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Green Bonds: Exploring the Corporate *Greenium*

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Master in Finance

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BUSINESS
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Resumo

As obrigações verdes apareceram nos mercados financeiros para materializar as necessidades "verdes" dos emissores e investidores. Para os emissores, estes ativos representam uma maneira de aceder a capital privado para investimentos verdes, e para os investidores são uma forma de contribuir para esses projetos que podem fazer a diferença na luta contra o flagelo que são as alterações climáticas.

Tecnicamente, as obrigações verdes e tradicionais, se emitidas pelo mesmo emissor, partilham as mesmas características (tirando o uso dos lucros em projetos verdes), e como tal, deviam ter um preço igual (ou semelhante) no mercado primário. No entanto, nem sempre esse é o caso.

O principal objetivo deste estudo é concluir se, financeiramente, as obrigações verdes representam uma alternativa mais barata para as empresas, do que as tradicionais. Por outras palavras, vamos averiguar se, no mercado primário, existe um *greenium* (as obrigações verdes são emitidas com uma yield mais baixa que as obrigações normais). Para tal, vamos recorrer a um processo direto de emparelhamento das obrigações, e a testes estatísticos, para inferir sobre a significância estatística das diferenças de yield encontradas.

Com base nos métodos utilizados, encontrámos um *greenium* nos grupos de obrigações verdes e tradicionais (2,3 pb), assim como nos subgrupos de obrigações emitidas em EUR (7,2 pb) e nas obrigações emitidas em 2017, 2019 e 2020 (36; 1,3; 1,9 pb respetivamente). Após vários testes, é possível concluir-se que nenhuma destas diferenças (excetuando a de 2017), é estatisticamente significativa. Deste modo, não é possível afirmar a existência de *greenium* no mercado obrigacionista.

Palavras-chave: Alterações Climáticas, Obrigações Verdes, *Greenium*, Performance Financeira, Preço das Obrigações

JEL Classification System: G12 (Asset Pricing; Trading Volume; Bond Interest Rates), Q01 (Sustainable Development)

Abstract

Green bonds appeared in financial markets as a way to materialize both issuers' and investors' "green needs". For issuers, these assets are a way to access private capital and fulfill green investment needs and for investors, represent a way to contribute to those projects that could make a difference on the fight against climate change.

Technically, green and vanilla bonds, if issued by the same issuer, share the same characteristics (besides the green use of proceeds) and therefore, should be priced the same (or similarly) in the primary market. However, that seems to not always be the case.

The main goal of this study is to conclude if, financially, green bonds represent a less costly alternative for companies, over traditional bonds. In other words, we will look for a *greenium* in the primary market (green bonds are issued with a lower yield than vanilla bonds). To do so, we will resort to a direct matching process to match the bonds, and to statistical tests, in order to infer on the statistical significance of the yield spreads found.

Based on the methods employed, we found a *greenium* on the groups of green and vanilla bonds (2.3 bps), and in the subgroups of EUR bonds (7.2 bps), as well as in the subgroups of 2017, 2019 and 2020 (36; 1.3; e 1.9 bps respectively). After several tests, it was possible to conclude that none of the differentials (except for 2017), is statistically significant. Thus, we cannot affirm the existence of a *greenium* in the corporate bond market.

Keywords: Climate Change, Green Bonds, *Greenium*, Financial Performance, Bond Pricing

JEL Classification System: G12 (Asset Pricing; Trading Volume; Bond Interest Rates), Q01 (Sustainable Development)

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1 Introduction

Now, more than ever, global warming is considered to be one of the biggest threats humanity has ever faced (Mathews et al., 2010). The OECD (2017) estimated that, in order to transition to a low-carbon and climate resilient economy it would be necessary to increase annual investment in green infrastructures to approximately USD 6.3 trillion between 2016 and 2030, a total investment accounting for approximately USD 95 trillion in this period.

The required investment to enable such necessary actions against climate change is too large to be supported only through public funding. Therefore, it is necessary to channel the private markets' investments into green activities and infrastructures in order to achieve the goal described above. Green bonds are a fairly recent debt instrument introduced into capital markets to satisfy both issuers' capital needs and the investors' thirst for "greener" finance.

Green and vanilla bonds share the same fundamental financial characteristics such as having a maturity, coupon rate, price as well as the issuer's risk of default. However, for green bonds, the use of net proceeds is specifically meant to finance green projects, and this may not be the case for traditional bonds. Therefore, for investors, there is also the need to assess the environmental purpose each issuance serves (The World Bank, 2015). Given these characteristics and considering bonds issued by the same issuer, one could assume that if the pricing, in the primary market of vanilla and green bonds is different, that could be attributed to the green label of the latter (Ehlers and Packer, 2017). In fact, the existence of a premium, also known as a *greenium*, could be originated from the excess demand for this type of environmentally friendly instrument and, consequently, two market dynamics can arise. On one hand, based on the considerable demand for green bonds, issuers might feel tempted to lower interest rates offered, and therefore lower their cost of capital. On the other hand, that situation can only happen if investors are willing to accept a lower repayment rate, in other words, a lower yield-to-maturity (YTM). Therefore, a *greenium* at issuance can prove that investors are willing to pay more and consequently get a lower return, and that issuers can leverage on this "green drive" and lower their financing costs (Partridge and Medda, 2019), which could be looked upon as an incentive for issuers to use green bonds instead of any other debt instrument available which could also be used in order to finance green investments.

The aim of this master dissertation is to infer on the existence, or lack thereof, of a corporate *greenium* in the bond market and thereafter understand if a lower cost of capital could be one of motivations that companies might have to join the green bond market. Furthermore, we intend to also contribute to the already existent and still scarce literature on the matter of the *greenium*, specifically the corporate *greenium*. To do so, this study will focus on the primary market to assess the existence of a *greenium* for EUR and USD corporate bonds, and therefore, conclude on whether or not green bonds are cheaper for companies to issue than conventional bonds.

This work will be organized in the following way. In the second section we will firstly introduce a market description of the green bond market, starting by doing a brief overview of green finance and the green investment framework, and then present the green bond market in depth by defining green bond, describing the typologies of this class of assets, existing green bond standards and frameworks and finally discuss the market development in the past decade. Lastly, in that chapter, we will display the already existent literature regarding the presence of a *greenium* in the primary market as well as the performance of green bond prices in the secondary market.

In the third section, the methodology will be inserted, including the description of this dissertation's goals, the data that will be employed to achieve the latter, as well as an in-depth explanation of the matching method chosen and detailing of the matching process. Moreover, it will include the specification of the hypothesis test that will be used accordingly in the empirical studies performed along with a theoretical overview of the latter. The descriptive statistics regarding the matches found in the third section will be explored in the fourth section, followed by all the results of the hypothesis tests on the presence of a *greenium* in our samples, as well as subsamples.

Lastly, section 5 and 6 will include a summary and discussion of the results found, along with the conclusions drawn from the latter.

2 Literature Review

This chapter is divided into three subsections. The first one consists of a definition of green finance, as well as the framework surrounding green investments, followed by a description of the green bond market. The latter part shows the existing literature on the *greenium* in the primary market.

2.1 Green Finance

2.1.1 Definition

To this day there has not been published an official definition of the term green finance (GF). Whilst some publications do not even attempt to, the ones who do so, put their own spin on the term.

IDFC (2013) proposed a definition for the term that reads as follows: "Green finance is a broad term that can refer to financial investments flowing into sustainable development projects and initiatives, environmental products, and policies that encourage the development of a more sustainable economy. Green finance includes climate finance, but is not limited to it. It also refers to a wider range of "other" environmental objectives (…)". Wang and Zhi (2016:1) define it as being "(…) a phenomenon that combines the world of finance and business with environmentally friendly behavior".

In summary, green finance is composed of investors who are environmentally conscious and are willing to allocate their wealth towards the so called green investments which include both climate related investments such as renewable energies, energy efficiency and other climate change mitigation, but also investments related to waste processing and recycling, biodiversity protection, water sanitation, among others (German Development Institute, 2014), through the multiple financial assets available in the market.

2.1.2 Green Investments' Framework

One could finally say that economic and attitude shift towards environmental issues among market players have begun as well as that, global consensus regarding these matters has been reached (HSBC, 2019).

Concerning investors, a survey conducted by HSBC (2019) has shown that 64% of global investors perceive environmental and social issues as very important. Moreover, 92% of the inquired investors take into account a company´s performance on Environmental, Social and Governance (ESG) issues when considering an investment. ESG refers to "(…) extra-financial material information about the challenges and performance of a company on these matters" (Bassen and Kovács, 2008:184), and the inclusion of these criteria has been one of the most important landmarks in the green investment market. Despite the lack of standardization in ESG criteria as well as in the risk assessment process (Moody's, 2020), ESG investment has boomed in the last couple of years. As a result, in 2019 it was estimated that sustainable assets under management were around USD 30 trillion worldwide (Cornell, 2020).

Companies are also exposed to different levels of climate risk, depending on the sector and geographical location of its operations (Labatt and White, 2007). Consequently, that may affect the firm's performance, return on investment and shareholder value. Therefore, to mitigate those threats it is necessary to identify, manage and disclose on climate risk (Kouloukoui et al., 2018). This has pushed corporations into highlighting their green capabilities and carrying out cutting edge green practices in order to preserve the environment as well as enhance the business' overall performance (Weng et al., 2015). Hence why carrying environmentally friendly actions also known as "going green", has become a global trend among companies.

The breakthrough that has been witnessed both in investors and in companies has also happened for international, supranational and governmental organizations.

The United Nations, in June 2015, introduced the Sustainable Development Goals (SDGs) to call for international cooperation on matters such as poverty, planet protection, peace and prosperity. Moreover, later that year, at the Conference of the Parties (COP21) to the United Nations Framework Convention on Climate Change (UNFCC), 196 countries came together and signed the Paris Agreement. This Agreement came as a global response to climate change and its main goal is to limit global temperature, this century, from increasing over 2° C above pre-industrial levels. In addition, further efforts will be pursued to limit that temperature increase to 1.5° C. In order to achieve this goal, parties agreed to target the reduction of Greenhouse Gases (GHG), as soon as possible, as well as committing to the determined Nationally Determined Contributions (NDCs) (United Nations, 2015).

More recently, following the European Union's (EU) goal to become carbon neutral by 2050, the European Commission announced that the EU would be issuing EUR 250 billion in green bonds as part of its pandemic recovery fund (accounting for approximately 30% of the total issuance). Furthermore, even central banks such as the European Central Bank (ECB) are now assessing climate changes' risks in the economy and financial markets. Christine Lagarde, President of the ECB, further added that "I want to explore every avenue available in order to combat climate change (…) This is something I hold very strongly" (Khalaf and Arnold, 2020).

Undoubtedly, this worldwide commitment comes as a justification of the outburst of new financial instruments that, on one hand are meant for investors to apply GF, and on the other, for issuers such as firms or international organizations to obtain capital to finance the transition into a "greener", more equal and safer world.

2.2 Green Bond Market Description

2.2.1 Definition

First and foremost, one can define in general terms, green bonds as being fixed-income debt instruments meant to finance or refinance green projects. However, due to the lack of a widely accepted definition for the term "green", there are currently multiple definitions of green bond (Horsch and Richter, 2017). Reboredo (2018:1) defines green bonds as being "(…) relatively new fixed-income asset-class that are similar to conventional corporate and government bonds in terms of pricing and rating but have the peculiarity that their proceeds are earmarked by the issuer for projects with environmental benefits consistent with a climate-resilient economy". To sum up, green bonds hold every financial characteristic of a conventional vanilla bond, apart from the commitment to invest the issuance's proceeds in environmentally beneficial projects (Jones et al., 2020).

2.2.2 Green Bond Typologies

The Green Bond Principles (GBP), identifies four types of green bonds with the following characteristics (Deschryver and de Mariz, 2020; ICMA, 2018; Jones et al., 2020):

(i) Standard Green Use of Proceeds Bond: this type of green bond has similar characteristics to vanilla bonds in terms of recourse rights. Additionally, it shares the same credit rating as the issuer.

(ii) Green Revenue Bond: in this category of bonds the recourse is narrowed to the revenue flow flows such as fees, taxes, and tolls, promised by the issuer.

(iii) Green Project Bond: this bond will finance one or multiple green projects, and the investor has direct risk exposure to those. Moreover, there may be a recourse.

(iv) Green Securitized Bond: this group of bonds is collateralized by the revenue generated by one or multiple green investments and that revenue is applied into the repayment of the bond. Furthermore, the recourse is constrained to the collateralized assets.

Altogether, there are several types of green bonds varying mainly in the "scope of legal recourse" (Jones et al., 2020:50). Furthermore, green bonds also differ according to the investor's type of risk exposure – investors can be more exposed to the project's risk or the company's risk depending on the bond chosen.

2.2.3 Existing Standards and Frameworks

The rapid expansion of the green bond market, combined with the fact that most green bonds are self-labelled by the issuer, has increased the need for a universally accepted framework for green bond issuance. Therefore, it is necessary "(…) credible guidelines and standards accepted by financial markets and clearly indicating what should be considered as green investment (…)" (Bieliński and Mosionek-

Schweda, 2018:15) in order to increase market transparency and as consequence maintain investors' confidence in those instruments, ultimately boosting market growth.

Currently there are several voluntary guidelines for green bond issuance, some of which are the GBP by the International Capital Market Association (ICMA) and Climate Bond Standards (CBS) by the Climate Bond Initiative (CBI). There are also regional frameworks such as the European Union's Green Bond Standard (EU-GBS).

In what concerns GBP, these were introduced in 2014 to promote transparency in the green bond market by recommending to the issuers full disclosing and reporting on the use of proceeds to, therefore, increase investors' confidence on the issuance. The GBP stands on four main pillars: (i) Use of Proceeds; (ii) Process for Project Evaluation and Selection; (iii) Management of Proceeds and (iv) Reporting. Regarding the Climate Bonds Standard (CBS), this is a certification scheme fully aligned with the GBP, meaning that it stands on the same four core pillars described above. However, as the GPB focuses on the general process of green bond issuance (not climate bonds), the CBS adds to the latter, a thorough taxonomy of "(…) investment areas and eligible criteria for a climate bonds certification scheme." (Bartels and Kurznack, 2016:6). That scheme refers to the Climate Bond Certification which is attributed to bonds if they align with environmental standards as well as if the issuer acts accordingly to the proper issuance process (Ehlers and Packer, 2017).

The European Commission, in 2019, set up the Technical Expert Group (TEG) on sustainable finance aiming to among other goals, create the EU-GBS[1]. In August 2021, the European Parliament as well as the European Council proposed the framework for the EU-GBS which details not only which activities should be financed through green bonds (EU Taxonomy), but also the terms in which green bonds should be issued to be labeled as a "European Green Bond".

This framework stands on four main pillars: (i) Alignment with the taxonomy regulation; (ii) Transparency; (iii) External review and (iv) Supervision by the European Securities Markets Authority (ESMA). Generally speaking, the main difference between GBP (and consequently, the CBS), and the EU-GBS lies on the compulsory character of the issuance's steps. For instance, the disclosure of the use of legal proceeds in legal documentation as well as the publication of external verification are only recommended in the GBP, as it consists of a voluntary set of guidelines, whereas those are required steps according to the EU-GBS (EU TEG, 2019).

As of the execution of this study, there is not an official list elaborated by any international authorities or institutions that identify green bonds, and as such, the guidelines that do exist are mere voluntary guidelines. Moreover, there are very few stock exchanges which supply independent identification of green bonds in their listings. Because of this, green bonds have been normally purchased by institutional rather than retail investors (Doronzo et al., 2021).

[1] The official version of the EU-GBS has yet to be released as of the release of this dissertation. The claims regarding the EU-GBS are based on preliminary versions of the document.

Table 2.1: Summary of the GBP

Principle	Description of Issuer Responsibility
Use of Proceeds	Choose na eligible "green project" from a list of recognized categories, such as renewable energy
Process for Project Evaluation and Selection	Detail the decision process underlying project selection
Management of Proceeds	Ring-fence bond proceeds to be used for environmental projects
Reporting	Provide qualititive and quantitive metrics regarding the environmental impact of projects

Source: Preclaw and Bakshi (2015)

2.2.4 *Greenwashing*

What is contemplated as eligible projects to be financed through the issuance of green bonds varies greatly depending on the framework considered. Furthermore, it also can vary within the same framework according to the sector, with specific eligibility criteria for each sector (Ehlers and Packer, 2017). This lack of consistency in the definition of eligible green projects can create a fear of *greenwashing*, which can be described as "(…) a misleading communication practice concerning environmental issues (…)" (Torelli et al., 2020:429), meaning that companies proclaim a greater environmental commitment than there actually is. Bachelet et al. (2019) identifies the gain in reputation as well as in the willingness-to-pay of investors as advantages of this practice. Nevertheless, when the public becomes conscious of this farse, corporations can be further punished, for instance, in their stock prices.

Overall, *greenwashing* can become a hazard both for investors and issuers, and therefore, keeps the green bond market from reaching its full growth potential. Since there is currently no restriction as to which companies are allowed to issue green bonds, around 20% of all green bonds in the market were issued by companies that generate negative environmental externalities (Doronzo et al., 2021).

2.2.5 Market Overview

The first bond issued with the purpose of financing environmentally friendly projects (mainly focused on renewable energy and energy efficiency), was issued by the European Investment Bank in July 2007 and consisted of a EUR 600 million Climate Awareness Bond (Deschryver and de Mariz, 2020). In 2008, the World Bank issued the first labelled green bond in an amount of approximately USD 440 million (to focus on climate change mitigation and adaptation projects) (The World Bank, 2015). The first corporate bond was issued in 2013 by a Swedish real estate company, Vasakronan. 2014 was marked by the introduction of the GBP which became a catalyzer for growth in the green bond market and since then, this market has experienced great growth every year (Ehlers and Packer, 2017). Additionally, we can add that since 2007, the cumulative green bond issuance has exceeded USD 1 trillion (Shabi, 2021). Figure 2.1 shows the annual issuance of green bonds from 2007 to August 2021.

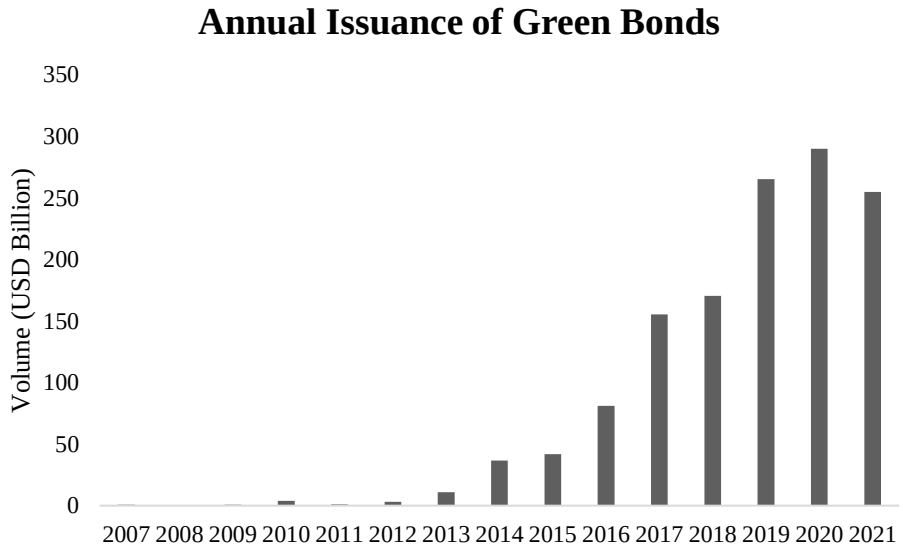

Figure 2.1: Green Bond Annual Issuance from 2007 to 2021 (data as of 14th of August 2021)

Source: CBI

In terms of the overall distribution by issuers, Appendix A, Financials and Corporates each represents 21% of all issuers, followed by Agencies (16%), as well as Supranational entities (16%). Those issuers are distributed across the globe, however, some regions are more represented than others (Appendix B). Most of green bond issuance has happened in Europe (43%), followed by North America (25%). This difference can be justified by Europe's tight environmental goals and push for a green transition across sectors. Nevertheless, the differential between those reagions might ease in a near future since, under the presidency of Joe Biden, the USA has pledged to reduce the emissions of GHG in 50%-52% until 2030 (which will require a sizeable amount of investment) and have also rejoined the Paris Agreement[2] (Epstein and Dlouhy, 2021). The boost in green bond issuance, followed by these announcements, is already clear as US green bond sales have increased more than 50% in 2021 year-on-year (Shabi, 2021). This growth could also be potentiated if Biden's administration introduces a green bond framework to increase market transparency. On the opposite end, green bonds issued in Africa and Latin America only represent 0% and 2%, respectively, of total issuance.

Regarding the bonds' issuance currency, Appendix C, 40% of green bonds were issued in EUR and 35% in USD. The maturity profile of green bonds (Appendix D) shows that the highest volume of green bonds matures in 2024. Finally, in terms of the use-of-proceeds, most issuers utilize green bonds in order to finance the green transition of building (25%), as well as their energy transition (34%) – Appendix E.

Regardless of the fact that the green bond market is rapidly growing, green bonds still represent a marginal part in the overall bond market – BloombergNEF registered a total issuance, in 2019, of USD 271 billion, which accounted for only 4% of the total bond issuance in the world (The Economist, 2020).

[2] The US pulled back from the Paris Agreement under Donald Trump's presidency (Epstein and Dlouhy, 2021).

As one can see, the green bond market is still in its infancy stage, and as such, the number of issuances as well as the size of the latter have been increasing year-on-year. Furthermore, there is also evidences of a growing issuer group and broader investor base (Deschryver and de Mariz, 2020). However, one could say that green bonds are still a drop in the ocean in the bond market, with the latter authors identifying the following reasons for that:

(i) Unclear benefits in green bond issuance.
(ii) Perception of higher costs and complex issuance process.
(iii) Lack of standardization in the market.
(iv) Because of the market's infancy, there is still no good credentials for issuers nor enough supply to meet investors' demand.
(v) Fear of *greenwashing*.

It is also relevant to address (ii). According to Flammer (2021), the process of issuing green bonds is extremely cumbersome and expensive for issuers since it involves several third-party entities such as certification agencies and independent auditing companies, which audit the reporting of use-of-proceeds, in order to comply with the existing green bond standards. To sum up, the expenses related to administrative and compliance processes might still be one of the reasons to explain the lack of size of the green bond market compared to the overall bond market.

2.2.6 Green Bond Market in 2020

Even though the COVID-19 global pandemic decelerated the growth of the green bond market in the first semester of 2020, in the second half of the year, issues picked up (Kuchtyak, 2021), and according to the Climate Bonds Initiative (2021), in 2020, it was raised a total of USD 290.1 billion through green bonds that were aligned with Climate Bonds Initiative (2021) definitions, which represented an increase of 9% when compared to 2019's values. The average issue size of green bonds increased 19% year-on-year (USD 171 million in 2020), and the number of issuers also grew by 14% year-on-year (634 issuers in 2020). Moreover, the volume issued in 2020 was mainly in the European market (approximately 54% of global issuance).

The main issuers were Government-Backed entities and Non-Financial Corporate institutions. Additionally, net proceeds were mainly allocated towards Green Energy and Green Buildings projects with both accounting for almost 63% of total proceeds (Climate Bonds Initiative, 2021). The United States of America (USA) were the country that issued the most volume of green bonds, followed by Germany and France – the geographic distribution of green bond issuance during the year of 2020 can be found in Figure 2.2. (Kuchtyak, 2021) quoted Moody's as the latter stated that they expected the green bond market growth momentum from the second half of 2020 to continue in 2021 due to the investors' strong appetite for sustainable assets. Furthermore, the agency added that they anticipated that total issuance for 2021 would be approximately USD 375 billion. As of August 2021, the global issuance of green bonds was USD 254.9 billion.

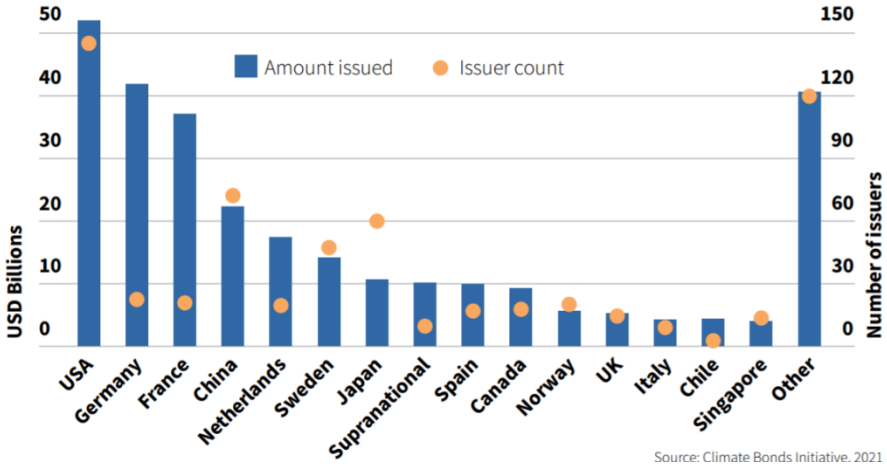

Figure 2.2: Geographic Distribution of Green Bonds in 2020

Source: Harrison and Muething (2021)

2.2.7 Drivers of market growth

As previously mentioned, and shown, despite all the problems identified in the the green bond market, it has been experiencing great growth over the past years and there are several forces that could explain such growth. Tu et al. (2020) conducted a study with Vietnamese bonds to identify the forces that had been driving the Vietnamese green bond market's expansion and concluded that the factors that most influence that market's expansion are: the legal infrastructure, official interest rate of the green bonds, as well as the economic and political stability of the country. Deschryver and de Mariz (2020) also attempted at understanding the driving forces behind green bond market growth and identified the following:

(i) Marketing tool for issuers: the growing interest of investors and stakeholders (and consequent growing demand) in more sustainable assets and activities allied with the increasing number of studies and research that have been conducted regarding "the impact of climate risks on returns" (Deschryver and de Mariz, 2020:4) make green bonds into a great marketing tool to signal a green drive.

(ii) Financial institutions encouraging the trend: several financial institutions have been supporting the expansion of the green bond market by, for example, creating designated offices in charge of supporting clients who wish to issue green/sustainable bonds.

(iii) Pressure from stakeholders to join the market: as mentioned in (i), green bonds work as a marketing tool to signal the institution's green strategy. Furthermore, issuers can resort to this asset type due to peer pressure (for example, other companies from the same industry issuing green bonds); to reinforce the entity's commitment and pride among employees (some professionals are really invested in green investments); and finally, to intensify its relationship with investors (the process of issuing green bonds can strengthen investors' understanding of a company's processes and operations).

Likewise, Flammer (2021), identified the subsequent arguments to justify the rational behind corporate green bond issuance:

(i) Market signaling: green bonds signal the market of the company's pledge to environmental causes.

(ii) *Greenwashing*: green bonds can be issued with the intent to simulate a commitment towards the environment but without actually using the money for those purposes.

(iii) Cost of capital: corporations might be able to finance themselves at a lower cost than they would by issuing conventional bonds if investors are inclined to trade-off lower financial returns for societal and environmental benefits.

2.3 *Greenium* in the primary market

Since the green bond market's early days there has been talks of a pricing differential between green bonds and their vanilla correspondents. However, the scarcity of data made it impossible to prove such statements. The first research study regarding this matter was conducted by Barclay's analysts (Preclaw and Bakshi, 2015) and, two years later (2017), the term *greenium* was introduced in a paper for the annual conference of CBI (Harrison et al., 2020). Ma et al. (2020) defines the *greenium* as a yield differential between green bonds and other identical non-green bonds that share similar characteristics such as issuer, maturity, payment rank and, currency. In this study, we will refer to *greenium* as a negative yield at issue spread between green bonds and conventional bonds that share similar features.

There are several theories and explanations as to why green bonds are priced differently than their traditional counterparts. Loffler et al. (2020) pointed out the following theoretical paradigms that could explain this difference: the first one is associated with the effect of environmental preferences on bond yields. According to this, investors are disposed to accept paying a higher price because of the environmentally friendly label of the bonds ("green" label), meaning that they are not only focused on the investment's payoff, but rather treat it like a consumption good[3] (Fama and French, 2006). The other paradigm is related to the Asset Pricing Theory- Capital Asset Pricing Model (CAPM). Different risk profiles may explain the return differential between green and their traditional counterparts, meaning that, in the case of a *greenium* investors accept a lower yield than they would get by getting a traditional bond with the same characteristics, and this might indicate that green bonds offer a lower risk profile than conventional bonds. Green bonds' use of proceeds and environmental impact are meant to be constantly monitored, therefore, that may reduce its risk of default. On the contrary, vanilla bonds are exposed to more environmental risks than their green peers. The latter difference might explain the yield differential.

In the meantime, several other academics and researchers began to center their studies around this issue, and many of which, have been focusing on the US green municipal bond market due to the lack

[3] Goods that are directly used to grant satisfy consumer's needs

of data available to perform a matched-pair analysis, with corporate and supranational bonds. Furthermore, this market, is not only mostly tax exempt, but also "(…) has smaller green bonds issued more frequently, which enables more direct comparisons." (Harrison et al., 2020:67).

While Partridge and Medda (2019), Larcker and Watts (2020), and Baker et al. (2018) focused on the green US municipal bond market and Doronzo et al. (2021) concentrated on sovereign bonds. Tang and Zhang (2020), the CBI (2020), CBI (2021) as well as Ehlers and Packer (2017) focused on EUR and USD labelled green bonds. Gianfrate and Peri (2019) used in their research EUR corporate bonds. Moreover, Loffler et al. (2020) considered in their sample's bonds issued in several currencies.

Partridge and Medda (2019) conducted a yield analysis on a sample of 453 matched pairs of green-labelled US municipal bonds that were issued synchronously with vanilla bonds from 2013 to 2018. These bonds share the same issuer, use of proceeds, tenor, coupon and similar market timing. This study found that there were no signs of a clear significant variation between the green-labelled and normal bonds- a *greenium* was found both in 2017 and 2018 but that difference was not statistically significant. However, they concluded that green bonds do not come in the primary market at a discount, meaning that these are "(…) at a minimum competitive with their non-labelled counterparts." (Partridge and Medda, 2019:46). Moreover, the authors alluded to the fact that based on 2017 and 2018, the *greenium* might become a trend in the market for years to come.

Larcker and Watts (2020) also conducted a study focusing on the green US municipal bond market and concluded that investors are not willing to sacrifice lower returns to support green causes. This conclusion was based on the analysis of a sample of 640 matched pair of green and non-green bonds, issued between 2013 and 2018, with the same maturity, rating and issuer, and issued on the same day. They found that in roughly about 85% of matched bonds there was no evidence of a premium given that the yield differential was 0. In fact, in some cases, some of the green bonds were actually issued at a slight discount with a spread[4] of 0.45 basis points (bps). Moreover, when the analysis was expanded to include matched pairs of green and vanilla bonds, but his time with different issuance dates, the authors also found evidence of a negligible *greenium*.

Doronzo et al. (2021), in their body of work, targeted sovereign bonds issued between the end of 2016 and 2020. They compared the yield at issuance of 38 pairs of green and conventional bonds matched according to the issuer, credit ranking, seniority as well as currency of denomination.

The authors found that among the 38 pairs, only 9 showed signs of a statistically significant *greenium*. Furthermore, in the overall sample, green bonds had on average a yield at issuance that is 3.8 bps higher than the conventional bonds' yield, hence why the authors concluded that green bonds were a more expensive debt instrument for issuers than traditional bonds.

[4] The yield spread is computed as the difference between the yield at issue of the green bonds and the yield at issue of their conventional counterparts

Tang and Zhang (2020), when trying to identify potential benefits shareholders would get from green bonds, examined the existence of a *greenium* on a sample of corporate bonds issued from 2007 and 2017. They split the study between two analysis, a within-firm analysis between green bonds and conventional bonds issued by the same company, and furthermore, they matched green and conventional bonds issued by similar firms with similar size, market-book value, and stock liquidity, issued in the same year. When considering bonds issued by different firms, they found a 6.9 bps *greenium*, indicating that green bonds carry a price benefit compared to vanilla bonds issued by similar firms. Nevertheless, when analyzing green and conventional bonds issued by the same firm on the same year, the yield differential was not significant. This way, the authors concluded that "(…) we do not have strong evidence supporting the "financing cost" channel" Tang and Zhang (2020:2). In other words, there is not enough evidence that issuers can finance themselves at a lower cost by issuing green bonds than they would with conventional bonds.

Additionally, the CBI has been surveying, every semester, the green bond pricing in the primary market. The study focuses on USD and EUR labelled green bonds with an issuance size over USD/EUR 500 million (size requirement set in 2018). The one referent to the period between January and June 2020 (CBI, 2020), found that from a sample of 21 green bonds, only 5 priced above their correspondent vanilla bonds, exhibiting a *greenium*. Since the premium at issuance can only be found in some bonds, the presence of a premium in the green bond market cannot be affirmed. Nonetheless, in the period between July and December 2020, in a sample of 33 bonds, 19 showed signs of a *greenium* by pricing above their vanilla counterparts (CBI, 2021). In their report, CBI (2021) even states that the fact that in the first half of the year only around 10% of bonds showed evidence of a *greenium*, which increased to a whopping 58% in the second half of 2020 suggesting a very strong demand for green-labelled instruments translating into "(…) the strongest evidence of investor support we have seen for the green label to date." (CBI, 2021:8).

Some other studies encountered the presence of a premium upon issuance. Ehlers and Packer (2017) compared the credit spreads[5] at issuance of 21 EUR and USD corporate denominated green bonds issued between 2014 and 2017, with the credit spreads of vanilla bonds issued by the same issuer and with the closest issue date as possible. Their results show that in fact, green bond issuers have borrowed at a lower cost compared to conventional bond, with green bonds being priced at a *greenium* of 18 bps in relation to their conventional bonds.

These results are also aligned with Loffler et al. (2020), which conducted research on a sample of green and conventional bonds to examine the existence of a *greenium* both in the primary and secondary market. They considered a sample of all green bonds issued between 2007 and October 2019, including 187,757 vanilla and 1,928 green bonds, sharing the same issuer structure (rating and sector), same

[5] Credit spreads were computed as the difference between the yield at issue over the yield curve of US Treasury securities (USD denominated bonds) and German Federal Treasury securities (EUR denominated bonds)

issuance volume, bond seniority and time to maturity. The sample consisted of 649 different issuers from across multiple sectors and ratings, as well as bonds issued in several currencies, and different seniorities. The matching methods used to construct the sample were the Coarsened Exact Matching (CEM), as well as the Propensity Score Matching (PSM). They performed a regression analysis both on the unmatched as well on the matched samples using the previously stated methods, and the results showed that the ask yield (at issuance) of green bonds was negative (-15 bps) for the unmatched sample and fell in the range of -16 to -24 bps for the matched samples, concluding that "(…) a "*greenium*" exists." (Loffler et al., 2020:1).

Gianfrate and Peri (2019)'s goal was to assess the convenience (for issuers) of issuing green instead of conventional bonds, using PSM techniques. The samples used consisted of EUR bonds with fixed interest payments, issuance size above EUR 200 million, investment grade and only those priced using European rates, issued between January 2007 and December 2017. The final dataset was comprised by 3,055 bonds, of which 121 were green, which were also split into two subsamples "Corporate Issuers" as well as "Non-Corporate Issuers". The authors concluded that, in the primary market, there is in fact a "(…) Green convenience (lower returns paid to investors)" (Gianfrate and Peri, 2019:130) for corporate issuers with a yield spread of about -17 bps, on average. Moreover, for non-corporate issuers, the average yield spread of -15 bps.

Another body of work found a *greenium* at issuance in the US green bond municipal market. Baker et al. (2018) focused on the yield at issuance on a sample of 2,083 green US municipal bonds against 643,299 vanilla US municipal bonds issued between 2010 and 2016, to uncover any potential difference in expected returns between green and conventional bonds. Firstly, the authors focused on a simple yield analysis and detected that, on average, after-tax yields of green bonds were lower than the ordinary bonds' yields (2.28% Vs 2.50%). Moreover, they ran an after-tax yield regression accounting for fixed effects (such as maturity and rating), as well as some dummy variables such as "Green" and "CBI Certified Green". Overall, they found that green bonds are issued at an after-tax yield around 5 to 7 bps lower than the conventional bonds. Another interesting find relates to the certification scheme of the bonds – CBI certified bonds are priced at an even greater premium than the non-green.

More recently, in May 2021, Germany issued the world's first global twin sovereign bonds by issuing a 30-year Green Federal Bond with a coupon of 0% to twin the 30-year, 0% Traditional Federal Bond that had previously been issued in August 2019. Also, the green bonds are issued in a smaller amount than its traditional twin. This model, essentially, allows investors to swap their green bonds by their vanilla equivalents and it is intended to ensure that the Green Federal Bonds do not negatively affect the general liquidity of German government bonds. It also serves as a transparency tool in the green bond market making it easier to identify a possible *greenium*. The green version of these bonds was priced 2 bps[6] below the German vanilla bond- pointing at a *greenium.*

[6] https://www.deutsche-finanzagentur.de/en/institutional-investors/federal-securities/green-federal-securities/

The literature regarding the existence of a *greenium* in the primary market is very mixed, which can be a result of different samples, time periods, methodologies, currencies and other bond and issuer properties. As such, the studies conducted on this matter do not make it possible to reach a unanimous conclusion.

One of the contributions of the present study is to further add to the already existent studies focused around the *greenium*, more specifically the corporate *greenium*, with the newest market data.

3 Methodology

3.1 Objectives of the Study

As aforementioned, this study's objective is to analyze whether green bonds are a cheaper source of capital than conventional bonds for corporate issuers. In order to conclude on that, we will match green and conventional bonds with similar characteristics and thereafter, compare the yield at issue of those matches, as well as ultimately judge on the statistical significance of the differences found.

3.2 Data and Sample Selection

To perform the previously described studies on the existence of a *greenium* at issuance of green bonds against their traditional counterparts, we first start by retrieving the necessary data, and thereafter, build our samples. All the bonds and data are collected from the Bloomberg Terminal. Even though, green bonds are issued by several different entities such as corporates, development banks, and sovereigns, in this study we will consider only corporate as well as supranational bonds issued both in USD and EUR, between 1st of January 2014 and 30th of March 2021. The rationale behind using only bonds issued from 2014, is that this was the first year in which a self-labelling bond certification scheme was introduced to the market – the GBP – which resulted in increased market transparency and clarity and consequently more players in the green bond market. What is more, corporate green bonds were very scarce in the market before 2013 (Flammer, 2021). The sample will be further narrowed to bonds regarded as investment grade bonds (those rated above BBB- or Baa3).

The Bloomberg database is widely acknowledged as one of the most comprehensive data bases, hence our preference. One of the drawbacks of this database could be the fact that issuances are registered manually on the platform which could lead to potentially entry errors, however, that risk could be diminished by performing a cross-check analysis with the CBI's comprehensive green bond list.

In order to infer and get the most insight on the effect of the green label both in the pricing at issuance against their conventional counterparts, it is essential to isolate the effect of that variable. It is therefore, necessary to match green and vanilla bonds for as many characteristics as possible, except for the one we are interested in studying, which in this case it is the green label, also known as greenness. Thus, data selection is done to exclude the effect of the influence of such factors that can affect bond pricing and ultimately our conclusions such as divergence in credit risk, currency risk, tax status, bond structure and characteristics as well as maturity and liquidity risk.

Regardless of the chosen matching method, which is implemented to compare green and vanilla bonds, it is important to firstly identify the control as well as the treated sample. Since our goal is to conclude on the effect of the greenness, we regard the conventional bond sample as the control group, and therefore, the green bond sample is considered the treated group.

3.3 Matching Method

A matching process is conducted in order to preprocess data and turn the estimations made based on the treated sample much less model-dependent (less sensitive to modeling choices), biased and inefficient (by eliminating heterogeneity) (Iacus et al., 2009). Across the literature on green bonds, it is possible to find several matching approaches used to assemble the formerly reported samples. In this sub-section, our intention is to present the various methodologies employed in the literature found and afterwards select the one we will be carrying out in this body of work.

Firstly, it is important to include the disclaimer that, regardless of the chosen matching approach, it only accounts for financial observable variables, as non-financial variables, such as the reputation of the issuer effect (in our study we only consider issuers that issue both types of bonds, green and vanilla, so that effect must be pretty negligible) are not observable and therefore, cannot be accounted.

As previously mentioned, there are many matching methodologies utilized in research and academic papers. Some authors and academics such as Bachelet et al. (2019), Zerbib (2019), Larcker and Watts (2020) as well as Partridge and Medda (2019), among several others, used a direct matching approach. This method, essentially, consists of doing a one-to-one match and look for a vanilla correspondent for each green bond in the dataset. The match of the two bonds must be as close as possible, meaning that the bonds must have as much similar properties as possible (in this case, properties that could affect bond pricing), except for the one property we are interested in studying, which is the greenness. All in all, if it is identified any significant difference between the bonds, we can then interpret that difference as the effect of the variable of interest.

Another matching methodology found, for instance on Baker et al. (2018), consists of running an Ordinary Least Squares (OLS) regression on a sample of green and vanilla bonds issued between a pre-determined time period, in order to determine, for example, the yield spread (dependent variable). In this instance, there are several regressors used as proxy for bond and issuer's particular characteristics, which have been proven to impact bond yields, as well as some binary or dummy variables to study the influence of that specific variable on the dependent variable. A green label binary variable is always incorporated.

Other authors have used other matching techniques, such as Loffler et al. (2020) as well as Gianfrate and Peri (2019) who used a PSM method which consists of using a probit model to estimate the probability of issuing a green bond, using several control variables such as year of issuance, currency, time to maturity, among others. The green and vanilla bonds are then matched according to their propensity scores (both the control and treated group fall in the same range of propensity scores), forming a control and treated group. Furthermore, Loffler et al. (2020) also utilized a matching approach known as the CEM. In this approach, the observations attributed to each bond feature are split into groups – the data is coarsened. For example, the same numerical value is generated for an interval of maturity dates. Afterwards the bonds are exactly matched, using the coarsened values, for certain

characteristics such as currency, seniority, issuer's rating, among others, and finally one can analyze the uncoarsened values of the matched pairs.

Each approach has its advantages and drawbacks, and in order to choose the one we will be using in this study, we will have to further dive into the "good and the bad" of each method.

Regarding the exact matching approach, besides the fact that it is the easiest to implement, when done properly it can be a very useful technique to isolate the effect of the one variable we are interested in studying, since all matched pairs of bonds have identical characteristics and properties. However, this method could be also hard to conduct since the green bond market is not matured yet and therefore, it is very difficult to exactly match every single bond attribute (especially the issue date and time to maturity). Thus, there is the risk of ending up with a very small sample size which in turn would not be representative of the full bond universe.

Concerning the OLS regression, the soundness of this approach highly relies on the specification of the model, meaning that, this model must hold as many proxies as possible of risk factors that could influence the bonds' yields (for example market risk, credit risk, liquidity risk, currency risk, among others) are incorporated to isolate the effect of the green label variable. On one hand, if one employs a small number of regressors, there is a risk of omitted variables. On the other hand, if one considers a very large number of regressors, this might lead to multicollinearity issues. Nevertheless, the identified drawbacks of this method could be overcome by experimenting with different regressors, simply, by trial and error.

As for the PSM approach, this may prove to be a good alternative to the former approaches since it allows to bundle up the extensive bond properties we would like to match, in order to isolate the greenness effect, "(…) in a single-index variable, the propensity score (…)" (Gianfrate and Peri, 2019:129). Nevertheless, in order to obtain valid results, some conditions have to be met. The first one is in regard to the Conditional Independence Assumption, which requires that the dependent variable or the outcome is independent of treatment conditional on the propensity score (the properties that affect the score and consequently, the matching and the outcome have to be noticeable). This assumption is impossible to prove as there are, for instance, several non-financial factors such as the issuer's reputation or the economic and/or political environment in the country of issuance, that could affect bonds' yields. In the end, this might lead to a biased estimation. The second and third conditions state that both samples must have bonds with similar propensity scores, as well as that similar propensity scores must be based upon similar observed properties.

With respect to the CEM method, this has been considered a very simple and easy-to-use method (Iacus et al., 2012). The main goal of this matching technique is to reduce the imbalance (differences) between the treated and the control groups, since it allows the researcher to choose the maximum deviation (coarsening) that each variable can be unbalanced between the treated and the control group. Furthermore, this method is highly efficient in large datasets (Blackwell et al., 2009). Anyway, like the other methods it carries some disadvantages. For instance, choosing the coarsening is the main issue of

this approach. On one hand, if the coarsening is set too largely, too much information and data are considered, which in the end affects the conclusions of the study. On the other hand, if the coarsening is set too small, a lot of relevant information might not even be considered. To conclude, "(…) the less precise the match, the more burden is put on getting the modeling assumptions correct in the analysis stage" (Iacus et al., 2012:23).

Taking into consideration all the information previously presented, and following the example of other academics and researchers, we have decided that moving forward on this body of work, we will be carrying out the Exact Matching approach due to its easy application and usefulness.

3.4 Matching Process

In order to initiate the matching process, we have to sample from the universe of corporate and supranational, investment grade bonds issued in EUR and USD, between 1st of January 2014 and 30th of March 2021 from the Bloomberg Terminal. Our bond universe then consists of 31,682 vanilla bonds and, 639 bonds identified as green – totaling 32,321 bonds.

As previously mentioned, the goal of any matching method is to isolate the effect of the variable we are interested in studying, therefore, data selection must be conducted in order to exclude as many factors that influence bond pricing as possible, such as currency, liquidity, maturity and credit risk, tax status, currency risk as well as the risk associated with the coupon's structure and bond characteristics.

Firstly, we decided to focus our study on bonds issued in EUR as well as in USD, to only consider the most liquid part of the bond market (Doronzo et al., 2021). It is also important to note that currency risk will be disregarded since the currencies considered, are universally accepted as hard currencies, and as such, are considered economically stable. Therefore, it is possible to dismiss this kind of risk.

To minimize the risk of investors not being able to trade their bonds in the market (liquidity risk) which could be translated into lower bond pricing, we will further restrict our bond universe, along the lines of Gianfrate and Peri (2019), to issue sizes above USD/EUR 200 million. This assumption is made based on the fact that this considerable issue size can only be achieved by certain issuers, most of which big and reputable corporations, ultimately lowering the risk of investors not being able to trade those assets. Our bond universe then consists of 18,208 vanilla bonds, as well as 574 green bonds.

Regarding the bonds' structure, we will disregard all floating rate bonds, to avert the effect that the uncertainty of flexible rates may have on the bonds' pricing.

We will also dismiss all bonds with zero-coupon rate since the latter usually trades at a discount compared to its face value (bond price < bond face value). The reason for this is because these bonds offer, as the name suggests, no coupon payments throughout its lifecycle and therefore, the only source of return an investor would have (if the bond is kept until maturity) is the difference between its price and face value. Both of the actions described above leave us with 16,780 conventional bonds and, 559 green bonds.

It will also be necessary to exclude from our sample all hybrid bonds. Given the equity component of these, investors often demand a higher yield than they would to normal bonds, to compensate for the risk taken. As such, we will exclude this class of bonds from our sample, leaving us with a sample of 16,401 vanilla bonds and, 543 green bonds. Additionally, it seemed reasonable to further restrict our sample from all convertible bonds. This type of bond allows the bondholder to exchange the fixed income asset for a pre-agreed number of shares of the firm, meaning that if the potential gains in holding the firm's stock surpasses the gains the investor would have gotten from holding the bond, the latter proceeds with the swap. Due to the nature of this feature, and taking into account potentially higher gains, this type of bonds may be issued at a higher price than they would if they had not had this feature. The exclusion of convertible bonds from our sample, laves us with 16,383 vanilla bonds and 543 green bonds. Lastly, we will take out from our sample all callable bonds. The reasoning behind this choice is that this type of instrument carries a higher risk (higher uncertainty) for the bond holder, and as such, are issued, typically, with a higher coupon. Moreover, according to the Corporate Finance Institute (n.d.) the call option affects negatively the price of a bond (compared to a vanilla bond) since if the option is exercised, the investor looses future coupon payments. After removing callable bonds, our sample consists of 7,198 vanilla bonds and 317 green bonds.

In Table 3.1 it is possible to find a summary of the formerly described actions taken to restrict our pool of bonds.

Table 3.1: Summary of the Filtering Process of the Bond Universe

Action	**Filter**	**Nº of Bonds Left**	
		Vanilla	Green
Include	Currency- EUR and USD Issue Date- between 01/01/2014 and 30/03/2021 Bloomberg Composite Rating- between AAA and BBB-	31,682	639
Include	Issue Size above 200,000,000 EUR/USD	18,208	574
Exclude	Floating Rate Bonds	16,843	559
Exclude	Zero-Coupon Bonds	16,780	559
Exclude	Hybrid Bonds	16,401	543
Exclude	Convertible Bonds	16,383	543
Exclude	Callable Bonds	7,198	317
	Total Bonds	7,198	317

Source: Own Elaboration

Appendix F exhibits some descriptive statistics provided by the Bloomberg software on that universe of bonds which will be further explored below.

In terms of the amount issued, since both the green and vanilla bond sample include bonds issued in different currencies (EUR and USD), we will have to carry different analysis between those currencies in both samples. Looking at the bonds issued in EUR, it is clear that, on average, traditional bonds are

issued in far higher amounts than green bonds (around 1.5 times larger). The same difference can be noticed in the bonds issued in USD.

Regarding the bonds' coupon rates, looking at the two types of bonds, it is evident that vanilla bonds in that universe, offer on average a coupon rate that is greater than green bonds (approximately 87 bps higher). The same trend happens in the bonds issued in EUR and USD, however, the difference is more prominent in USD bonds – 28 bps for EUR bonds Vs 57 bps for USD bonds.

The analysis conducted for the amounts issued will also be performed for the bonds' price at issue. In what concerns EUR bonds, vanilla bonds are issued with a slightly higher price than green bonds (3 bps). The contrary happens for USD bonds, where there is evidence that green bonds carry a higher price at issue than vanilla bonds (15 bps).

As far as the yield at issue is concerned, green bonds are, on average, issued with lower yield (55 bps lower) when compared to conventional bonds. The median for the green bonds also falls under that of vanilla bonds by 65 bps. This contrast could indicate early signs that there is a *greenium* in that universe of bonds. Additionally, there are also signs of a *greenium* in the subsamples of USD and EUR bonds, but yet again, the negative yield spread is superior for the bonds issued in USD (-52 bps for EUR bonds Vs -56 bps for USD bonds). Nevertheless, it is not possible to draw any plausible conclusions from this set of data since no matching method was applied on these bonds, and therefore, the latter do not share similar characteristics.

The next step in the matching process will be to identify and define our matching criteria. Firstly, we only consider standard green use of proceeds bonds since these share similar attributes to conventional bonds in terms of recourse rights, meaning that the bonds share the same credit rating as the issuer. Since the issuer is one of the matching criteria for green and vanilla bonds, this will remove the likelihood of issuers having divergent credit ratings. Furthermore, as said, we will only consider investment grade bonds in order to exclude high-yield bonds from our samples, as well as the increased price volatility inherent to the latter.

As for the bonds' maturity, this factor also has an influence on bond pricing as normally (normal yield curve), longer-term bonds are associated with higher yields, and as such, should be taken as an important matching criterion. Therefore, we look for green and vanilla bonds that share similar maturities. Even though Bachelet et al. (2019) as well as Zerbib (2019) considered a maturity differential of two years, to ensure the maximization of the number of bonds studied whilst minimizing maturity risk, we consider (when is not possible to get a perfect match) green and vanilla bonds with a maturity differential of three years.

Ideally, to minimize the tax status effect on the pricing of the bonds, we would have to exclude taxable bonds from our sample. Given that our study focuses on corporate (and supranational) green and vanilla bonds, the latter step will not be feasible.

In terms of the issue date, again, preferably it would be the same for both bonds, and that is in fact possible for US municipal bonds as Larcker and Watts (2020) have shown. However, the same cannot

be replicated for corporate bonds. Since the matching process always presents a trade-off between the accuracy of the process and the number of securities, we are able to study, we have decided to only match bonds that were issued within the same calendar year.

With respect to the amount issued and coupon rate, we are aware of the fact that those factors may influence bond pricing. Nevertheless, to maximize the treated and control group we do not contemplate those characteristics as part of our matching criteria. Finally, regarding the bonds' seniority, when it is not possible to perfectly match the bonds' payment ranks, we will try to match green and vanilla bonds with as similar payment ranks as possible.

All the matching criterion used in this dissertation can be found on Table 3.2.

Table 3.2: Criterion Used to Match Green and Vanilla Bonds

Bond Characteristics	Matching Criterion
Issuer	Same
Currency	Same
Rating	Same
Coupon Type	Same (fixed rate)
Seniority	Similar
Issue Date	Same year
Maturity Date	± 3 years

Source: Own Elaboration

To sum up, to build our control and treated group to perform the intended analysis, we will select matches according to the criterion stated above. Instinctively, if we cannot find a vanilla bond to match the green bond, the latter will not be part of the sample as it will be excluded.

In order to group the bonds, we will divide the matching per year, and for every green bond in each year we will then look into the pool of vanilla bonds for its match. For matching purposes, it is easier to look firstly into the green bond sample, which will later turn into our treated group, since there are clearly far less green than vanilla bonds. This will make our matching process much less tedious than doing it the other way around. Additionally, it is relevant to note that we will, for obvious reasons, exclude all bonds in which there is no information available regarding the bonds´ price at issue and/or yield at issue.

3.5 Hypothesis Test and Theoretical Overview

Hypothesis testing consist of the use of statistics in order to confirm the likelihood of a certain hypothesis to be true. As Dias Curto (2019:2) puts it, "Hypothesis testing is sometimes called confirmatory data analysis (…). In statistics, a result is called statistically significant if it is unlikely to have occurred by chance.". As such, it is not enough to simply compare the average yields of the groups we are focusing our attention on – a further statistical analysis is required to verify if our results are statistically

significant and therefore, did not happen by chance. The latter mentioned author, divides the hypothesis test in four steps which we will be following in this subsection.

The first step consists in defining the null (H_0) as well as the alternative hypothesis (H_1). Since it is always assumed (until proven otherwise) that the null hypothesis is true, we will consider as our null hypothesis that there is no difference between the average yields of green and vanilla bonds. Accordingly, the alternative hypothesis states that there is a difference between the average yields of the groups. More concretely, that the average yield at issue of traditional bonds is higher than the one of green bonds and therefore, there is evidence of a *greenium*. The hypothesis goes as follows:

$$\begin{cases} H_0: \overline{Yield\ at\ Issue_{Green}} - \overline{Yield\ at\ Issue_{Vanilla}} = 0 \\ H_1: \overline{Yield\ at\ Issue_{Green}} - \overline{Yield\ at\ Issue_{Vanilla}} < 0 \end{cases} \quad \textbf{(1)}$$

The second step entails deciding what statistical test will be used in order to gauge if we have sufficient statistical evidence to reject the null hypothesis. To do so, it is essential to know the distribution of the test statistic we will use in our analysis. In this situation, we are considering two dependent groups because every pair of bonds shares the same issuer – "paired samples". As our hypothesis states we want to understand if there is a difference between the average yields at issue of the groups and therefore infer on the effect of the green label on the latter. For these reasons, a one sample T-Test for the difference in means, is the one used to carry forward. The specification of that test goes as follows:

$$t = \frac{\bar{d}}{S_d / \sqrt{n}} \quad \textbf{(2)}$$

In this formula, $\bar{d}$ represents the mean difference between the values (difference between the yields at issue) of each pair; S_d is the standard deviation of the yield differences, and n is the number of matches.

The third step is dedicated to defining the critical region, also known as rejection area. The values that fall within that region are related to a probability of those values occurring under the circumstances of the null hypothesis Dias Curto (2019), the so-called significance level. In this dissertation we will consider a significance level of 0.05. If the test value falls within the rejection region there is statistical proof to question the veracity of the null hypothesis, and consequently reject it. In the case of the test value falling outside the rejection region, there is not enough statistical evidence to reject the null hypothesis, and therefore, we do not reject the latter and take it as a true statement.

The fourth step, which will be further carried out in the section 5- Results, will involve obtaining the test value based on our bond groups and afterwards determining whether we will reject the null hypothesis or not.

4 Data

After the matching process is concluded, we are left with a total of 50 green and vanilla bond matches, totaling 100 bonds issued by 31 different corporations and supranational agencies – the issuers as well as the number of issues relative to each one are identified in Appendix G. Furthermore, descriptive statistics of the matched bonds are exhibited on Appendix H.

As expected, considering the several constraints imposed on our bond universe throughout the matching process, our final sample size is much smaller than the ones from the studies previously mentioned in the literature review section of this body of work. Nevertheless, we believe these samples will give us an accurate answer to whether or not there is a *greenium* in the corporate green bond market.

This next section will consist of a detailed analysis of our matched bonds. Since both the control (vanilla bonds) as well as the treated group (green bonds) share the same issuer, and therefore credit rating and issuer's class, currency as well as issue year, we will first start by analyzing those common characteristics.

Regarding the firms' sizes, even though, we have no empirical data to prove it, we anticipate that most of the companies included in the control and treated group are larger companies than the ones included in the bond universe. The reason for this is because our matching process requires that our matches are made of green and vanilla bonds that are issued by the same company, in the same year, as well obey other criteria as seen on Table 3.2. Since a higher number of bonds tends to correlate with the firm size, there is a high probability of bigger companies being included in our samples – this conclusion is consistent with the findings of Larcker and Watts (2020).

Considering the years of issuance, the number of matched bonds registered an increase year-on-year until the year of 2020. The maximum number of matches found in a year was in 2019 (12 matches), followed by 2020 (10 matches). The years with the least matches found were 2014, 2015 as well as 2021 with 2 matches found in each of those years. However, it is relevant to note that we only considered the first 3 months of 2021 – given that 2021 it is expected to be a record-breaking year in terms of green bond issuance, it would also be predictable to find the most number of matches there. The following table (Table 4.1) displays the distribution of the matches between the years considered in this study.

Table 4.1: Yearly Distribution of the Matches

Year	Number of Matches
2014	2
2015	2
2016	6
2017	7
2018	9
2019	12
2020	10
2021*	2
Total Matches	**50**

*Data as of 30th March 2021

Source: Own Elaboration

Regarding the currency distribution (Appendix I), the majority (66%) of the bonds in our sample were issued in EUR rather than USD, which is aligned with the overall issuance of green bonds – according to Dax and Kreipl (2021), green bond issues in EUR account for 40% of all outstanding green bonds, as seen on Appendix C.

In what concerns the issuers' class distribution, 42% of our bonds were issued by banks, which is supported by Otterstrom and Singh (2018:2), which states that "(…) most green bonds are issued by banks (…)". Moreover, 16% of the issuers are supranational agencies, followed by local authorities (10%), the rest of the issuers' classes are very evenly distributed as seen on Appendix J – these results are also in line with the ones shown on Appendix A. In terms of the issuers´ credit rating (Appendix K), since we are only analyzing investment grade bonds, obviously the latter's rating falls within that range. Nevertheless, it is interesting to note that 14 out of 52 matches have a Bloomberg Composite Rating (which aggregates the ratings provided by several rating agencies) of AAA (the highest rating score). On the opposite side, only 2 companies were rated the lowest score, BBB-.

Now that we looked at the shared characteristics between the control and treated group, we are able to analyze the different features of the two groups such as the bonds' maturity, seniority, coupon rate, amount issued, price at issue as well as the yield at issue – which will give a first indication on the possible *greenium*, or lack thereof.

4.1 Descriptive Statistics

Looking at the maturity distribution of both samples (the control and treated group), green bonds seem to mature later than their traditional counterparts. As seen on Appendix L, more than half of the green bonds in the control sample (27 out of 50) will mature between 2024 and 2026, whereas the majority of the vanilla bonds (Appendix M) in the treated sample (31 out of 50) will mature between the years of 2022 and 2024 (in line with the data shown in section 2.2.5.

Provided that we are considering bonds issued both in EUR and in USD we choose, for the sake of coherence to only compare the amounts issued of bonds in the same currency. That being said, it is evident that the amount issued of green bonds both in EUR and in USD is, in every indicator, far less than the amount issued of their vanilla counterparts in those currencies. On average, the amount issued of EUR vanilla bonds is almost 2 times the amount issued of EUR green bonds. A similar disparity can be witnessed on USD bonds, with the amount of USD vanilla bonds being roughly around 2.5 times the amount issued of USD green bonds.

As for the bonds' coupon rate, on average, the coupon of the control and treated group are very close, with the average coupon of the control group (vanilla bonds) exceeding the average coupon of the treated group (green bonds) by approximately 4.1 bps. The average coupon of the treated group is more or less along the lines with the one found earlier in the green bond universe (Appendix F), with the latter exceeding the former by roughly 22 bps. However, the average coupon of the control group is exceeded by over 1% when considering the average coupon rate of the vanilla bond universe. Another finding worth mentioning is the contrast between the average coupon rate between the EUR and USD bonds in both groups. In the control group, the bonds issued in USD pay a coupon 2.7 higher than the bonds issued in EUR. When looking at the treated group that difference increases to more than 3 times. To sum up, both of our samples show a clear indication that USD bonds tend to pay a much higher coupon than EUR bonds.

In terms of the bonds' seniority, our findings are consistent with the ones from Loffler et al. (2020) – Appendix N and Appendix O. The latter found that green bonds tend to be senior unsecured debt instruments. Our findings show that 68% of the matched green bonds are senior unsecured. In terms of the vanilla bonds, the results are similar since 70% of the bonds in the control group are senior unsecured as well.

When it comes to the bonds´ issue price (in terms of face value) we look at it through two different perspectives as we have been doing thus far. Firstly, when it comes to EUR bonds, green bonds are issued, on average, at a higher price than their traditional counterparts. In fact, that difference is of almost 3%. Nevertheless, the difference between the median issue price between the groups is negligible. This could suggest that the average of either the green or the vanilla bonds is influenced by extreme values. Furthermore, this theory is confirmed by the fact that the maximum issue price of both groups is similar; however, the minimum value is extremely divergent – on the green bond group is 98.734% and, on the vanilla bond group is 1.146%. Next, in what concerns bonds issued in USD, green bonds are issued, on average, at a slight discount when compared to their traditional counterparts – the difference is merely of around 0.10. In the latter case, the extreme values affecting the average does not pose as a problem as seen by the maximum as well as minimum values as shown in Appendix H.

Lastly, and probably one of the most important analysis in this study, we will investigate the yields at issue of our groups. Looking solely at the EUR bonds, on average, green bonds are issued with a slightly lower yield (around 7.2 bps) than vanilla bonds – at first glance, meaning without further

analysis, this is an indication that there could be a *greenium* in the EUR bonds. This means, as previously explained, that investors are willing to obtain a lower return, due to the green label, than they would by acquiring a vanilla bond with similar characteristics from the same issuer. Consequently, issuers are able to finance themselves at a lower cost than they would by issuing traditional bonds.

Pertain to the bonds issued in USD, on average, green bonds are issued at a higher yield (approximately 7.1 bps) than vanilla bonds. In this instance there is no evidence of a *greenium*. Furthermore, it is interesting to mention that the average yields at issue of USD bonds are considerably greater the EUR bonds' yields, and this is valid for both the control and treated group (over 1.5% in the case of green bonds as well as around 1.4% for vanilla bonds). We can also add that in both groups, the standard deviation of the bonds issued in EUR is lower than the one of the bonds issued in USD. This is an indication that values of the yields of EUR tend to be less disperse than USD bonds, as seen on Appendix P and Appendix Q.

Finally, considering the yields of both groups (including bonds issued in both of the currencies we are studying), as one can see again in Appendix H, on average, there is a negative yield spread of a little over 2.3 bps. The median of the yield at issue of the treated group is higher than the yield at issue of the control group. However, by looking at the minimum as well as the maximum values of both samples, we can conclude that those do not vary much between the groups, and as such, the means are not influenced by extreme values. Appendix R shows the distribution of the yields throughout the years and the relationship between the average value and the yields of both groups. The fact that green bonds appear to have a lower yield at issue than vanilla bonds could be evidence of a corporate *greenium*. However, we cannot confirm that without performing a deeper analysis on the statistical significance of that difference in the variables – we will further elaborate on the latter in the next section.

5 Results

As mentioned throughout section 3, in this section we present the results of the T-Test as defined by Equation 2. Firstly, we will look into the significance of the difference between the average yield at issue of the treated group, composed of green bonds, and the average yield at issue of the control groups (the green bonds' conventional counterparts). Afterwards, we will look further into a possible *greenium* in the subsamples of EUR, as well as USD bonds to check if there is any difference in the results, we get that could be attributed to the currency the bonds are isued in, as well as an analysis of the yield differencial across the years to check for a possible trend in the time period we are studying.

5.1 *Greenium* in the control and treated groups (EUR and USD)

In section 4.1., we noticed a possible *greenium* since the average yield at issue of green bonds was around 2.3 bps lower the average yield at issue of the vanilla bonds. To further confirm that suspicion we will perform a Paired T-Test as specified in Equation 2, for the control and treated group. The results are presented in Table 5.1.

Table 5.1: T-Test for Green and Vanilla Bonds

T-Test: Paired Two Sample for Means

	Control Group (Vanilla Bonds)	*Treated Group (Green Bonds)*
Mean	1.2858	1.2624
Observations	50	50
t Stat	0.3156	
P(T<=t) one-tail	0.3769	

Source: Own Elaboration

Taking into consideration the specifications of Equation 1, we will look at the one-tail p-value, which is half of the two-tail p-value and compare it to 0.05 – the significance level identified in section 3.5.

In this particular situation, as one can see, the probability related with the test's value is higher than 0.05 (0.3769 > 0.05) which means it falls outside the rejection area. Therefore, given the sample and the significance level we cannot reject the null hypothesis and thus, conclude that there is no statistical evidence that there is a difference between the average yields at issue of the green and vanilla bonds – there is no statistical proof of the *greenium* found in section 4.1.

5.2 *Greenium* in EUR Bonds

Along the lines of what we found looking at the groups as a whole in section 4.1, by analyzing just the EUR bonds (subsample) we found evidence of a *greenium* of approximately 7.2 bps. Furthermore, as stated beforehand, the statistical analysis done in 5.1 can similarly be performed, but this time for the bonds issued in EUR. The null and the alternative hypothesis are defined in the following way:

$$\begin{cases} H_0: \overline{Yield\ at\ Issue_{EUR\ Green}} - \overline{Yield\ at\ Issue_{EUR\ Vanilla}} = 0 \\ H_1: \overline{Yield\ at\ Issue_{EUR\ Green}} - \overline{Yield\ at\ Issue_{EUR\ Vanilla}} < 0 \end{cases} \quad \textbf{(3)}$$

Again, we will perform a paired T-Test (Equation 2) with a significance level of 0.05, and the results are displayed in Table 5.2.

Table 5.2: T-Test for EUR Green and Vanilla Bonds

T-Test: Paired Two Sample for Means

	Control Group EUR (Vanilla Bonds)	*Treated Group EUR (Green Bonds)*
Mean	0.8184	0.7462
Observations	33	33
t Stat	0.8722	
P(T<=t) one-tail	0.1948	

Source: Own Elaboration

These results show, just as in the previous situation, that the one-tail p-value is higher than our significance level (0.1948 > 0.05) and as such, the test´s value falls outside of the rejection area – we are not able to reject the null hypothesis given that significance level. Consequently, there is no statistical evidence that supports that the average yields of the green and vanilla bonds and thus we cannot acknowledge the existence of a *greenium* in this subsample.

5.3 *Greenium* in USD Bonds

Unlike what was registered in the case of the groups as well as in the subsample for EUR bonds, in the subsample of bonds issued in USD there is no evidence of a *greenium*. In fact, our results show that, there is a positive yield spread of 7.1 bps. To infer on the statistical significance of this finding, we will use the following hypotheses, as well as a paired T-Test (Equation 2) with a significance level of 0.05.

$$\begin{cases} H_0: \overline{Yield\ at\ Issue_{USD\ Green}} - \overline{Yield\ at\ Issue_{USD\ Vanilla}} = 0 \\ H_1: \overline{Yield\ at\ Issue_{USD\ Green}} - \overline{Yield\ at\ Issue_{USD\ Vanilla}} < 0 \end{cases} \quad \textbf{(4)}$$

Results are exhibited on Table 5.3.

Table 5.3: T-Test for USD Green and Vanilla Bonds

T-Test: Paired Two Sample for Means

	Control Group USD (Vanilla Bonds)	*Treated Group USD (Green Bonds)*
Mean	2.1931	2.2645
Observations	17	17
t Stat	-0.4824	
P(T<=t) one-tail	0.318	

Source: Own Elaboration

As in the previous situations, the one-tail p-value is higher than the significance level (0.3180 > 0.05), and as such, the test´s value falls outside the rejection area – we cannot reject the null hypothesis

given this significance level. Subsequently, there is no statistical proof that what was found in this subsample is true, meaning we cannot affirm that the USD green bonds are issued with a higher yield than USD traditional bonds. In fact, there is evidence that there is no difference between the yields at issue of green and vanilla bonds issue in USD.

5.4 *Greenium* throughout the years

Just as previously mentioned, in this subsection we will be looking for a possible *greenium* trend that is forming across the years we are studying. To do so, we will use the same strategy as for the other subsections, meaning that we will perform a paired T-Test (Equation 2) considering a significance level of 0.05, as well as the following hypothesis:

$$\begin{cases} H_0: \overline{Yield\ at\ Issue_{YearX\ Green}} - \overline{Yield\ at\ Issue_{YearX\ Vanilla}} = 0 \\ H_1: \overline{Yield\ at\ Issue_{YearX\ Green}} - \overline{Yield\ at\ Issue_{YearX\ Vanilla}} < 0 \end{cases} \quad \textbf{(5)}$$

It is important to mention that we will only conduct this analysis for the years of 2017 to 2020, since due to the extensive criterion used in the matching process, the number of matches found in some years is not significant to proceed with a statistical analysis, hence our decision.

As one can see (Table 5.4), looking at the means of the subsamples, there is evidence of a possible *greenium* (the average yield at issue of green bonds is lower than the average yield at issue of vanilla bods) in 2017, 2019 and, 2020 with a differential of -36, -1.3, and -1.9 bps, respectively. On the contrary, in 2018 the average yield at issue of the vanilla bonds is approximately 21 bps lower than the one in the green bonds' group. It may be interesting to note that between 2017 and 2021, the difference in the average yields has been decreasing going from -36 bps in 2017 to -1.9 bps in 2020. Nevertheless, it is not conceivable to infer the existence of a trend since we are basing this analysis only on 4 years and we do not possess enough data to conclude on that.

Now, we will look at the results of the paired T-Tests year-by-year (Table 5.4), to assess the significance of the findings above-said. As always, considering a significance level of 0.05, and, as in the other analysis, compare the one-tail p-value (accounting for the specifications of Equation 1, the significance level chosen.

Table 5.4: T-Tests for the Green and Vanilla Bonds bonds pairs found in the years of 2017, 2018, 2019, and 2020

T-Test: Paired Two Sample for Means

	Control Group 2017 (Vanilla Bonds)	*Treated Group 2017 (Green Bonds)*
Mean	1.3916	1.0286
Observations	7	7
t Stat	3.8145	
P(T<=t) one-tail	0.0044	
	Control Group 2018 (Vanilla Bonds)	*Treated Group 2018 (Green Bonds)*
Mean	2.0581	2.2639
Observations	9	9
t Stat	(2.7203)	
P(T<=t) one-tail	0.0131	
	Control Group 2019 (Vanilla Bonds)	*Treated Group 2019 (Green Bonds)*
Mean	0.8277	0.8150
Observations	12	12
t Stat	0.0854	
P(T<=t) one-tail	0.4667	
	Control Group 2020 (Vanilla Bonds)	*Treated Group 2020 (Green Bonds)*
Mean	0.9666	0.9477
Observations	10	10
t Stat	0.0812	
P(T<=t) one-tail	0.4686	

Source: Own Elaboration

In 2017 (Table 5.4), the one-tail p-value is lower than our significance level ($0.0044 < 0.05$). Therefore, for this significance level, we reject the null hypothesis and conclude that in the year of 2017, it was identified a statistically significant *greenium* of 36 bps.

Contrary to the other years, in 2018, the average yield at issue of the green bonds was higher than the average yield at issue of the vanilla bonds (around 21 bps higher). Moreover, the results from the paired T-Test (Table 5.4) show that, again, we reject the null hypothesis (for this significance level) since $0.0131 < 0.05$. Consequently, we can affirm that the yield differential found is statistically significant. However, this difference is not a *greenium*, in fact, it shows that green bonds were issued at a higher yield than their traditional counterparts.

During the year of 2019 (Table 5.4), we found evidence that green bonds were issued, on average, with a yield 1.3 bps lower than their counterparts. That difference was found to be not statistically significant since the one-tail p-value is higher than our significance level ($0.4667 > 0.05$) – we cannot reject the null hypothesis. Therefore, there is no statistical evidence that there is a difference between the yields of both types of bonds.

The same can be inferred for the yield differential found in 2020 (Table 5.4). We observed that, on average, green bonds were issued with a yield 1.9 bps lower than their traditional counterparts. Since the one-tail p-value is greater than the significance level ($0.4686 > 0.05$), and consequently we cannot reject the null hypothesis. Therefore, the yield differential is not statistically significant, and as such, there is no proof that the yields actually differ.

In the next sections, we will summarize the steps taken thus far, as well as further analyze and discuss the results found in this section. Thereafter, we will finally be able to draw a conclusion based on the findings of this dissertation.

6 Summary and Discussion of Results

The present dissertation aimed to analyze if a lower cost of capital would be one of the motivations for corporate issuers to take part in the green bond market, more specifically in the corporate/supranational investment-grade green bond market. Thus, this dissertation was divided into 3 goals: (i) understand the complexities and dynamics and of green bonds and the green bond market; (ii) match green and vanilla bonds with similar characteristics to isolate the effect of the "green label" in bond pricing; (iii) assess the existence of a *greenium* in the primary market.

To meet those goals, firstly, in the literature review section, we recognized not only the characteristics of green bonds, but also the reasons for the development and growth of green finance, particularly the green bond market, which to this day only represents a small fraction of the overall bond market. Several of those reasons are related to marketing strategies, pressure from share and stakeholders, but also connected to a motivation to be more environmentally friendly. However, another underlying motivation, that has been subject to many research studies in recent years, may be related to the yields that green bonds hold compared to conventional bonds. On the investor's side, there is this market belief that, because climate change and other environmental causes have become such a topic of discussion, particularly in the last decade, that the demand for this type of green assets is greater than the demand for more conventional instruments, and as such, investors may be willing to accept a lower return (YTM) due to higher bond prices. Consequently, and looking at the issuer's side, the latter might be able to finance their activities and green transition at a lower cost than they would by issuing vanilla bonds.

To achieve the first proposed goal, we started by defining the pool of bonds from which we would form our matches. We decided to consider only corporate/supranational, investment grade bonds issued in EUR and USD, between the 1st of January 2014 and the 30th of March 2021. In order to proceed with the matching process and isolate the effect of the "green label" in the matched pairs, we further restricted that pool of bonds to issue sizes above USD/EUR 200 million, floating rate, zero-coupon, hybrid, convertible, as well as callable bonds. By conducting descriptive statistics on that pool of bonds, we found initial signs that there could be a *greenium* of 55 bps, along with 52 bps and 56 bps for EUR and USD bonds, respectively. In the next stage, the matching criterion was defined – we focused the pair on bonds issued by the same issuer, currency, rating, coupon type (fixed rate) and issued within the same year. The pairs would also be consisted of bonds with similar payment rank, as well with a maturity differential of maximum 3 years. After the process was concluded, the matches were formed and thereafter, the control and treated groups, consisting of vanilla and green bonds respectively, were ready to be analyzed.

Following the matching process, we took the matched pairs and performed descriptive statistics not only on the control and treated groups, but also on the subsamples within each group of bonds issued in EUR and USD. By doing so, there were some interesting findings – 66% of the bonds were issued in

EUR and 42% of the issuers were banks. Even though our sample size is still very small, the fact that these outcomes are aligned with finding that some agencies like HSBC and KPMG observed in this market, it leads us to believe that the matches are a pretty good representation of the green bond market. Furthermore, 27% of the companies in our samples carry the highest rating score attributed by various raring agencies. Considering the bonds' maturity, it is curious to notice that green bonds seem to mature later than their traditional counterparts. Additionally, we found that both EUR and USD green bonds are issued in far less amounts than vanilla bonds, which makes sense due to the market size for these assets. There is also evidence that the average coupon rate of the control and treated group is very similar, with the former exceeding the latter by only 4 bps. Nevertheless, when looking at the subsamples of EUR and USD, we came across some very contrasting values – in both groups (vanilla and green bonds) it was evident that bonds issued in USD pay a much higher coupon than EUR bonds. In terms of the bonds' payment rank, we found that around 70% of the bonds were senior unsecured in both groups.

We continued our analysis with the bonds' prices. In terms of face value, EUR green bonds are issued at a premium (3%), compared to their traditional matches. On the contrary, USD green bonds are actually issued at a slight discount (10 bps) compared to vanilla bonds.

The last part of our assessment consisted of comparing the yield at issue of our samples, as well as subsamples. We discovered that EUR green bonds were issued, on average, with a lower yield (around 7.2 bps) than traditional bonds– pointing at a *greenium* in that subsample. The same can be said for the control and treated group, which includes bonds issued with both currencies. On those groups we found evidence of *greenium*, since green bonds were issued on average with a yield 2.3 bps lower than vanilla bonds. On the contrary, USD green bonds are issued with yield 7.1 bps higher than USD conventional bonds – in this situation there is no evidence of a *greenium*. Even though we found evidence of a *greenium*, there is till need to further check if those are statistically significant, hence why the need to perform a hypothesis test on each of those.

In order to infer if there is enough evidence to reject our null hypothesis, which states that the yield at issue of green bonds is the same as the yield at issue of vanilla bonds, we carried out a one sample T-Test for the difference in means. The outcomes were very clear – all the negative spreads found and identified in the above paragraph were found to be not statistically significant, meaning that, there is not enough statistical evidence to not reject the null hypothesis, which states that the yields at issue of green and vanilla bonds do not differ. Consequently, we cannot assert that the yield at issue of green bonds is lower than the yield at issue of vanilla bonds. In conclusion, there is no *greenium* neither in the EUR and USD investment-grade corporate bond market, nor in the subsample of EUR bonds. Regarding the positive spread found in the USD subsample, we found that difference to be not statistically significant as well. These conclusions are aligned with the ones of Partridge and Medda (2019), Larcker and Watts (2020), Doronzo et al. (2021), Tang and Zhang (2020), CBI (2020) along with many other researchers and academics who also were not able to find strong evidence of a *greenium* in their respective samples.

Partridge and Medda (2019) suggested, as previously mentioned, that the *greenium* might become a trend in the US municipal bond market in the years to come.

Moreover, the latter authors suggested to the fact that based on 2017 and 2018, the *greenium* might become a trend in the market for years to come. To infer if that statement would also apply to the corporate bond market, and if a trend was forming regarding the "intensity" of the *greenium*, we ran the same hypothesis test for the years of 2017, 2018, 2019, and 2020. We found that there was a negative yield spread in the years of 2017, 2019 and, 2020 of -36, -1.3, and -1.9 bps respectively, as well as a positive yield spread in 2018 (21 bps). Yet again, after running the T-Test for each of those differences, we concluded that none of the *greeniums* were statistically significant, apart from the one in 2017. Since we could only find a statistically significant *greenium* in the year of 2017, we cannot acknowledge that a trend is forming in that market, nor say how this situation will evolve in years to come.

7 Conclusion

Green bonds are a financial instrument that, just like conventional bonds, aims to capture capital in order to finance the operations of an organization. However, green bonds have the particularity of using its proceeds only towards green investments, whose goal is to promote the transition of that entity towards more sustainable processes. In recent years, with topics like sustainability and climate change reaching the mainstream culture and becoming a major source of concern to governments and supranational organizations across the world, as well as investors, that might explain why the green bond market, as well as other green finance instruments went from being a niche to being a rapidly growing market, becoming more liquid and diverse as each year goes by.

Still, the contribution of these bonds to the transition into a "greener" economy is still very questionable since all green bonds are still self-labelled meaning that there is yet to be published official green bond frameworks that regulates not only what is considered as "green projects" that should be financed through the issuance of green bonds, but also the issuance and post-issuance process itself. As we have seen before, even though there is the widely accepted GBP and CBS in the market, as well as the proposed EU-GBS (which could serve as blueprint for other green bond frameworks in the future), the definition of "green projects" is still very dubious. Furthermore, without proper regulation and auditing regarding the use-of-proceeds, the green bond market will always lack transparency and *greenwashing* will continue to take place in that market.

Nevertheless, and despite that lack of regulatory framework, the green bond market has continuously grown, and with several countries and companies proposing very ambitious climate-related goals for the years to come, there is currently no signs of it slowing down. Along with that market growth, there has been an increase interest of researchers and academics in studying and identifying the advantages that green bonds carry over conventional bonds for investors and issuers. One of the main matters of discussion around green bonds is the possibility of a price differential between green and conventional bonds motivated by the green label of the former – more specifically, the chances of green bonds being issued at a higher price, and consequent lower yield, than vanilla bonds (*greenium*). When comparing bonds with the similar characteristics such as issuer, currency, maturity, issue date among others, the existence of a *greenium* could indicate that investors are overvaluing that green label by paying a premium for those bonds, as well as those issuers would be able to finance their green projects at a lower cost than they would by issuing vanilla bonds.

After extensively looking for a *greenium* in the EUR and USD (investment grade) corporate bond market the results were very clear – there is no statistically significant difference in the prices of green and vanilla bonds. Hence, we cannot affirm that there is a *greenium* in that market, nor that there is a trend pointing towards that direction considering the results we obtained.

Taking into consideration these deductions several questions arise, one of which being – if there is no direct cost advantage in issuing green bonds rather than traditional bonds, why is the green bond market growing at such a fast pace for example, in number of issuers and issuances? This is a relevant

matter since the green use of proceeds is not exclusive to green bonds, therefore, issuers are more than able to issue normal bonds and apply the proceeds towards green projects. The answer to this question, as in with every question regarding financial markets and the rationale behind any investment decision, is very complex since it implies all market participants and several investment motivations that go beyond simply the financial return of the assets.

As previously stated, based on our results, companies are not issuing green bonds to access capital at a lower cost than they would with green bonds. Furthermore, it is also known that green bonds typically carry greater costs related to reporting the use-of-proceeds (administrative and compliance costs) and third-party auditing. Even though there is currently no official green bond certification scheme that demands that process, it is required by the existing frameworks such as the CBS. Moreover, it is highly recommended and even encouraged to decrease the possibility of *greenwashing*, which is still one of the reasons why some investors might always shy away from green bonds. All this said, it is clear that, the biggest motivation for companies to issue green bonds is to use it as a marketing tool.

Regarding the investors' motivations to acquire green bonds, besides the obvious financial incentives to obtain return from holding and/or trading green bonds, there is also the intention to diminish the risk of default by supporting companies to become "greener" and therefore, reduce the potential of that entity being subject to high environmental risks which may disrupt their operations, and consequently increase default risk. Additionally, as aforementioned stakeholders have been showing an increasing concern on the impact that companies are having on the world and the role they play in the fight against climate change. All this said, by issuing green bonds, companies are pleasing stakeholders and investors by signaling their commitment to become "greener", and therefore, become more appealing to those investors who are more sensitive to those subjects – appeals to a broader investor base. Also, it has proven by, for example, Flammer (2021), that the stock market reacts positively to the issuance of green bonds, particularly for first-time issuers and for bonds that are certified by third-party, independent entities.

All of the above reasons might explain why resorting to green bonds instead of conventional bonds to finance green investments ends up paying off, despite the higher issuance costs previously discussed and lack of cost advantage (lack of *greenium*), and in the end, it seems as though that green bonds are mainly used as a marketing strategy and a way for companies to ride the "green wave".

It is important to bear in mind that our results and conclusions are constrained not only by the amount of data available which is a direct result from the green bond market's infancy, but also from the very conservative matching decisions taken throughout our research which restricted the number of observations we had to analyze – small sample tests. Therefore, the non-rejections of the null hypothesis, that lead to the assumption that there is not a *greenium* in the corporate green bond market may not be reliable.

In the end, green bonds are currently under a lot of scrutiny and are a topic of much interest in the finance field. As such, we reckon that as more issuances occur and the market develops into a more

mature stage, future studies will have more data available and perform larger-scale analysis, providing more accurate responses to all the lingering questions regarding this market.

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change/?utm_medium=cpc_search&utm_campaign=NB_ACQ_DSAXX_DSATESTTCPAXX_EVG_XXXX_XXX_COALL_EN_EN_X_BLOM_GO_SE_XXX_XXXXXXXXXX&gclid=Cj0KCQjwqp-LBhDQARIsAO0a6aJMfWauOCu0JPkiBiHNX8xlgnbppVzBPQcpwOYTaKn04A1zZc-yiRUaAiPKEALw_wcB&gclsrc=aw.ds

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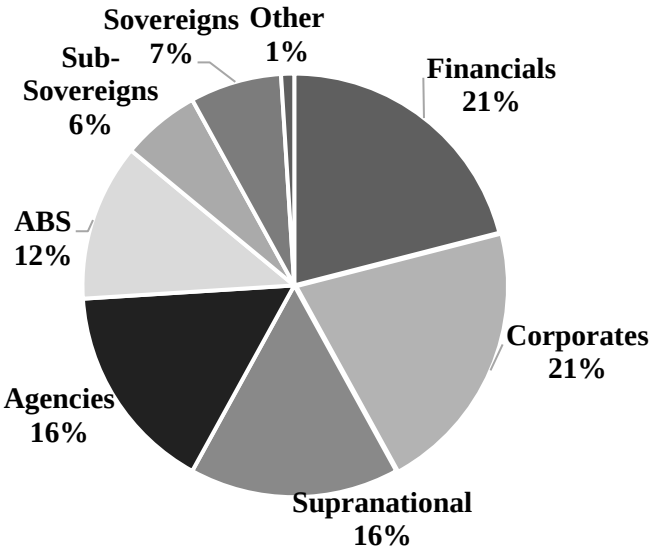
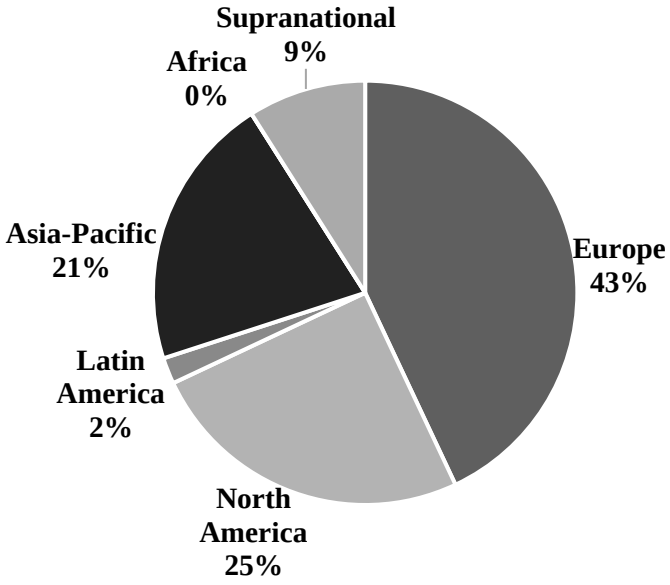
9 Appendixes

Appendix A - Issuer Profile of the Green Bond Market



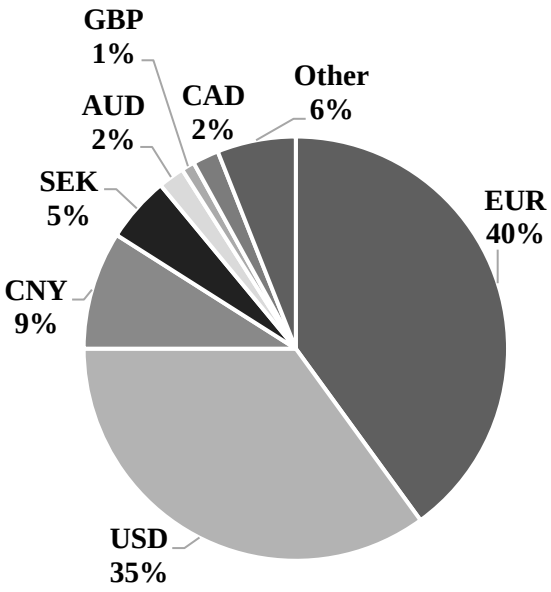
Source: Dax and Kreipl (2021)

Appendix B - Geographic Profile of the Green Bond Market



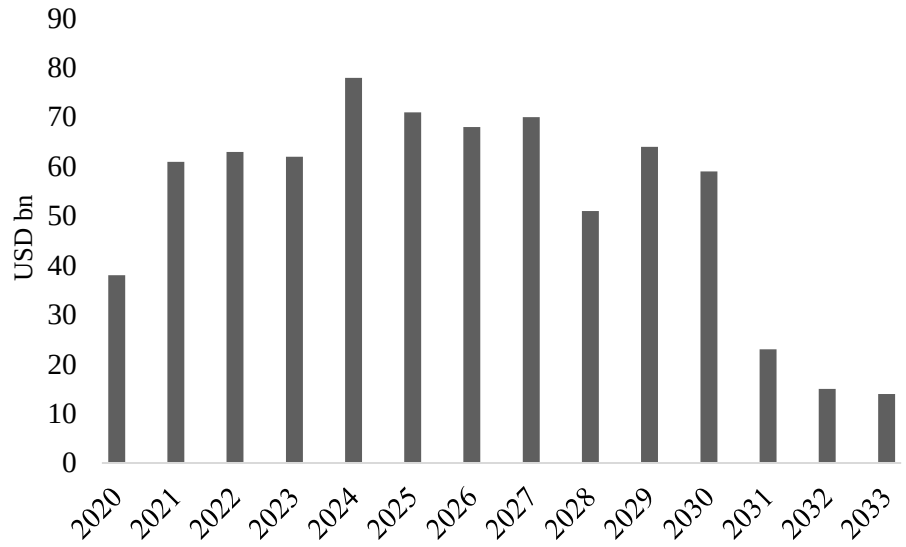
Source: Dax and Kreipl (2021)

Appendix C - Currency Profile of the Green Bond Market



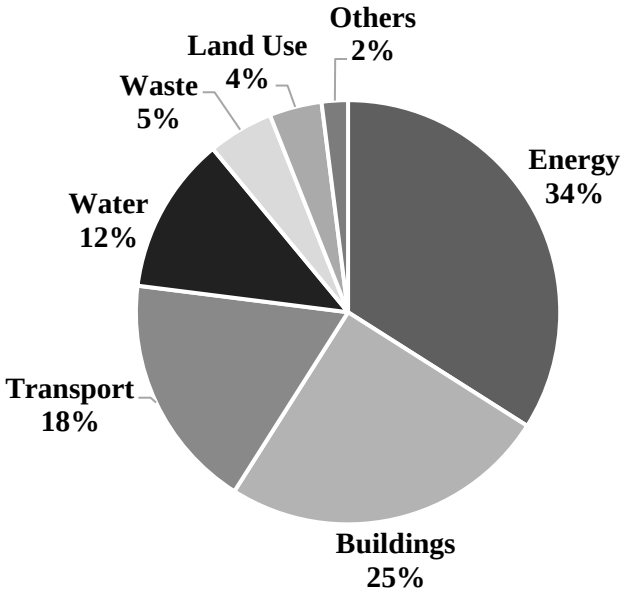
Source: Dax and Kreipl (2021)

Appendix D - Maturity Profile of the Green Bond Market



Source: Dax and Kreipl (2021)

Appendix E - Use-of-Proceeds in the Green Bond Market



Source: Dax and Kreipl (2021)

Appendix F - Descriptive Statistics of the Bonds' Universe

Panel A: Bond Characteristics (Green Bond Universe)

	Average	Median	Standard Deviation	Minimum	Maximum	*N* Bonds
Amount Issued						
Amount Issued (EUR)	822,820,000	600,000,000	699,270,000	250,000,000	6,100,000,000	192
Amount Issued (USD)	742,380,000	600,000,000	370,380,000	200,000,000	2,000,000,000	125
Coupon (%)	1.438	1.000	1.419	--	6.000	317
Coupon EUR Bonds (%)	0.711	0.625	0.633	--	3.500	192
Coupon USD Bonds (%)	2.524	2.375	1.282	0.220	6.000	125
Issue Price (% of face value)						
Issue Price EUR Bonds	99.640	99.680	0.840	97.330	103.410	192
Issue Price USD Bonds	99.840	99.740	1.760	98.490	116.470	125
Yield at Issue (%)	2.335	2.271	1.572	0.053	6.250	317
Yield at Issue EUR Bonds (%)	1.007	0.624	0.804	0.053	2.538	192
Yield at Issue USD Bonds (%)	2.516	2.431	1.358	0.220	6.250	125

Panel B: Bond Characteristics (Vanilla Bond Universe)

	Average	Median	Standard Deviation	Minimum	Maximum	*N* Bonds
Amount Issued						
Amount Issued (EUR)	1,260,000,000	1,000,000,000	1,720,000,000	200,000,000	25,110,000,000	2,826
Amount Issued (USD)	1,090,000,000	750,000,000	966,360,000	200,000,000	11,460,000,000	4,372
Coupon (%)	2.310	2.250	1.636	--	8.750	7,198
Coupon EUR Bonds (%)	0.988	0.750	0.856	--	4.750	2,826
Coupon USD Bonds (%)	3.086	3.125	1.505	--	8.750	4,372
Issue Price (% of face value)						
Issue Price EUR Bonds	99.670	99.670	0.760	95.320	108.040	2,826
Issue Price USD Bonds	99.690	99.840	0.500	91.200	104.700	4,372
Yield at Issue (%)	2.882	2.923	1.435	(0.196)	8.375	7,198
Yield at Issue EUR Bonds (%)	1.525	1.412	0.982	(0.196)	4.750	2,826
Yield at Issue USD Bonds (%)	3.079	3.106	1.355	0.180	8.375	4,372

Source: Own Elaboration

Appendix G - Issuers and Number of Issues of the Matched Bonds

Issuers	Number of Bond Issues
African Development Bank	1
Asian Development Bank	2
Banco Santander SA	2
Bank of Nova Scotia	1
BNP Paribas	3
BPCE	2
Canadian Imperial Bank	1
Cooperatieve Rabobank UA	1
Danske Bank A/S	1
DNB Boligkreditt AS	1
EDP Finance BV	1
European Bank for Reconstruction & Development	2
European Investment Bank	2
Ferrovie dello Stato Italiane SpA	1
Iberdrola	2
ING Groep NV	2
International Bank for Reconstruction & Development	1
Intesa Sanpaolo SpA	2
Kreditanstalt fuer Wiederaufbau	3
Landesbank Baden-Wuerttemberg	2
Met Life Glob Funding I	2
Mitsubishi UFJ Financial Group Inc	1
NRW Bank	3
QNB Finance Ltd	1
Royal Bank of Canada	1
Societe Generale SA	1
SpareBank 1 SMN	1
Sumitomo Mitsui TR BK LT	2
Svenska Handelsbanken AB	2
Toyota Motor Credit Corp	2
Westpac Banking Corp	1
Total	**50**

Source: Own Elaboration

Appendix H - Descriptive Statistics of the Matched Bonds

Panel A: Bond Characteristics (Matched Green Sample- Treated Group)

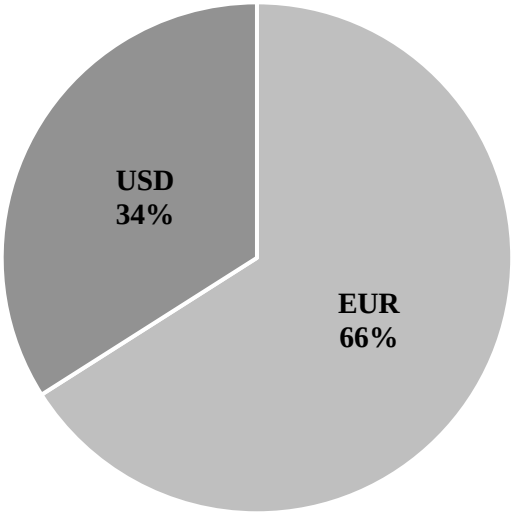
	Average	Median	Standard Deviation	p25%	p75%	Minimum	Maximum	*N* Bonds
Amount Issued								
Amount Issued (EUR)	751,515,151.5	600,000,000	396,170,111.9	500,000,000	750,000,000	300,000,000	2050,000,000	33
Amount Issued (USD)	701,470,588.2	500,000,000	357,560,155.4	500,000,000	750,000,000	50,000,000	1500,000,000	17
Coupon (%)	1.2189	0.975	1.0966	0.375	1.7188	0	4.625	50
Coupon EUR Bonds (%)	0.6991	0.5	0.6352	0.2	1.125	0	2.5	33
Coupon USD Bonds (%)	2.2281	2	1.1120	1.55	2.527	0.95	4.625	17
Issue Price (% of face value)								
Issue Price EUR Bonds	99.7109	99.679	0.5602	99.455	99.849	98.738	102.155	33
Issue Price USD Bonds	99.7788	99.818	0.2142	99.744	99.953	99.172	100	17
Yield at Issue (%)	1.2624	1.026	1.1038	0.438	1.768	(0.213)	4.666	50
Yield at Issue EUR Bonds (%)	0.7462	0.572	0.6561	0.239	1.173	(0.213)	2.538	33
Yield at Issue USD Bonds (%)	2.2645	2.053	1.1197	1.555	2.527	0.958	4.666	17

Panel B: Bond Characteristics (Vanilla Bond Sample- Control Group)

	Average	Median	Standard Deviation	p25%	p75%	Minimum	Maximum	*N* Bonds
Amount Issued								
Amount Issued (EUR)	1412,424,242.4	1000,000,000	1454,333,568	700,000,000	1250,000,000	375,000,000	6000,000,000	33
Amount Issued (USD)	1720,588,235.3	1300,000,000	1152,179,839.4	1000,000,000	1750,000,000	350,000,000	5000,000,000	17
Coupon (%)	1.2598	0.85	1.1466	0.3938	1.9688	0	4.55	50
Coupon EUR Bonds (%)	0.7972	0.5	0.6988	0.375	1.125	0	2.625	33
Coupon USD Bonds (%)	2.1578	2.125	1.3227	0.9	3	0.25	4.55	17
Issue Price (% of face value)								
Issue Price EUR Bonds	96.8005	99.727	17.1832	99.494	99.874	1.146	102	33
Issue Price USD Bonds	99.8898	99.909	0.3834	99.767	99.944	99.335	101.175	17
Yield at Issue (%)	1.2858	0.867	1.1429	0.4673	1.8913	(0.262)	4.593	50
Yield at Issue EUR Bonds (%)	0.8184	0.574	0.6815	0.394	1.059	(0.262)	2.655	33
Yield at Issue USD Bonds (%)	2.1931	2.149	1.3217	0.949	3.089	0.287	4.593	17

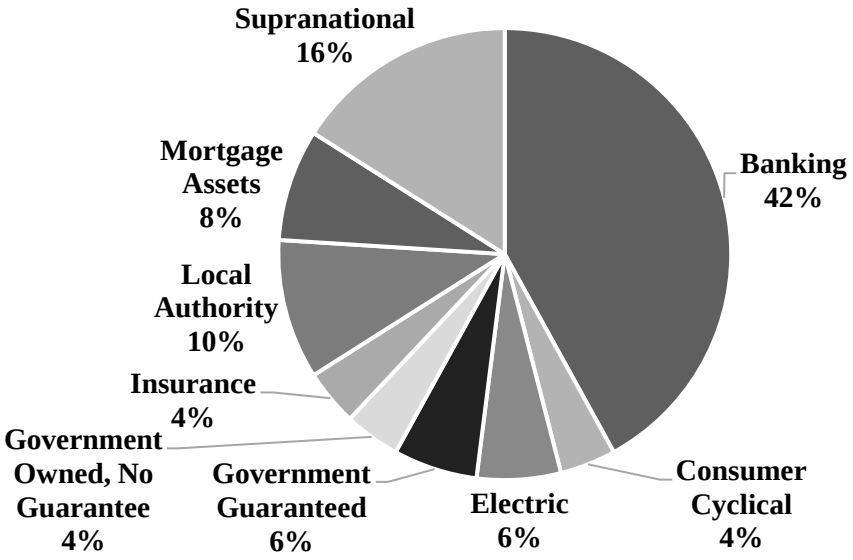
Source: Own Elaboration

Appendix I - Currency Distribution of the Matches



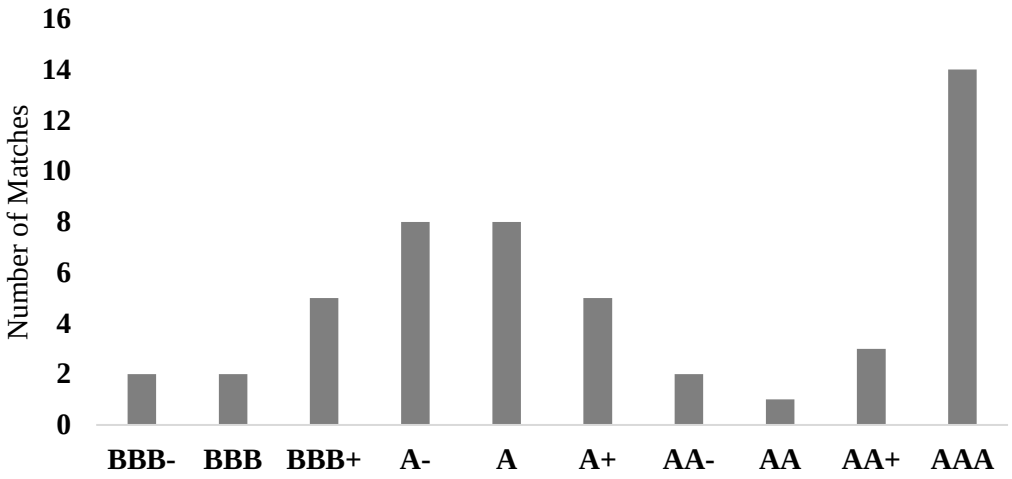
Source: Own Elaboration

Appendix J - Class Distribution of the Matches



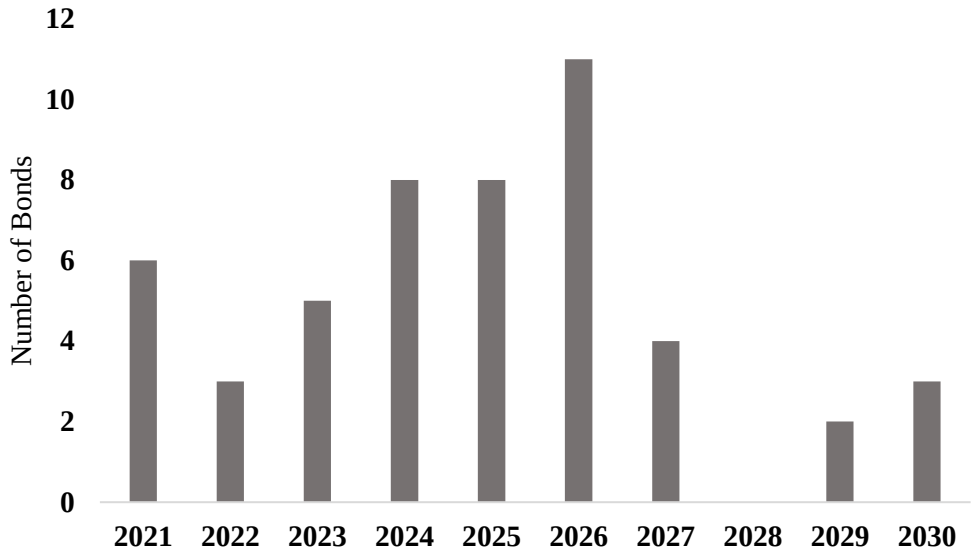
Source: Own Elaboration

Appendix K - Rating Distribution of the Matches



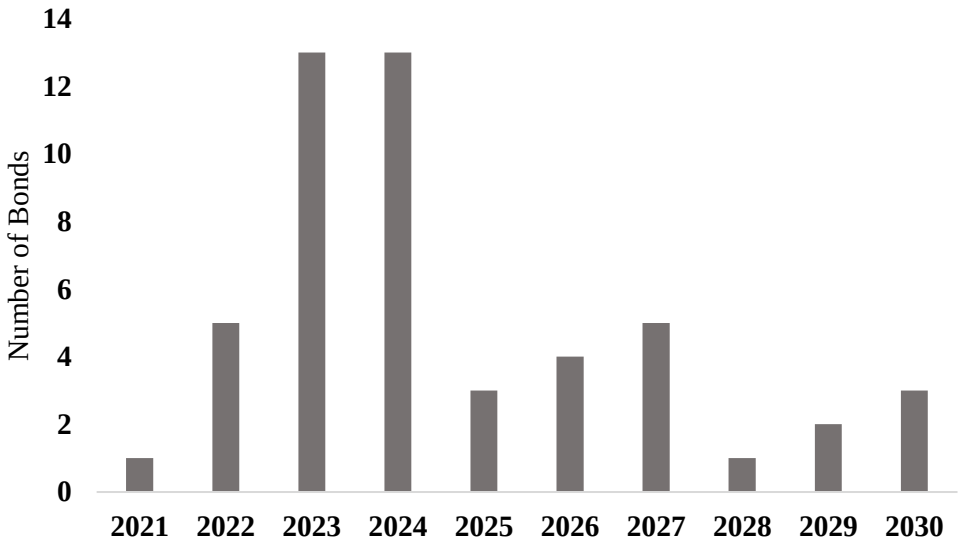
Source: Own Elaboration

Appendix L - Maturity Distribution of Green Bonds



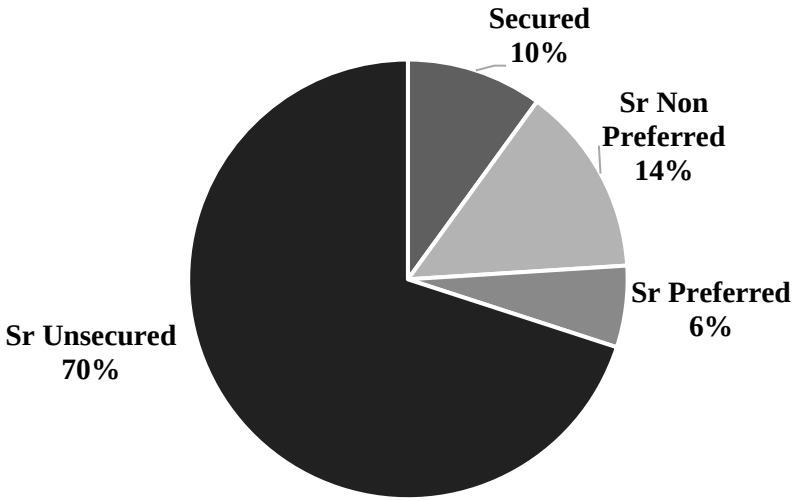
Source: Own Elaboration

Appendix M - Maturity Distribution of Vanilla Bonds



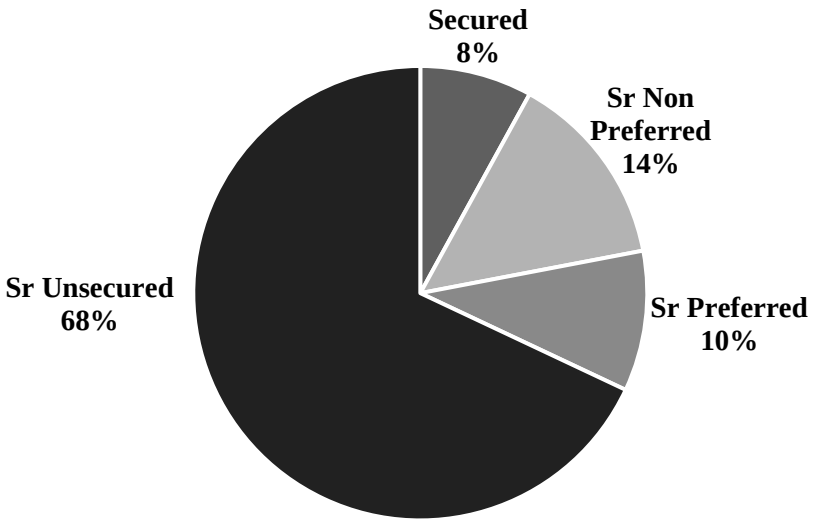
Source: Own Elaboration

Appendix N - Seniority Distribution of Vanilla Bonds



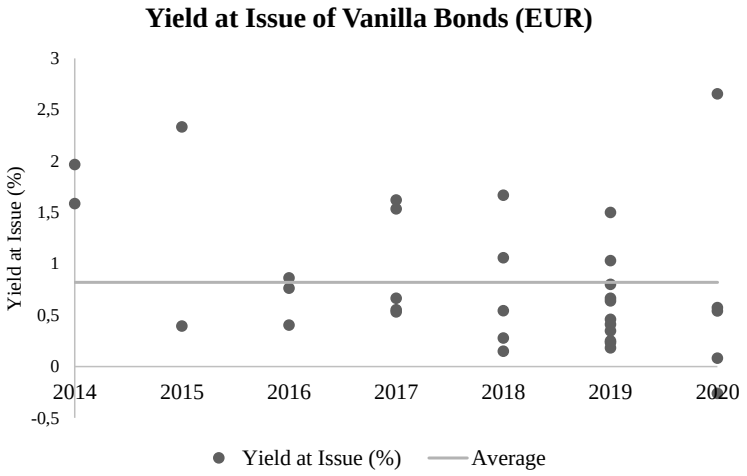
Source: Own Elaboration

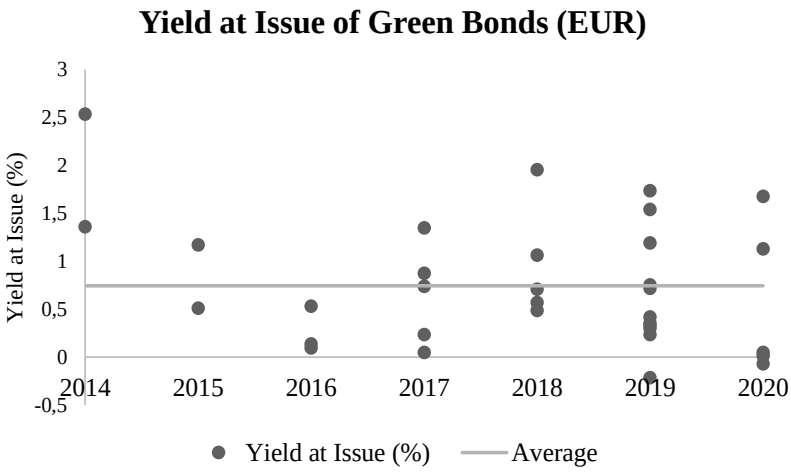
Appendix O - Seniority Distribution of Green Bonds



Source: Own Elaboration

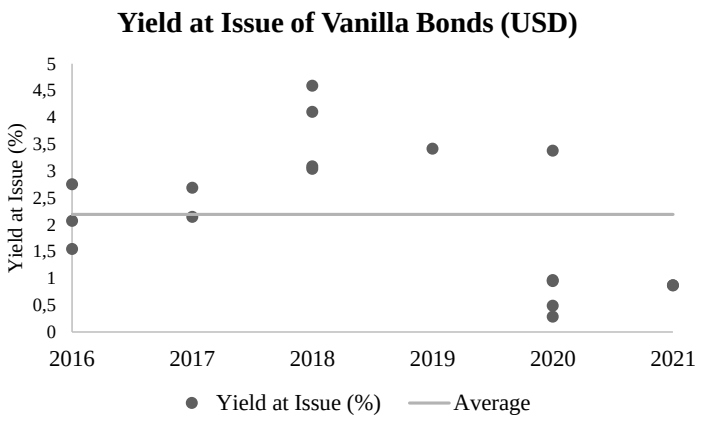
Appendix P - Concentration of the Yields at Issue Throughout the Years (EUR Bonds)

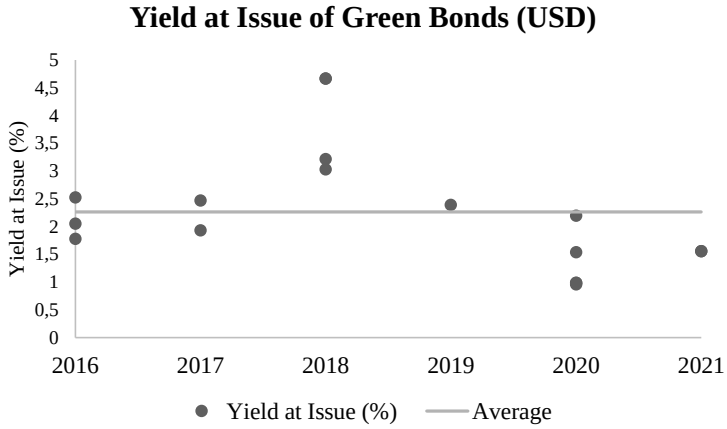




Source: Own Elaboration

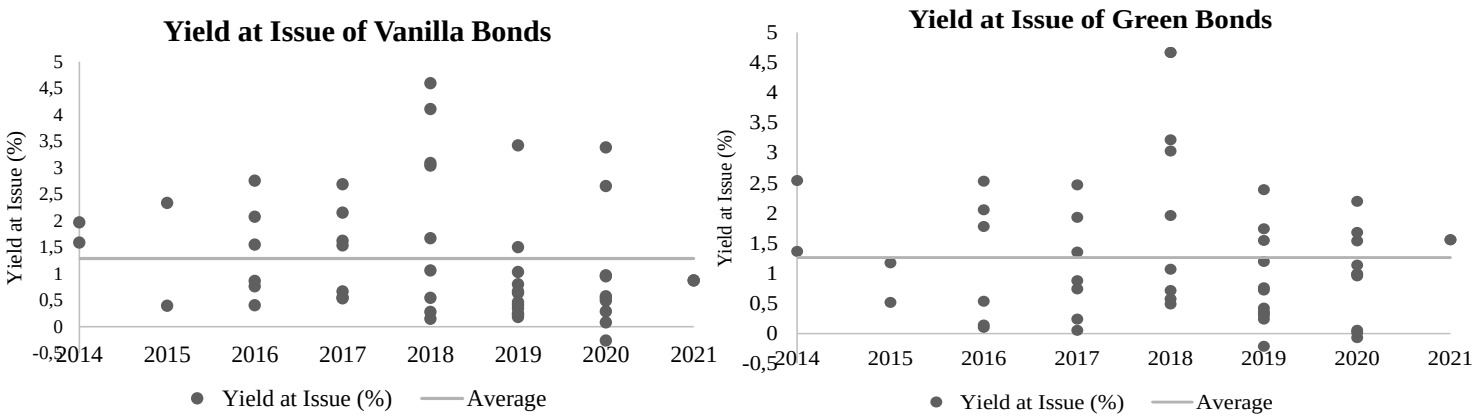
Appendix Q - Concentration of the Yields at Issue Throughout the Years (USD Bonds)





Source: Own Elaboration

Appendix R - Concentration of the Yields at Issue Throughout the Years



Source: Own Elaboration