeniums were categorized based on the green bond maturity. As can be seen, neither of the maturity groups exhibits a significant greenium. The most negative average greenium was

found in short-term maturity bonds. However, the pattern is also not clear, as the greenium first increases then decrease again as maturity grows. Therefore, maturity does not represent a relevant factor for determining the green bond premium at this step.

The Wilcoxon test results indicate a significantly high green bond discount for some subsamples based on the issuers' ESG score. The +43 bps and +44 bps discounts are significant at 5%, and 10% for the A-graded issuers on the ESG and ESG combined rating scales. Moreover, a +70 bps green bond discount which is significant at a 10% level, was found among the C-graded issuers on the ESG combined rating scale. On the other hand, an insignificant green bond premium of -71 bps was found among the C-graded issuers based on the simple ESG rating scale. This shows that the resulting greenium depends on whether the issuers are grouped based on the voluntarily disclosed information or a combination of the voluntary disclosed information and media controversies. There is a clear pattern in the former. The greenium ranges from -71 bps to a significant green bond discount of +43 bps as the ESG rating improves. However, the same pattern cannot be observed along the ESG combined rating scale. It can be related to the fact that issuers have more effect on their ESG scores than they have on the ESG combined scores since the voluntarily disclosed information on which the former is based is at issuers' discretion and therefore is more prone to manipulations. At the same time, the green bond issue yields are also primarily determined by the same issuers. The remarkable pattern of greenium evolution along the ESG rating scale implies that it is relatively cheaper for less sustainable issuers to raise funds for their environmental initiatives than it is for more sustainable issuers. On the other hand, judging by the ESG combined rating scale, the situation is the opposite. All in all, the market's evaluation of the issuers' sustainability performance is expected to represent a relevant factor in the determination of the green bond premium. However, this factor seems to be the most complicated and controversial one.

When grouped by countries, a significant greenium of -20 bps was found among the green bonds issued in Switzerland. Moreover, an insignificant average greenium of -11 bps was also discovered among the green bonds issued in Japan and the United States. On the other hand, France, which is one the dominant players in the European green bond market, on average exhibits an insignificant green bond discount of +30 bps. It should be noted that the additional value of country analysis

alongside the currency analysis is questionable since most of the bonds are denominated in the currencies of the countries they are issued in, and, therefore, there is a high overlap between "Currency" and "Country" groups. Nevertheless, either the country of issue or the currency is expected to represent a significant greenium factor. Next, the greenium estimates were grouped based on the use of proceeds to check if investors differentiate between various green projects and value some types over the others. A significant at 10% level green bond discount of +93 bps was found among the green bonds, the proceeds from which were going to fund projects within the "Clean transport" category. On the other hand, green bonds from the "Eligible Green Projects" category, which is the broadest category, exhibit an insignificant premium of -24 bps. This seems counter-intuitive that investors require significantly higher yields from the green bonds intended to fund clean transport. This discrepancy implies that the issuers may benefit from not specifying the use of proceeds before the green bond issuance. However, it should also be noted that the "Clean Transport" category consists of only 5 greenium estimates, which is not representative of the whole market given that clean transportation is one of the largest categories. All in all, the considerable average difference in greenium in these project categories implies that investors may have preferences for some of the project types and are willing to accept different yields. Therefore, the "Use of Proceeds" can represent another potential greenium factor. Lastly, greenium estimates were subsampled based on the green bonds' issue date to check for any patterns in greenium evolution over time. Neither a significant green bond premium was detected in either of the subgroups nor was it possible to discover any time patterns. Therefore, the issue date does not appear to be a significant determinant of the green bond premium.

Based on the Wilcoxon test results, we reject the first null hypothesis about the overall greenium existence in favor of the alternative hypothesis H2. Therefore, we could conclude that the green bond premium is significantly different from zero in some subsamples, namely, sector, currency, issue amount, coupon type, ESG score and ESG combined score, country, and the use of proceeds. Moreover, it should also be noted that based on the analyzed subsamples, a significant green bond discount was spotted in five of the subgroups compared to only four subgroups that exhibited a significantly negative green bond premium. It should also be noted that the subsample analysis conducted is of limited usefulness due to the unknown correlation effects. It provides a general

overview of the market but can only serve as a mere indication of greenium existence. As was already shown, the same greenium estimates may drive the results in multiple subsamples. For example, all green bonds which were issued in Japanese Yen were also issued in Japan. Therefore, the average greenium is exactly the same for both categories. There may also exist significant correlations between other categories, such as, for example, "Sector" and the "Use of Proceeds." Therefore, there was a need for the subsequent OLS analysis, which provides deeper and less biased insights into the potential greenium factors.

5.3. Greenium determinants

Country and currency could not be used in the same model due to the high correlation. Therefore, specifications 1 and 2 were formed to include them separately. Both models include all of the other variables except the sector, which was correlated with many other variables. In order to avoid significant multicollinearity, the sector was therefore excluded from both models and analyzed separately in specification 3. The initial specifications used in the primary analysis of this thesis were the following:

$$\text{Specification 1.1: } \hat{g}_i = \beta_0 + \beta_1 \ln(\text{Issued Amount}_i) + \beta_2 \text{Verification}_i + \beta_3 \text{Maturity}_i + \sum_{j=1}^{N_{\text{Issue Date}}-1} \beta_4 \text{ Issue Date}_i + \sum_{j=1}^{N_{\text{Issuer Type}}-1} \beta_5 \text{ Issuer Type}_i + \sum_{j=1}^{N_{\text{Country}}-1} \beta_6 \text{ Country}_i + \beta_7 \text{Coupon Type}_i + \sum_{j=1}^{N_{\text{Seniority}}-1} \beta_8 \text{ Seniority}_i + \sum_{j=1}^{N_{\text{Use of proceeds}}-1} \beta_9 \text{ Use of proceeds}_i + \varepsilon_i$$

$$\text{Specification 2.1: } \hat{g}_i = \beta_0 + \beta_1 \ln(\text{Issued Amount}_i) + \beta_2 \text{Certification}_i + \beta_3 \text{Maturity}_i + \sum_{j=1}^{N_{\text{Issue Date}}-1} \beta_4 \text{ Issue Date}_i + \sum_{j=1}^{N_{\text{Issuer Type}}-1} \beta_5 \text{ Issuer Type}_i + \sum_{j=1}^{N_{\text{Currency}}-1} \beta_6 \text{ Currency}_i + \beta_7 \text{Coupon Type}_i + \sum_{j=1}^{N_{\text{Seniority}}-1} \beta_8 \text{ Seniority}_i + \sum_{j=1}^{N_{\text{Use of proceeds}}-1} \beta_9 \text{ Use of proceeds}_i + \varepsilon_i$$

$$\text{Specification 3: } \hat{g}_i = \beta_0 + \sum_{j=1}^{N_{\text{Sector}}-1} \beta_1 \text{ Sector}_i + \varepsilon_i$$

Through the GETS procedure, further described in the method, the two general specifications were further specified to:

Specification 1.2: $\hat{g}_i = \beta_0 + \beta_1 \ln(Issued\ Amount_i) + \beta_2 Verification_i + \sum_{j=1}^{N_{Issuer\ Type}-1} \beta_3\ Issuer\ Type_i + \sum_{j=1}^{N_{Country}-1} \beta_4\ Country_i + \sum_{j=1}^{N_{Seniority}-1} \beta_5\ Seniority_i + \sum_{j=1}^{N_{Use\ of\ proceeds}-1} \beta_6\ Use\ of\ proceeds_i + \varepsilon_i$

Specification 2.2: $\hat{g}_i = \beta_0 + \beta_1 \ln(Issued\ Amount_i) + \sum_{j=1}^{N_{Issuer\ Type}-1} \beta_2\ Issuer\ Type_i + \sum_{j=1}^{N_{Currency}-1} \beta_3\ Currency_i + \sum_{j=1}^{N_{Seniority}-1} \beta_4\ Seniority_i + \sum_{j=1}^{N_{Use\ of\ proceeds}-1} \beta_5\ Use\ of\ proceeds_i + \varepsilon_i$

The coefficients from all five specifications and their level of significance are shown in Table 5. As was explained in the method, each category has a reference value in the regressions. For the ESG Assurance, the reference value is "Yes", issue year has "before 2017" as the reference, issuer type has corporate as the reference, the country has France as the reference, the currency has Euro as the reference, coupon type has plain vanilla fixed coupon as the reference, seniority has senior unsecured as the reference, the sector has utility – other as the reference, and lastly, the reference for the use of proceeds is eligible green projects. In the table below, all coefficients are expressed in percent. The first value is the coefficient, followed by a p-value in parenthesis.

		Specification				
Category	**Subcategory**	**1.1**	**1.2**	**2.1**	**2.2**	**3**
Issue Amount		-0,5562	-0,5117	-0,7205	-0,6801	
		(0,065)*	(0,069)*	(0,022)**	(0,019)**	
Verification		0,6941	0,8798	0,1625		
		(0,323)	(0,168)	(0,810)		
Maturity		-0,0246		-0,0285		
		(0,362)		(0,516)		
Issue year	2017	-0,3146		-0,1169		
		(0,707)		(0,899)		
	2018	0,4359		0,4131		
		(0,632)		(0,667)		
	2019	0,3664		0,3268		
		(0,638)		(0,682)		
	2020-2021	0,7488		0,6289		
		(0,363)		(0,430)		
Issuer type	Agency	-0,7729	-0,5555	-0,9543	-0,7731	
		(0,261)	(0,375)	(0,198)	(0,252)	
	Other GS[1]	0,5159	0,3598	0,3258	0,3395	
		(0,478)	(0,574)	(0,637)	(0,584)	
	Others	-1,1185	1,1049	-1,3719	-1,3321	
		(0,255)	(0,172)	(0,185)	(0,113)	
Country	Eurobond market	-0,3309	0,4346			
		(0,766)	(0,648)			
	Japan	-1,6440	-1,1967			
		(0,128)	(0,211)			
	Spain	-1,3716	-0,7926			
		(0,157)	(0,335)			
	Switzerland	-1,6963	-1,2826			
		(0,025)**	(0,040)**			
	United States	-3,1827	-2,9335			
		(0,004)***	(0,004)***			
	Others	-1,8467	-1,5997			
		(0,034)**	(0,037)**			
Currency	Japanese Yen			-1,3919	-1,0319	
				(0,212)	(0,297)	
	Swiss Franc			-1,7233	-1,4505	
				(0,013)**	(0,017)**	
	US Dollar			-2,5286	-1,8464	
				(0,047)**	(0,052)*	
	Others			-0,9692	-0,6538	
				(0,210)	(0,339)	
Coupon type	Fixed then Floating	-0,4117		-0,8863		
		(0,662)		(0,362)		
Seniority & Collateral	Senior Non-Preferred	-0,2005	0,1707	0,5670	-0,3895	
		(0,859)	(0,821)	(0,624)	(0,625)	
	Senior Preferred	-0,9278	-0,3195	-0,5871	-0,1341	
		(0,327)	(0,690)	(0,553)	(0,874)	
	Senior Secured - FM[2]	2,3387	2,1794	2,0402	1,5818	
		(0,039)**	(0,021)**	(0,121)	(0,142)	
	Unsecured	-0,6947	-0,3169	-1,2095	-0,9630	
		(0,496)	(0,738)	(0,266)	(0,330)	
	Others	1,7865	1,4689	1,9410	1,4618	
		(0,085)*	(0,081)*	(0,094)*	(0,123)	
Use of Proceeds	Clean Transport	0,9588	1,0157	1,4366	1,5415	
		(0,243)	(0,192)	(0,093)*	(0,055)*	
	Energy Efficiency	0,1199	-0,0530	0,3428	0,2541	
		(0,801)	(0,901)	(0,491)	(0,555)	
	Enironmental PP[3]	0,8666	1,3809	0,8684	1,1348	
		(0,349)	(0,073)*	(0,380)	(0,157)	
	Others	-0,3721	-0,5065	-0,4909	-0,4980	
		(0,535)	(0,318)	(0,443)	(0,356)	
Sector	Agency					-1,2027
						(0,054)*
	Banking					-0,3235
						(0,565)
	Financial					-0,1294
						(0,852)
	Official and Municipal					-0,3622
						(0,506)
	Oil and Gas					0,4298
						(0,536)
	Supranational					0,7933
						(0,256)
	Others					-0,9342
						(0,182)
Constant		0,3488	0,1333	0,0054	0,1071	0,9342
		(0,679)	(0,772)	(0,995)	(0,821)	(0,672)
N		63	63	63	63	63
R-Squared		0,5907	0,5587	0,4972	0,4624	0,1488
Adjusted R-Squared		0,2950	0,3486	0,1796	0,2593	0,0405

*p<0,1, **p<0,05, ***p<0,01

[1] Other Governmental/ Supranationals

[2] Senior Secured - First Mortgage

[3] Enironmental Protection Projects

Table 5 – OLS Regression 1-3

5.3.1. Specification 1

Regarding specification 1.1, the general form of specification 1, the model exhibited weak signs of multicollinearity. The variance inflation factor does show a value slightly above the limit of 10. Due to the slight deviation and the model should be specified further, the specification was kept as a starting point. The Breusch-Pagan test for heteroskedasticity and the Shapiro-Wilk test for normality among the residuals both indicated acceptable results. The adjusted R-squared implies that this specification can explain 29,5% of the variability in the greenium.

VIF	Adjusted R-Squared	Breusch - Pagan	Shapiro - Wilk
10,50	0,2950	0,7011	0,38294

Table 6 – Statistical Tests 1

With this specification, we followed the GETS procedure discussed in the method section and eliminated variables judging by their significance. The variable with the highest p-value was coupon type, which exhibited a p-value of 0,662, far from any appropriate level of significance. Eight new regressions based on specification 1 were formed to ensure the potential multicollinearity did not affect the exclusion order. Each of the eight regressions included eight of the nine variables. The excluded variables were different in all of the regressions. With this approach, it was possible to see if the potential multicollinearity biased the regression in the way that it pointed out the wrong variable as the most insignificant one. In this case, all eight models implied that coupon type both was an insignificant variable and that it was the most insignificant variable in the regression. Therefore, the multicollinearity indicated by the variance inflation factor was not a problem in the procedure and had no decisive power. A decision was therefore made to drop coupon type due to its insignificance. The exclusion of coupon type increased the adjusted R-squared. This indicates that the new model was more appropriate in explaining the size of greenium than the more general model.

VIF	Adjusted R-Squared	Breusch - Pagan	Shapiro - Wilk
10,06	0,3104	0,6580	0,49106

Table 7 – Statistical Tests 2

After this step, the variance inflation factor was just at the limit for multicollinearity. Both the Breusch-Pagan test and the Shapiro-Wilk tests were fine. This regression indicated that the issue

date was the next variable to be dropped. The lowest p-value was 0,368, which also is far from an acceptable level of significance. To ensure the weak signs of multicollinearity did not affect the decision to exclude the issue date, the same procedure as described above was performed, but this time with seven models. All of them implied that the issue date was an insignificant variable. This time, only three out of seven regressions showed that issue date was the most insignificant variable. Together with the previous regression, half of them pointed in the same direction. Since the variance inflation factor was on the limit, and half of the regressions pointed towards the issue date, the decision was made to follow the first result and drop the issue date. Which year the bond is issued can therefore be concluded not to impact the size of greenium.

VIF	Adjusted R-Squared	Breusch - Pagan	Shapiro - Wilk
9,93	0,3465	0,4575	0,62057

Table 8 – Statistical Tests 3

This step further increased the adjusted R-squared. It was also the first regression that passed all of the three tests. In this regression, the maturity had a p-value of 0,358, which was the highest in the model. This implies that even though maturity impacts the yield, it was found insignificant in explaining the difference between green and conventional bond yields. The variable cannot help estimating the size of greenium.

VIF	Adjusted R-Squared	Breusch - Pagan	Shapiro - Wilk
9,78	0,3486	0,3998	0,65411

Table 9 – Statistical Tests 4

Without maturity, the adjusted R-squared was further increased. The variance inflation factor further decreased, and the Breusch-Pagan test and Shapiro-Wilk tests generated acceptable p-values. In this model, the issuer type had the highest p-value of 0,172, which was also the highest among all variables. This variable was therefore excluded.

VIF	Adjusted R-Squared	Breusch - Pagan	Shapiro - Wilk
9,35	0,3406	0,4230	0,77375

Table 10 – Statistical Tests 5

Without the issuer type in the model, the adjusted R-squared was decreased for the first time. The new value of 0,3406 is a 2,3% decrease. The tree tests all generated acceptable values. To evaluate if the elimination of variables should stop or not, the variable with the highest p-value was once again excluded. This time it was "verification," which had a p-value of 0,186. This step further decreased the adjusted R-squared to 0,3291, a total decrease of 5,6% from the highest value. A decision was therefore made to undo these two last steps. Issuer type and ESG Assurance were added back to the model. The final specification for this model is, therefore, specification 1.2.

VIF	Adjusted R-Squared	Breusch - Pagan	Shapiro - Wilk
9,78	0,3486	0,3998	0,65411

Table 11 – Statistical Tests 6

As shown in Table 11, none of the tests indicated any problems with this specification.

5.3.2. Specification 1.2

In specification 1.2, the issue amount, country, seniority, and lastly, the use of proceeds are all significant at the 10% level. This also implies that neither verification nor issuer type was significant at any appropriate level. The issued amount has a negative coefficient of -0.5117 that is significant at the 10% level. This implies that the difference in yield between green and conventional bonds is more negative for larger issue sizes than smaller ones. According to this result, the likelihood of finding a greenium is, therefore, larger with increased issue amount.

The p-value for verification is 0,168 and therefore concluded to be insignificant in this regression. The coefficient is positive at 0.8798. If the variable had been significant, this would have implied that a verified bond is more likely to exhibit a green bond discount. Since the coefficient is insignificant, the results contrast the findings by earlier studies that have found strong evidence that a third-party verification was the factor with the greatest influence on the size of the yield (MacAskill et al., 2021; Sheng et al., 2021; Wang et al., 2019). Also, the issuer type is found insignificant in specification 1.2. The p-values are 0,375, 0,574, and 0,172, which is above the required levels of significance. These results are in line with MacAskill et al. (2021), who also

found it insignificant but in contrast with Sheng et al. (2021) and Kapraun & Scheins (2019), who argued that the type of issuer affects the size of greenium.

The same regression also generates interesting insights regarding the country or region in which the bonds were issued. There is no significant difference between France as it is the reference value and the Eurobond market, Japan, or Spain. On the other hand, Switzerland comes with negative coefficients of -1.2826, significant at a 5% level. The coefficient for the United States is negative with a value of -2.9335. This value is significant at the 1% level and implies that the yield for a green bond issued in the United States is on average 293 basis points lower compared to a similar bond issued in France, all else equal. The last dummy variable for the country, "Other," incorporates those countries with less than three greenium estimates. These countries are Australia, Belgium, and Germany. Also, this mix of countries implies a lower by 160 bps yield compared to France. This value is significant at the 5% level. This regression, therefore, shows that which country the bond is issued in is a relevant factor in determining the greenium. A global issuer interested in accessing cheap funding can potentially do so by issuing the bond in the United States instead of, for example, in France. The results presented in this section are in line with the findings by Kapraun & Scheins (2019), discussed in the literature review. They also concluded that country is relevant for determining the size of greenium.

Specification 1.2 also indicates that seniority and collateral as a combination is a relevant factor. The regression implies no significant difference in the size of greenium between the reference value, Senior Unsecured, and Senior Non-Preferred, Senior Preferred, or Unsecured. On the other hand, the coefficients for Senior Secured – First Mortgage is positive with a value of 2.18, significant at the 5% level. Compared to Senior Unsecured bonds, bonds classified as Senior Secured – First mortgage do, on average, exhibit higher yields, all else equal. The model also implies that the variable "Others" is significant at the 10% level. The variable does, in this case, include Senior Secured, Senior Secured – First and Refunding Mortgage, Senior Secured – General & Refunding Mortgage, and Subordinated Unsecured. Since it is a mix of different levels, this coefficient only tells that seniority and collateral are relevant factors. It cannot be used to determine any specific patterns. Since only one of the categories except for the combined "Others" is significant, it is impossible to compare the coefficients between the different categories to evaluate

any trend. Therefore, it is impossible to conclude whether the yield is expected to be higher or lower due to either seniority or collateral. However, since there is a significant difference between senior unsecured and senior secured bonds, it is possible to conclude that collateral or collateral in combination with seniority is a relevant factor and does impact the size of greenium.

Additionally, the use of proceeds exhibits significant coefficients. At the significance level of 10%, "Environmental Protection Projects" exhibit a coefficient of 1.3809. Compared to the reference value, "Eligible Green Projects," this category is expected to generate a yield that on average is 138 bps higher, all else equal. Neither Clean transport, Energy Efficiency nor the category "Others," here including Acquisition, Environmentally Sustainable Projects, General Purpose/Refinancing, Green Construction, Refinance/Financing Expenses, Renewable Energy Projects, Social Bond/Loan, or Toll Roads/Streets/Highways indicated any significant difference in greenium compared to the reference value. It is therefore hard to draw any general conclusions based on this result. Despite this, it can still be concluded that the use of proceeds is a relevant greenium determinant.

5.3.3. Specification 2

The general specification 2.1 exhibits weak signs of multicollinearity with a variance inflation factor of 12,37. Despite this, it was still possible to estimate an OLS regression with all the variables. Since the intention was to eliminate insignificant variables further, the VIF was expected to drop in the final model. The Breusch-Pagan test and the Shapiro-Wilk test generated acceptable p-values, which implied that the model did not suffer from heteroskedasticity and that the residuals did follow a normal distribution.

VIF	Adjusted R-Squared	Breusch - Pagan	Shapiro - Wilk
12,37	0,1796	0,9283	0,67449

Table 12 – Statistical Tests 7

According to the GETS procedure, "Verification" should be dropped from the model due to a p-value of 0,810. Eight different models were created to make sure the multicollinearity did not have an impact on this decision. In each of the models, one of the other variables was excluded. All of

the models indicated that the variable for verification was insignificant. Seven of the eight models also showed that verification was the variable with the highest p-value. Therefore, the variable "Verification" was dropped out of the regression and considered insignificant.

VIF	Adjusted R-Squared	Breusch - Pagan	Shapiro - Wilk
10,48	0,1994	0,9322	0,68352

Table 13 – Statistical Tests 8

By dropping verification, the adjusted R-squared increased. The VIF indicated an improvement and decreased but still was above the limit of 10. The p-values were acceptable for both the Breusch-Pagan and the Shapiro-Wilk tests. In this step, the maturity variable had a p-value of 0,523, which was the highest among all variables. Due to a variance inflation factor of 10,48, the process of conducting several regressions without one variable in each was repeated. This time, seven regressions were performed of which all implied that maturity was insignificant. Five of those seven also indicated that maturity was the most insignificant variable left in the regression. The decision was, therefore, to drop maturity.

VIF	Adjusted R-Squared	Breusch - Pagan	Shapiro - Wilk
9,50	0,2111	0,8928	0,57115

Table 14 – Statistical Tests 9

This step further increased the adjusted R-squared. An evaluation of the variance inflation factor did show a value below the critical limit. The Breusch-Pagan test and the Shapiro-Wilk test showed acceptable p-values that implied no heteroskedasticity problems and that the residuals were normally distributed. In the next step, the variable with the highest p-value was the issue date. Within the issue date category, the lowest p-value was 0,457, which is clearly above the significance level. The issue date was, therefore, dropped out of the regression.

VIF	Adjusted R-Squared	Breusch - Pagan	Shapiro - Wilk
8,94	0,2603	0,9723	0,59784

Table 15 – Statistical Tests 10

In the new regression, the adjusted R-squared further increased. All of the three tests did also show acceptable results. Next, the coupon type showed the highest p-value of 0,309 and was, therefore, dropped out.

VIF	Adjusted R-Squared	Breusch - Pagan	Shapiro - Wilk
8,58	0,2593	0,9087	0,76510

Table 16 – Statistical Tests 11

In this step, the adjusted R-squared declined slightly. Since the decrease in adjusted R-squared was only 0,38%, the decision was made to continue eliminating insignificant variables. The values from the three tests were all acceptable. In this regression, the variable with the highest p-value was seniority. Within the category, the lowest p-value was 0,123. The decision was, therefore, to drop seniority and collateral. The adjusted R-squared declined further to 0,2426, which is 6,4% below the previous level. Since this step caused the model to explain the variation in greenium to a significantly lower extent, the variable "Seniority & Collateral" was added back to the regression. The final test results for this regression are displayed in Table 16 above.

5.3.4. Specification 2.2

In specification 2.2, three variables, namely, the issue amount, currency, and the use of proceeds, were found significant at least at the 10% level. On the other hand, the issuer type and the seniority & collateral were found insignificant. The coefficient for the issue amount is significant at the 5% level. The coefficient is negative with a value of -0.6801. This implies that the difference in yield between green and conventional bonds is more negative when the issue amount increases. This result is not surprising since it is well in line with specifications 1.2. Further, the issuer type was found insignificant. Also, this in line with specification 1.2. The variable "Others" with a p-value of 0.113 is almost significant at the 10% level. This implies that it is likely that the issuer type can explain some of the variations in greenium. However, it cannot be concluded that its effect on the greenium size is significant.

One of the significant variables in this model is currency. The regression shows that all else equal, green bonds issued in Swiss Franc trade at a yield significantly lower than bonds issued in Euro, which is the reference currency. The difference between the two currencies is 145 bps. At the 10% level of significance, it is also shown that green bonds issued in USD exhibit lower yields. On average, green bonds denominated in USD are issued at a yield of 185 bps lower than bonds issued in Euro. The overall conclusion is that currency is a relevant factor in determining the size of greenium. These results are in line with those of Kapraun & Scheins (2019), who also concludes that currency is a significant determinant of greenium. Their analysis further shows signs that green bonds denominated in Euro and USD are traded at more negative greenium than other currencies.

This regression does not show any evidence that seniority and collateral are relevant in explaining the variation in greenium. This result contradicts the findings from specifications 1.2. On the other hand, two of the p-values are close to being significant at the 10% level. Despite this, it is impossible to draw any general conclusions about the variable based on this specification. Similar to Specification 1.2, the use of proceeds is significant at the 10% level. The variable for clean transport has a coefficient of 1.54, which implies that bonds used for this purpose are issued at a 154 bps higher yield than the reference value, "Eligible green projects." Even though specification 1.2 also found the use of proceeds to be a significant factor, significant variables within the category differ. For this analysis, the most relevant finding is that the category overall is significant and that both specifications indicate it.

5.3.5. Specification 3

Since it was not possible to include sector in either specification 1 or specification 2, specification 3 was formed, including the factor as the only independent variable. Since sector was the only variable included in the model, there was no need to test for multicollinearity.

Adjusted R-Squared	Breusch - Pagan	Shapiro - Wilk
0,0405	0,9781	0,15892

Table 17 – Statistical Tests 12

The table above shows that the model does not suffer from heteroskedasticity and that the residuals follow a normal distribution. The model has an adjusted R-squared of 0,0405, which means that it does not have the same degree of explanatory power as specifications 1.2. and 2.2. The variable for the agency is different from the reference variable, utility – other, at the 10% level of significance. Its coefficient equals -1.2027, which means that greenium is on average 120 bps lower for agencies than it is for the utility sector, all else equal. The other sectors do not show any difference compared to the reference value. Despite this, it implies that the sector is a relevant factor in explaining the variation in greenium.

5.3.6. Specifications with ESG Scores

In the next step of the analysis, the purpose was to repeat the steps performed with specifications 1 and 2 but with the green bonds for which the ESG scores were available. Due to this limitation, the number of bonds in the regressions shrank to 34. The ESG scores were also only available for bonds issued by corporations. Due to the small sample size, multicollinearity for the multivariable regressions was very high (Sari et al., 2018). Therefore, the decision was made not to specify multivariable regressions, including all the factors used in the previous analysis. The correlation between the five different ESG scores was also too high, which would have made it impossible to include all of them in the same model, even for a larger sample size. The "ESG score" and the "ESG combined score" are correlated with each other and with "E," "S," and "G" scores because they are essentially based on them.

Moreover, due to the high correlation shown in Table 18 below, it was not possible to include the "E," "S," and "G" scores together in the same regression since they are correlated as well. For such a specification to work, the correlation must be less than 0,7 (Lind et al., 2018). The decision was therefore made to conduct multiple single-variable regressions instead. This way, it was possible to estimate the impact from the different scores shown by specifications 4-8.

Correlations	E score	S score	G score
E score	1		
S score	0,8370	1	
G score	0,7970	0,5926	1

Table 18 – Correlation Matrix E, S, and G

Specification 4: $\hat{g}_i = \beta_0 + \beta_1 ESG\ combined\ score_i + \varepsilon_i$

Specification 5: $\hat{g}_i = \beta_0 + \beta_1 ESG\ score_i + \varepsilon_i$

Specification 6: $\hat{g}_i = \beta_0 + \beta_1 E\ score_i + \varepsilon_i$

Specification 7: $\hat{g}_i = \beta_0 + \beta_1 S\ score_i + \varepsilon_i$

Specification 8: $\hat{g}_i = \beta_0 + \beta_1 G\ score_i + \varepsilon_i$

The following five regressions were estimated based on the Specifications 4-8, with the coefficients reported in percent and the corresponding p-values in parathesis:

	Specification				
Category	**4**	**5**	**6**	**7**	**8**
ESG combined score	0,0129				
	(0,170)				
ESG score		0,0170			
		(0,056)*			
E score			0,0157		
			(0,067)*		
S score				0,0158	
				(0,078)*	
G score					0,0120
					(0,085)*
Constant	-0,0569	-0,9973	-0,9899	-0,8350	-0,6454
	(0,318)	(0,115)	(0,132)	(0,161)	(0,201)
N	34	34	34	34	34
R-Squared	0,0580	0,1097	0,1010	0,0941	0,0898
Adjusted R-Squared	0,0286	0,0819	0,0729	0,0658	0,0614
Breusch-Pagan test	0,6487	0,9952	0,8627	0,6297	0,9239
Shapiro-Wilk test	0,22052	0,49644	0,35620	0,42669	0,60864
			*p<0,1, **p<0,05, ***p<0,01		

Table 19 – OLS Regression 4-8

Since all the models only include one variable, the variance inflation factor equals 1 for all models. The test for multicollinearity was, therefore, neither required nor applicable. As shown in Table 19, none of the specifications did show any signs of heteroskedasticity. The residuals for all models also follow a normal distribution concluded numerically by the Shapiro-Wilk tests and graphically by plotting the residuals together against the normal distribution curve.

According to specifications 5-8, Table 19, the ESG score, E score, S score, and G score were significant at the 10% level. ESG combined score in specification 4, on the other hand, was found insignificant. The ESG combined score has a coefficient of 1,29 bps with a p-value of 0,17. The adjusted R-squared of 0,0286 is also low, which means that the model cannot explain much of the variation in greenium. Since the ESG combined score is the only variable included and found insignificant, it implies that the factor is not relevant in determining the size of greenium. In specification 5 with the ESG score, the coefficient is 0,0170 with a p-value of 0,056. This implies that an increase in the ESG score on average leads to a higher greenium. This means that when the

ESG score of the issuer improves by 1, the greenium is on average increasing by 1.7 bps. In other words, on average, the greenium is lower for the less sustainable issuers and higher for the more sustainable ones. The model predicts an average greenium of 0 for the issuers with an ESG score around 59. This means that green bonds from the issuers with the ESG score below this threshold exhibit a green bond premium and above this threshold exhibit a green bond discount, accordingly. The adjusted R-squared is at 0,0819, which is considered relatively high for a single variable regression model. Since two different ESG scores show different results, with one significant and one insignificant, it strengthens the study's credibility. The correlation between the two scores is 0,7. Therefore, it is unlikely that the ESG score is significant due to the omitted variable bias. If that had been the case, ESG combined score would have been significant too.

Specifications 6-8 imply that the coefficients for all of the induvial scores are positive and significant at the 10% level. The coefficients for the "E", "S" and "G" scores are 1,57, 1,58, and 1,20 bps with the corresponding p-values 0,067, 0,078, and 0,085, respectively. This implies that all of the three scores do affect the greenium positively. A bond issued by a corporation with higher scores on either of the dimensions exhibits a more positive greenium on average. The adjusted R-squares from the regressions are 0,0729, 0,0658, and 0,0614, respectively, which further implies that the three scores can explain the variation in the size of greenium. Since all of the coefficients are of the same sign, the implications are the same for all of them. An issuer with a better sustainability performance on either environmental, social, or governance dimensions is expected to face a more positive green bond premium. If there is a greenium, it will be lower for the issuers with lower ESG scores and closer to zero for the issuers with higher ESG scores. In the case of a green bond discount, the issuers with a higher ESG score are expected to exhibit a higher green bond discount. This implies that the issuers with a relatively low sustainability performance may access cheaper funding by issuing a green bond than issuing a conventional one. In addition to this, it should be noted that the "E" score has the lowest p-value, which means that the issuers' environmental performance can explain the variation in greenium to a more significant extent than their social or governance performance. This conclusion is further supported by a higher adjusted R-squared of the "E" score than other pillars.

In the previous study, Kapraun & Scheins (2019) also concluded ESG scores to be a significant factor. They found evidence suggesting that investors favored both top performers and bottom performers for their ESG initiatives while the mid performers experienced the least negative greenium. Their findings on investors favoring low performers are consistent with significantly positive coefficients. Our results indicate that greenium increases steadily from being negative on the lower part of the ESG rating scale to being positive for the upper part. Therefore, our results are similar to Kapraun & Scheins (2019) for the bottom performers but are different for the top performers since their relationship is not linear. Another study conducted by (Immel et al., 2020) also concluded ESG scores to be relevant in explaining the variation in greenium. Similar to our study, the authors analyzed the scores separately. However, in contrast to our results which indicate that all three separate scores are significant, with the "E" score exhibiting the highest level of significance, they only found the "G" score significant.

As earlier stated, the hypotheses referring to the existence of greenium and greenium determinants are:

Hypothesis 1:
H0: The green bond premium is insignificant in the primary green bond market
H1: The green bond premium is significant in the primary green bond market
H2: The green bond premium is significant in some market segments of the primary green bond market

Hypothesis 2:
H0: Bond-specific characteristics cannot explain the green bond premium
H1: Bond-specific characteristics can explain the green bond premium

Hypothesis 3:
H0: Issuer-specific characteristics cannot explain the green bond premium
H1: Issuer-specific characteristics can explain the green bond premium

The results presented above imply that all three null hypotheses are rejected. The average greenium in the main sample is -8 bps. It points to greenium existence, however not to a significant extent.

The issue size weighted greenium is -67 bps, which indicates that the market is evolving towards a more negative greenium environment. A significant greenium was found when the main sample was subsampled based on the sector, currency, issue amount, coupon type, ESG, and ESG combined scores, country, and the use of proceeds. This means that the issuers in some specific categories can raise funds at lower yields by issuing green bonds compared to conventional bonds. However, an average issuer cannot do that since the overall market does not exhibit a significant greenium. Therefore, H0 of the first hypothesis is rejected in favor of H2. It was also shown that the variation in greenium could be explained by some of the bond-specific characteristics, namely, issued amount, country, currency, seniority & collateral, and the use of proceeds. Moreover, some of the issuer-specific characteristics, such as the sector, ESG, "E," "S," and "G" scores, explain the greenium to a significant extent. Therefore, both the second and third null hypotheses are also rejected. On the other hand, the results indicate that the variation in greenium cannot be explained to a significant extent by either the third-party verification, maturity, issue year, issuer type, coupon type, or ESG combined score.

6. Discussion

6.1. Theoretical implications

The significant greenium found in some of the subsamples challenges traditional economic and financial theories. The bond pricing and arbitrage theories predict that when the market is efficient, the price of an asset should be based on its fundamental characteristics and equals the present value of its future cash flows. Therefore, in the market equilibrium, two identical assets should have the same price. If there are any price differences, they represent an arbitrage opportunity that arbitrageurs will exploit. Since the green and conventional bonds in our sample have the same fundamental characteristics, it implies that both green bond discount and green bond premium are against the traditional theory. However, given the situation with green bonds oversubscription, the green bond market currently is very scarce. Given the rapid market expansion, as the new issuers come and saturate the green bond market, the traditional theory predicts that market forces will balance potential yield differences. This implies that greenium may soon disappear, and green bonds will be traded on par with their conventional counterparts.

The challenge to the traditional theory can be viewed from two perspectives. It can either mean that bond pricing models are wrong as they do not account for non-economic variables, such as investors' sentiments. It can also mean that the pricing models are correct, but some economic factors are currently not included in the model. The pricing models may not objectively represent reality because they are based on simplifying assumptions. First of all, they assume that investors are rational utility maximizers with homogeneous views on the market. In reality, we observe that some investors are driven by non-pecuniary motives and have diverging tastes and preferences. This is similar to the argument of Fama & French (2007) that market participants' tastes can lead to long-lasting deviations from CAPM equilibrium. Later, Pedersen et al. (2020) have developed an ESG-adjusted CAPM that considers investors' ESG preferences and shows that there might be multiple equilibriums depending on investors' ESG awareness. Therefore, investors' pro-environmental preferences can be one explanation of this phenomenon. Zerbib (2019) also supports this view.

The second perspective implies an unknown factor that has not been adequately investigated and incorporated in pricing models. This view is supported by Jason Mortimer (Climate Bonds Initiative, 2018), who found the superior risk-adjusted performance of green bonds in the secondary market compared to conventional bonds and attributes it to the "green factor." The author further states that issuers' commitment to green bond issuance can imply their superior sustainability and strategic governance. Therefore, the market can eventually agree to justify the green factor as a fundamental quality factor, similar to the "insurance premium." For instance, an issuer's sustainability performance which can be proxied by their ESG score can represent a quality factor that would have affected the issuer's default probability if it had been adequately accounted for. However, there is a problem with this explanation. If a green factor would communicate information on companies' fundamentals, it would similarly affect all the companies' debt. In other words, their sustainability performance should affect their probability of default equally for both their green and conventional bonds. Since the bonds were matched on bonds' grade, seniority, and collateral and were also issued by the same issuer, this explanation does not hold.

Another way to analyze the green factor would be to assume that it relates solely to specific green bonds and not the issuer. Thus, it communicates positive information about green bonds to investors, which is not adequately accounted for by the rating agencies. In other words, rating agencies do not incorporate climate-related risks in their evaluations of green bonds. Therefore, green bonds as financial instruments are less risky than their conventional counterparts even though they have the same rating. If investors believe in it, that will explain why they are ready to pay a premium for green bonds compared to "identical" conventional bonds. However, that would no longer be greenium. That would mean that less risky assets are traded at lower yields than more risky assets, which is perfectly in accordance with the theory. Suppose credit ratings of green bonds did not fully represent their actual risk level. In that case, greenium calculations are biased since less risky green bonds would be matched with more risky conventional bonds.

Since the research objective was to explain greenium, the study was focused on finding and analyzing factors that might affect it. The results show that some factors, such as the issuers' ESG score, can explain variation in greenium significantly. However, they do not explain the reasons for its existence. According to traditional theory, investors should be indifferent to any non-

economic factors if two financial instruments have the same fundamental characteristics. Therefore, the only valid explanation is that greenium is driven by investor's sentiments, tastes, environmental awareness, and climate-related goals. However, this argument fails to explain the nature of the green bond discount.

6.2. Practical implications

The results indicate that green bonds with an ESG assurance provider on average exhibited -11 bps greenium compared to a +2 bps greenium for the green bonds without it. This implies that investors are willing to accept lower yields provided by green bonds issued under the ESG framework previously examined by a third party, which aligns with the expectations defined by the literature review and theory. The causes, however, may vary. The lower offer yields may be motivated by relatively high costs incurred due to the verification procedure on the issuers' part. On the investors' side, the willingness to accept lower yields may be motivated by the decreased information asymmetry and, therefore, the decreased risk for greenwashing provided by the third-party verification. On the other hand, investors, on average, are ready to acquire green bonds without such assurance only at a discount. It implies that issuers who issue green bonds under the uncertified ESG framework may decrease their cost of capital by funding the same green projects with conventional bonds until they obtain the necessary verifications for their ESG framework.

It should be noted that verification can be of 2 kinds, namely, issuer-specific and bond-specific. One can obtain verification for the ESG framework as a whole or choose to obtain a certification, such as the one provided by the CBI, before issuing a specific green bond. The former was analyzed in this study, and it is the latter that had on average been found significant by other studies. This implies that investors consider bond-specific certifications to a higher degree in evaluating green bonds and are less interested in the overall framework. It means that issuers can benefit from a more negative greenium by obtaining certification for some specific green bonds rather than verifying the whole framework.

However, as concluded earlier, the results were not significant. It means that issuers' efforts in signaling their trustworthiness by investing in third-party approvals do not pay off in terms of a

significantly negative greenium. This can explain why some issuers prefer to refrain from obtaining the necessary verifications given their relatively high costs. Moreover, as earlier described in the literature review, the green bond certification market is at its early development stage and is highly heterogeneous, especially in some countries such as China (Wang et al., 2019). This can further restrain issuers from obtaining a certificate, given that investors' preferences regarding assurance providers vary. Therefore, the current state of the green bond certification market calls for standardization. As the certification market moves towards a more regulated environment, we expect third-party verification to become a norm which will further contribute to market legitimacy.

The results indicated that issuers' ESG score has a higher explanatory power in defining greenium than their ESG combined score. It means that a weighted average of companies' performance on environmental, social, and governance dimensions based on publicly reported data, such as companies' CSR reports, determines greenium to a larger extent compared to the same score, which is discounted for ESG controversies captured from global media that materially impact the companies. In other words, the information that companies disclose about themselves is more significant in defining the greenium size than a more comprehensive evaluation of their ESG performance. Generally, it means that investors consider companies' sustainability performance. However, their view is primarily affected by the information disclosed by the companies themselves.

Another interpretation would be that since issuers themselves largely define the yields in the primary market, it is natural that they rely on self-reported information when defining the yields. Moreover, it may not be in their primary interest to consider negative media stories, scandals, ongoing legislation disputes, lawsuits, or fines on which the ESG controversy score is based. On the other hand, in the secondary market, the ESG combined score that incorporates ESG controversies is expected to significantly affect greenium. The yields are mainly driven by supply and demand forces and are less dependent on the issuer. For the market, standardized mandatory non-financial reporting is required to provide a more objective picture of companies' ESG performance. It would allow investors to make a more comprehensive and rounded evaluation of

issuers' sustainability performance and, with this, make their investment decisions by incorporating all material information.

The results also showed a significantly positive relationship between greenium and the issuers' ESG score. Issuers with a "C" grade on average exhibited a -71 bps greenium while "A" graded issuers on average exhibited a greenium of +43 bps. It means that greenium is negative for the less sustainable issuers, and it turns into a green bond discount for the more sustainable ones. It implies that investors favor less sustainable issuers and are ready to accept lower yields. At first glance, it sounds counter-intuitive that investors are ready to pay a premium for acquiring green bonds from less sustainable issuers. However, it may be explained by the additionality theory. If pro-environmental investors driven by climate-related concerns seek the most efficient way to allocate their funds, they should be investing in green bonds from less sustainable issuers. Issuers who score low on the ESG rating scale, specifically on the environmental pillar, have the largest potential for improvement. Therefore, by unlocking green capital for the least sustainable issuers, investors can achieve the highest value-added. On the other hand, it makes much less sense from the additionality perspective to pay a premium to sustainability leaders.

Another way to look at this relationship would be to examine the motives of issuers from different groups. As discussed in the literature review and additionality theory, many issuers come to the green bond market primarily to gain access to cheaper funding and signal their environmental commitments to investors (Hamilton & Eriksson, 2011; Maltais & Nykvist, 2020). Therefore, this category of issuers is expected to act according to this agenda. On the other hand, sustainability leaders with ESG considerations deeply rooted in their DNA may be in a better position to offer higher returns to investors in terms of a green bond discount, as pro-environmental motives have driven them even before the emergence of the green bond market.

When the ESG score was decomposed into separate "E," "S," and "G" pillars, all of them were found to have a significant effect on the variation in greenium. Among all, the "E" score was the most significant in determining the greenium size. The overall results are similar to the findings of Immel et al. (2020). However, they concluded that the "G" score is the main driver for green bond spreads. The authors concluded that the trustworthiness of issuers represented through the

"G" score is more relevant than their environmental friendliness represented through the "E" score, as trust is crucial due to the peculiar properties of the use of proceeds. Therefore, the confidence that the proceeds will be used as promised is more important than their potential environmental benefits. A reason for the diverging findings can be that most of the ESG-rated bonds in our sample had an ESG Assurance provider. That means that a third-party assurance already covered the governance dimension, which is relevant to the use of proceeds. Since the third-party verification serves as the primary indication of issuers' trustworthiness, this may have downgraded the significance of the "G" score in our sample. On the other hand, if climate-related goals drive investors, then it is natural that green bonds' environmental performance, which is proxied by issuers' environmental performance, should be the main concern. Therefore, it should be no surprise that the "E" score is a more significant greenium determinant compared to "S" or "G" scores.

The results indicated that greenium values could range from being significantly negative to be significantly positive. The average greenium ranges between -106 bps and +93 bps in various subsamples. This means that some green bonds exhibit a premium while others are sold at a discount. If investors indeed have specific preferences for some project types over the others, it can explain this significant variation in greenium. This is also supported by the fact that the use of proceeds was a significant greenium determinant. Suppose pro-environmental investors prefer specific use of proceeds, such as the "Energy efficiency" over the "Clean Transport," because they believe it has a higher potential in achieving positive environmental outcomes in terms of a reduction in GHG emissions. In such a case, it can explain that these investors are willing to pay a greenium for the green bonds from the energy efficiency category. Suppose the same group of investors does not trust the environmental benefits of clean transportation projects. In that case, it can explain why they are not willing to pay a greenium to acquire bonds from this category. However, it does not explain the fact that these bonds are traded at a discount. It is counter-intuitive that investors require higher yields or are only willing to acquire some green bonds at a discount, even if they may not lead to the same environmental outcomes. This category should then be traded as conventional bonds without any greenium but also any discount. On the issuers' part, it also

remains a question as to why they choose to issue green bonds at a discount since funding the same project with a conventional counterpart would decrease their cost of capital.

Our findings underline the necessity for establishing a comprehensive universal tool that would help investors effectively evaluate issuers' sustainability performance, especially on the environmental dimension, and establish a clear link between green bonds' financial characteristics and environmental influence. The capital is allocated most efficiently only if it leads to the most significant positive environmental outcomes. A breakthrough in this area has already been achieved by introducing Climate Bonds Taxonomy which is science-driven guidance that identifies the projects needed to deliver a low carbon economy and provides a GHG emissions screening criteria for each of them. However, the Climate Bond Taxonomy only deals with the environmental side of the issue. At the moment, it does not have any clear linkages to the green bond premium. Therefore, it is recommended that future mechanisms focus on ways to align green bond yields with their environmental impact.

6.3. General implications

This research was motivated by the ongoing debate around greenium existence and its determinants. Therefore, the main focus of this study was to examine greenium phenomena and analyze the factors which might explain it. However, while the researchers in this area were trying to answer the question about greenium existence and its determinants, little has been said about the universal purpose of greenium and its overall role in transitioning towards a low-carbon economy. The purpose of greenium should be to facilitate the decarbonization of the economy by making green investments more financially attractive. However, the problem is that in market equilibrium, a financial instrument cannot be more attractive to both issuers and investors at the same time compared to an identical financial instrument. A negative greenium makes green investments more attractive only from the issuers' perspective. The results show that the pro-environmental preferences of investors are not a strong enough motivation to establish a significantly negative greenium in the market. When greenium is not significant, it raises the question if green bonds are any different from conventional bonds. On the other hand, when

greenium is positive, green investments are more financially lucrative than non-green investments only from the investor's perspective. Therefore, future research in this area should focus on aligning issuers' and investors' financial interests and making green investments attractive for all parties.

The ultimate goal of green bonds is to redirect capital to green investments and support the road to net-zero. As discussed in the additionality theory, the rapid market expansion does not necessarily imply a proportionate growth in the number of green projects. Therefore, the immediate benefits of the green bond market are constantly questioned. So far, the green bond market has been serving to raise investors' awareness and enhance the visibility of green investments. Moreover, the green bond market has provided other externalities to catalyze cultural change and new industry standards and practices. Therefore, it should not be assessed on its ability to provide immediate benefits. There should remain no doubt about green assets' importance in transitioning to a low-carbon economy. The focus should shift towards greenium, which is directly related to green projects' cost of capital. Therefore, greenium is the keystone of the green bond market evolution. Making green investments more lucrative than non-green alternatives by affecting the cost of capital should tip the scales in favor of the green projects on purely financial grounds. Therefore, the next stage of the market development should involve creating a real impact on the issuers' cost of capital and contribute to the realization of green projects that would not have taken place otherwise. We can expect the green bond additionality to materialize at a later stage in terms of a real shift in capital consistent with the long-term market objectives (Kidney, 2018).

The green bond market today calls for cooperation between the private and public sectors. The lack of government intervention at the early stages of the market development allowed the market forces of supply and demand to establish equilibrium. However, it has also led to multiple obstacles. The prevailing heterogeneity of private certification mechanisms, ESG frameworks, guiding principles, and standards requires standardization and harmonization to build the foundation for sustainable market growth. The public sector's involvement is crucial for the green bond market's viability. The question is what kind of economic intervention is the most efficient. As a minimum, policymakers should focus on establishing a universal regulatory framework with (1) a mandatory verification and labeling scheme for both ESG frameworks and green bonds, (2)

a standardized set of mandatory green bonds' guiding principles, and (3) a mechanism that would link green bond's financial dimension to their environmental outcomes. After that, (4) a credit rating mechanism to evaluate and incorporate green quality into bond pricing should be established. Finally, (5) special tax treatments represent one way to promote greenium and ensure green bonds' additionality. The first and the second aspects involve harmonizing and making mandatory the verification and labeling schemes and the guiding principles that already exist in the market and are currently being adopted voluntarily. The third aspect suggests connecting the monetary value of green bonds to their environmental benefits. For instance, investors should have a clear tool to calculate the avoided GHG emissions per dollar invested in a specific green bond. This would enhance green bonds comparability and allow for the efficient allocation of funds. The fourth point relates to incorporating climate-related risks into green and conventional bonds credit rating models. This is expected to lower the risk of climate-aligned investments compared to non-green alternatives. Lastly, special tax treatment for green bonds can make them more financially attractive compared to conventional counterparts. The implementation of these measures is expected to enable the full potential of the green bond market.

Our findings confirmed that greenium in the primary market is not significant at the current stage of market development. Moreover, classical economic and financial theories predict that greenium may soon disappear. Given the essential role that it plays in decarbonizing the economy, future research in this field should focus on the ways to nurture and maintain greenium in the long term. Moreover, a system-level change in the investment culture is necessary. Therefore, future research should also focus on cultivating environment-oriented investment culture since the ethical dimension of the financial world is currently largely underemphasized. This paper contributes to understanding the greenium phenomena and underlines the importance of shifting the focus from explaining the greenium to enabling and maintaining it.

7. Conclusion

This study aimed at finding greenium and explaining it. The results indicate an insignificant green bond premium of -8 bps. Therefore, we conclude that there is no significant difference in yield between green and conventional bonds in the primary market. It means that an average issuer offers a green bond yield comparable with the yield they would offer for a conventional bond with similar characteristics. It also means that an average investor is willing to accept a yield that is not significantly different from the yield they would receive from investing in an equivalent conventional bond. The issue size weighted greenium was found to be -67 bps which implies that green bonds of larger sizes exhibit more negative green bond premiums. The OLS results also support this. Moreover, it was discovered that the average issue amount is steadily growing over time. Therefore, given that the amount of green bonds increases exponentially, we conclude that the green bond market is evolving towards a more negative greenium environment. A significant greenium was found when the main sample was subsampled based on the sector, currency, issue amount, coupon type, ESG, and ESG combined scores, country, and the use of proceeds. It implies that green bond yields are significantly different from equivalent conventional bond yields in some specific categories and market segments. However, the results range from a significant green bond premium of -4.59% to a significant green bond discount of 4.54%. Either financial or non-financial theories cannot explain the latter.

It was shown that both bond-specific and issuer-specific characteristics can explain the variation in greenium. Issue amount, country, currency, seniority & collateral, and the use of proceeds are among the bond-specific characteristics which significantly affect the magnitude and direction of the green bond premium. The significant issuer-specific greenium determinants were found to be sector, ESG, "E," "S," and "G" scores. The results also indicated that the third-party verification, maturity, issue year, issuer type, coupon type, or ESG combined score could not explain the variation in greenium to a significant extent. Since the third-party verification was found to be an insignificant determinant of greenium, it means that the issuers' efforts in signaling their trustworthiness by investing in third-party approvals do not pay off in terms of a significantly negative greenium. However, we still expect the third-party verification to become a norm in the course of certification market standardization, regardless of whether it would lead to significant

differences in yields. It was also concluded that the ESG score, which is based on issuers' public disclosures, is a significant greenium determinant, unlike the ESG combined score, which also takes into account the ESG controversies.

These findings underline the need for standardized mandatory non-financial reporting, which is expected to allow for more comprehensive and rounded evaluations of issuers' sustainability performance. The "E" score was the most significant greenium determinant among all of the pillars. This is consistent with the notion that if climate-related goals drive investors, the environmental pillar should be of the main concern. Moreover, it was discovered that the greenium is more negative for less sustainable issuers. This result makes sense from the additionality perspective, which suggests that the capital should be allocated where it leads to the highest positive environmental outcomes. Given that the least sustainable issuers arguably have the biggest room for improvement, investors can achieve the greatest positive environmental benefits per dollar invested by unlocking green capital for the least sustainable issuers.

The greenium determinants discovered in this study can explain the variation in greenium to a significant extent. However, they do not explain its essence. After considering the traditional economic and finance theories, we conclude that greenium results from investors' non-pecuniary motives and are driven by their pro-environmental preferences and concerns. The same theories predict that if investors' tastes are not sustained in the long term, greenium may soon disappear. Therefore, there is an urgent need to realize the ultimate purpose of greenium, which is to facilitate the decarbonization of the economy by making green investments more financially attractive than non-green alternatives. The insignificant greenium implies that investors' climate-related concerns do not translate into a significant greenium in the overall market. At the same time, the additionality of green bonds is expected to materialize only when the issuers ' cost of capital is affected fully. In other words, a significantly negative greenium which leads to the lowered cost of capital for the issuers, is expected to tip the scales in favor of green projects on purely financial grounds.

However, paying greenium should not solely rest on investors' shoulders. Therefore, we propose a set of actions to promote and maintain greenium in the long term. This set of actions is expected

to justify the greenium from both issuers' and investors' perspectives. The action plan includes establishing a regulatory framework with (1) a mandatory verification and labeling scheme for both ESG frameworks and green bonds, (2) a standardized set of mandatory green bonds' guiding principles, and (3) a mechanism that would link green bond's financial dimension to their environmental outcomes, (4) a credit rating mechanism that would evaluate and incorporate green quality into bond pricing and (5) special tax treatments for green bonds. The implementation of these measures is expected to enable the full potential of the green bond market. To reach the goals set by the Paris Agreement, green bond premium as a phenomenon itself should become sustainable.

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