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Does the Issuance of Green Bonds provide a cheaper source of capital to firms?

Bruno Miguel Olivença Franco

Master in Finance

Supervisor:
PhD Luís Miguel da Silva Laureano, Assistant Professor,
ISCTE-IUL

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BUSINESS
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Department of Finance

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Resumo

As mudanças climáticas são consequência da atividade humana e, como tal, temos a responsabilidade de as solucionar através de estratégias de mitigação e adaptação, se queremos assegurar um Mundo limpo e sustentável para as gerações corrente e futura. No entanto, para implementar e seguir tais planos, existem custos substanciais envolvidos que ultrapassam o orçamento público. Como tal, as finanças desempenham um papel fundamental no desenvolvimento de instrumentos financeiros capazes de envolver o setor privado em avançar a sustentabilidade.

As Obrigações Verdes são uma destas inovações, exigindo que as empresas emissoras, com a sua cláusula de Uso dos Rendimentos, apliquem todos os rendimentos em projetos amigos do ambiente. Esta dissertação pretende responder à seguinte questão: "As Obrigações Verdes têm taxas de juro inferiores às Obrigações Convencionais?". Através do uso de diferentes métodos de correspondência e modelos de regressão, não encontrámos prova que as Obrigações Verdes têm um premium, sugerindo que os investidores não estão dispostos a trocar rendimento pelo apoio de projetos sustentáveis.

Determinar se existe uma diferença nas taxas de juro entre Obrigações Verdes e Convencionais é essencial para o desenvolvimento e implementação de iniciativas destinadas a ajudar o Mercado das Obrigações Verdes a atingir o seu potencial. Focando-nos nos resultados, de forma a elevar a agenda sustentável, governos e outras entidades responsáveis devem dar prioridade às Obrigações Verdes, melhorando a sua atratividade e diferenciando-as das Obrigações Convencionais, através da introdução de, por exemplo, políticas de compensação ou dedução de impostos.

Palavras-Chave: Sustentabilidade; Mudanças Climáticas; Obrigações Verdes; Greenium; Finanças Verdes; Métodos de Correspondência

Classificação JEL: G12; Q56

Abstract

Climate change is a human-induced problem and, as such, it falls upon us to deal with it through mitigation and adaptation strategies, if we are to secure a clean, liveable World for current and future generations. However, to implement and follow these plans, there are substantial costs that surpass the public budget. Hence, finance plays a key role in developing financial instruments that can involve the private sector in advancing sustainability.

Green Bonds are one of these innovations, requiring the issuer, with its Use of Proceeds clause, to allocate all its proceeds towards environmentally friendly projects. This dissertation tries to answer the following question: "Do Green Bonds have lower yields than Conventional Bonds?". Using different matching methods and regression models, we did not find proof of the Green Bond premium, suggesting that investors are not willing to trade return for the support of greener projects.

Determining if there is a difference in the pricing of Green and Conventional Bonds is key in the development and implementation of policies and initiatives to help the Green Bond Market unlock its full potential. Looking at our results, to further the green agenda, governments and policymakers should prioritise Green Bonds, increasing their attractiveness and differentiating them from their counterpart, by introducing, for instance, compensation or tax deduction policies.

Keywords: Sustainability; Climate change; Green Bonds; Greenium; Green Finance; Matching Methods

JEL Classification: G12; Q56

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Glossary of Acronyms

BBG C: Bloomberg's Composite Credit Rating
BCLASS: Bloomberg's Classification System
BLUE: Best Linear Unbiased Estimator
BNEF: Bloomberg's New Energy Finance
bps: Basis Points
CBI: Climate Bonds Initiative
CBS: Climate Bonds Standard
CEM: Coarsened Exact Matching
CFP: Corporate Financial Performance
CSP: Corporate Social Performance
CSR: Corporate Social Responsibility
DBRS: Dominion Bond Rating Service
EGBS: European Green Bond Standard
ESMA: European Securities Markets Authority
EUR: European Monetary Currency
GBP: Green Bond Principles
GDP: Gross Domestic Product
HAC: Heteroscedasticity and Autocorrelation Consistent
ICMA: International Capital Market Association
IEA: International Energy Agency
IRENA: International Renewable Energy Agency
ISIN: International Security Identification Number
OECD: Organisation for Economic Co-operation and Development
OLS: Ordinary Least Squares
pps: Percentage points
PSM: Propensity Score Matching
SDG: Sustainable Development Goals
S&P: Standard and Poor's
SRI: Socially Responsible Investing/Investment
UN: United Nations
UNIDO: United Nations Industrial Development Organisation
USA: United States of America
USD: United States of America Dollar
WLS: Weighted Least Squares
Z-spread: Zero Volatility Spread

Introduction

Climate change is the harsh reality we live in. The continuous growth of the population leads to, as should be expected, an increase in the consumption of natural resources. However, most of the methods currently available to harvest and collect these resources are associated with high greenhouse gas emissions, which have a devastating and possibly irreversible effect on the environment and climate. Thus, focusing on managing and minimizing the effects of climate change on society and the Planet is a job for all of us.

The Paris Agreement[1] faces these issues by recognising climate change as an undeniable threat that requires the cooperation of all countries. Hence, this agreement urges all participants to significantly cut their emissions and, ultimately, put the world on a path towards sustainable economic development. The main goal of this agreement is to hold the increase in the global average temperature to well below 2º Celsius (above pre-industrial levels) and to pursue efforts to limit this increase to 1.5º Celsius.

The 2030 Agenda for Sustainable Development[2] defined the Sustainable Development Goals (SDG), which are integrated goals and targets that aim to balance the three dimensions of sustainable development: economic, social and environmental. Also calling for action in all countries, these goals aim to eradicate poverty and hunger, as well as to promote peace, prosperity, inclusivity and cooperation. Protecting the Planet from degradation, encouraging sustainable consumption and production, along with taking urgent action against climate change are also objectives.

However, to take action against climate change, all countries require major investments in clean infrastructure and energy. According to a report by OECD (2017a), approximately 7 trillion USD are required annually, between 2016 and 2030, to meet development needs globally in a climate-compatible way. Following an alternative OECD (2017b) report, nearly 93 trillion USD are needed, until 2030, in infrastructure investment alone. Another report by IRENA (2021), details investments of 131 trillion USD to flow into a new energy system until 2050. The Bank of America Merrill Lynch (2014) estimates a 53 trillion USD investment need in energy by 2035 – 39 trillion USD to shift from fossil fuel and 14 trillion USD in energy efficiency.

To sum up, dozens, if not hundreds of trillions of dollars need to flow into a new energy system and infrastructure if we are to address climate change and avoid irreversible effects on the environment. Yet, reports also mention increases in the global GDP from reducing climate risks and, consequently, climate mitigation and adaptation costs, as well as other economic, employment and health benefits (Bank of America Merrill Lynch, 2014; IEA, 2021; IRENA, 2016, 2021; OECD, 2017a). In financing this transition to a low emission economy, the public sector plays a crucial role in creating climate-resilient, environmentally friendly policies, initiatives and incentives to engage the private sector. Among them

[1] https://www.un.org/en/climatechange/paris-agreement
[2] https://sdgs.un.org/2030agenda

is the need to prioritise, standardise and diversify current green financial instruments and, in particular, Green Bonds which are the focus of this master's dissertation.

According to some reports, Green Bonds are a key financial instrument to unlock private capital and finance the transition to the carbon-free economy (Bank of America Merrill Lynch, 2014; OECD, 2017b). Flaherty *et al.* (2016) expand on Sachs (2014) study, proposing an intergenerational three-stage model to finance climate policies through Green Bonds. Following this research, climate policies are funded through the issuance of Green Bonds. Afterwards, future generations, through an income tax, repay the bonds while enjoying the benefits of the climate mitigation policies. According to Sachs (2014:249), climate change policy goes from a "trade-off of current well-being and future well-being" to a "trade-off of climate change versus taxation facing future generations".

Nevertheless, what are Green Bonds? Green Bonds are "any type of bond instrument where the proceeds (…) will be exclusively applied to finance or re-finance (…) new and/or existing eligible green projects" (ICMA, 2021:3). However, due to the lack of standardisation and universally agreed definition, there is a major risk for investors: *greenwashing* (see Annex A: Concepts and Definitions). To avoid this risk, a consortium of investment banks in 2014 came up with the Green Bond Principles (GBP) which advocate for transparency, disclosure and integrity in the Green Bond Market. The creation of these principles acted as a catalyser to this market. In fact, by 2020, the CBI came up with an average annual growth rate of the Green Bond Market, since its inception, of approximately 95%.

One of the most discussed topics regarding Green Bonds in the literature is the pricing of Green Bonds, in particular, if the yield of Green Bonds is lower than Conventional Bonds or, in other words, if there is a *greenium*. Some studies found evidence of this *greenium* (Baker *et al.*, 2018; Ehlers & Packer, 2017; Fatica *et al.*, 2019; Gianfrate & Peri, 2019; Kapraun *et al.*, 2021; Karpf & Mandel, 2018; Löffler *et al.*, 2021; Meyer & Henide, 2020; Nanayakkara & Colombage, 2019; Preclaw & Bakshi, 2015; Zerbib, 2019), while others found no statistically significant difference in yields (Flammer, 2021; Larcker & Watts, 2020; Tang & Zhang, 2020). A study even found a Green Bond discount (Karpf & Mandel, 2017).

Considering these contradicting results, we set our eyes on determining if Green Bonds have a lower yield than Conventional Bonds. To do so we employ three different matching methods – Propensity Score Matching (PSM), Coarsened Exact Matching (CEM) and Direct Matching - to our initial sample of 148 Green Bonds and 4,996 Conventional Bonds collected from Bloomberg. These matching methods were employed in some of the Green Bond literature we studied and were used to introduce balance into the sample and, thus, make statistical inference more trustworthy. Basically, matching consists of forming pairs of Green and Conventional Bonds with similar characteristics, consequently reducing the impact these characteristics have on the outcome variable.

This study will contribute to the debate on sustainable finance and on the policies and incentives needed to "mainstream" this concept. If indeed there is a premium, it means investors are holding an asset that provides a lower return, implying investors value the *Green Label* and other non-pecuniary

characteristics. Policies and initiatives should therefore be focused on transparency and disclosure, to make sure the proceeds from these assets go towards sustainable development. On the other hand, if the premium does not hold, it means investors are not willing to forego their return in exchange for other non-monetary benefits. Resulting policies and incentives should focus on increasing the attractiveness of this type of assets, by rewarding investors for holding them, for instance.

Our results were not statistically significant, suggesting there is no relationship between the *Green Label* and the *Yield at Issue* of bonds, *i.e.*, based on our sample of corporate, investment grade, plain vanilla bonds, the yield of Green Bonds does not appear to differ from the yield of Conventional Bonds, beyond what is expected. This does not look good for the introduction and development of corporate sustainability since most firms, without the lower cost of debt benefit, will prefer to issue Standard Bonds, which come without the Use of Proceeds clause, allowing them to allocate their bond proceeds willingly. On the other hand, Green Bonds are prone to allocation restrictions.

Nevertheless, Green Bonds have other benefits such as improved reputation and environmental rating, reduction of greenhouse gas emissions, increased institutional ownership and stock liquidity, better media exposure and public reception along with real environmental impact (Bank of America Merrill Lynch, 2014; Flammer, 2021; Glomsrød & Wei, 2018; Meo & Karim, 2021; OECD, 2017b; Tang & Zhang, 2020; Tolliver *et al.*, 2019). Furthermore, Lourenço *et al.* (2012) state there is social pressure for firms to engage in Corporate Social Responsibility (CSR) activities, being often penalized for not doing so. Hence, issuing Green Bonds attracts investors' attention and puts the firm in the spotlight, allowing them to join the free-carbon economy movement while enjoying the benefits.

Focusing on the investors though, there are studies stating they are not willing to let go of return in exchange for supporting green projects (Larcker & Watts, 2020) and others that state otherwise (Delsen & Lehr, 2019). This shows that there are different types of investors, allowing us to introduce the notion of Socially Responsible Investing (SRI). SRI investors introduce moral values in their investment decisions, not letting monetary perks cloud their judgement. These investors are the main target for firms that issue Green Bonds since they have other non-pecuniary interests involved such as, for example, taking action against climate change and supporting the development of current sustainability policies and regulations by participating in the Green Bond Market. Thus, Green Bonds, premium or no premium, will always have an audience. In fact, at this time, some argue that, even though there is a premium, there is still a higher Green Bond demand than supply (Zerbib, 2019).

Comparing our study to previous Green Bond literature, we differentiate ourselves through the use of different matching methods, which originated different datasets, to determine if there is a Green Bond premium or not. By doing so, we believe our results become more robust and aligned with the market since different datasets, with different regression models applied, end up yielding the same result. Furthermore, we solely explore the primary, corporate Green Bond Market, which not many researchers have done - most focus on the municipal Green Bond Market, which has a higher issuance rate; on the general Green Bond Market, to include as many Green Bonds as possible into the analysis; or on the

secondary market, which provides information on the evolution of the yields, improving the amount of information available for the study.

However, working with different matching methods, also has its drawbacks, namely when contrasting results appear, which can complicate the conclusions drawn from such results. For example, even though there is virtually no statistically significant estimate for the *Green Label*, some methods predict negative estimates while others predict positive ones. Moreover, solely focusing on the primary, corporate market may have hindered our results as well since we ended up with a rather conservative amount of information on Green Bonds and their yields. Still, we believe we made the right decision in order to detach ourselves from previous research as well as to reach clearer and sturdier results.

For future research, we advise focusing on different areas of the Green Bond Market. Looking at the volatility of Green Bonds, it is still a greatly debated subject, with some believing Green Bonds have higher volatilities to reflect their higher perceived risk (for instance, lack of standardisation and certification) (Löffler *et al.*, 2021), while others argue the opposite, describing the loyalty investors hold for such bonds and their issuing companies (Bank of America Merrill Lynch, 2014). Another topic of interest would be to assess the impact of Green Bonds on sustainability. Even though the impact of Green Bonds on greenhouse gas emissions and on the environmental rating of the issuing firm is not contested, some believe that Green Bonds are not as impactful as they appear to be since they focus primarily on financing or re-financing green projects that would have been financed regardless of this financial instrument (Maltais & Nykvist, 2020).

The remainder of this dissertation is organised as follows. Chapter 1 details the Literature Review, highlighting the main scientific articles and reports that reference the benefits, limitations and other characteristics of Green Bonds, the Green Bond Market and Green Finance in general. Next, Chapter 2 is the Data chapter, which details the collection and filtering of the data from Bloomberg, necessary to construct our sample, as well as presents the main descriptive statistics along with a balance check for the dataset. Chapter 3 comprises the Methodology of this dissertation, describing what matching methods are and which ones will be employed, and the regression models we will apply to study the Green Bond premium. Following this, Chapter 4 consists of the Results and Discussion, where we will deliver our results and discuss them in the context of the Green Bond Market. Finally, we close this dissertation with the Conclusion, where we will summarise our entire study and provide recommendations.

1 Literature Review

Under this topic we will give some insight into the academic work developed around Green Bonds. We will start with a brief introduction on the Green Bond Market, after which we will shift our focus to the financial instrument itself: Green Bonds. Later we will also highlight academic work regarding CSR and SRI, as well as their contribution towards a firm's cost of capital, profitability and performance.

1.1 Green Bond Market

The Green Bond Market, as the name suggests, is where Green Bonds are traded. Overall, researchers studying this market show admiration for its fast growth and high demand among investors. However, they all agree that the market still has some barriers and challenges to overcome, namely when it comes to certification, to improve credibility and participation.

1.1.1 Green Bond Market: Numerical Analysis[3]

According to the CBI, the Green Bond Market had its inception in 2007, when the European Investment Bank issued the first Green Bond under the label Climate Awareness Bond, with a total issuance of around 800 million USD. By the end of 2012, total cumulative issuance added up to approximately 9 billion USD. In these first five years the Green Bond Market was characterized by the issuance of a few bonds per year, being limited to AAA-rated development bank issuers.

In 2013, the first corporate issuers arrived in the market, driving total Green Bond cumulative issuance to nearly 20 billion USD. Nevertheless, the main catalyser to the Green Bond Market came in 2014 with the creation of the GBP. According to the CBI, total Green Bond issuance in this year alone reached 36.6 billion USD, nearly tripling the size of the market. From here on out, the Green Bond

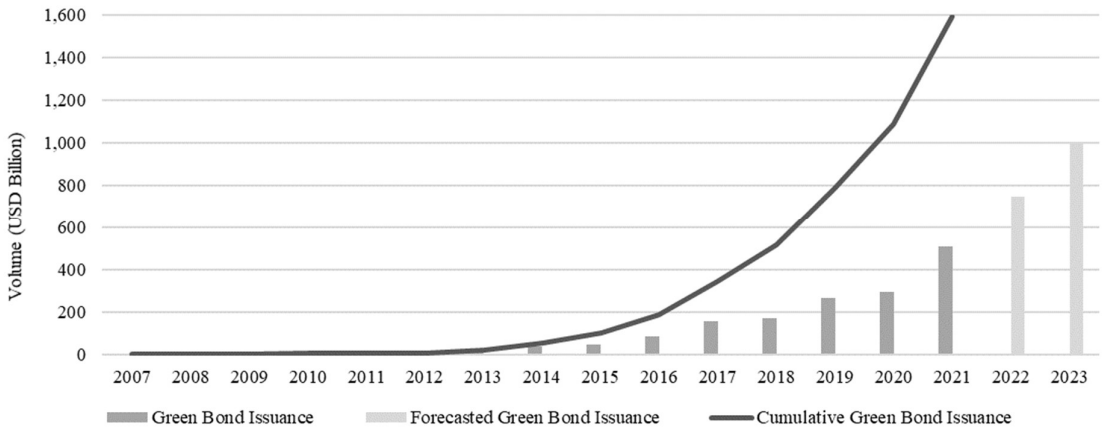

Figure 1.1: Total Green Bond issuance, forecasted Green Bond issuance and cumulative Green Bond issuance since the inception of the Green Bond Market until 2023.
(Source: CBI)

[3] https://www.climatebonds.net/market/data/

Market kept increasing, achieving, in cumulative issuance, the 100 billion USD milestone in 2015, the 250 billion USD milestone in 2017 and the 500 billion USD milestone in 2018.

In the second quarter of 2020, the Covid-19 pandemic proved to be a challenge to the Green Bond Market. Though total issuance was once again record breaking, it was far from the previously seen jumps – 298.1 billion USD issued in 2020 *versus* 269.3 billion USD issued in 2019. Still, by the end of this year, the biggest landmark to date in the Green Bond Market was reached – 1 trillion USD in cumulative issuance. Overall, the CBI reports an average annual growth rate of approximately 95%, from 2007 to 2020, stressing the continuous strong growth of this market.

According to CBI, total Green Bond issuance in 2021 was of 508.8 billion USD, putting this market back on track for yearly strong growths. In fact, early forecasts by this entity suggest that in 2023 alone total Green Bond issuance might reach 1 trillion USD.

1.1.2 Green Bond Market: Taxonomy[4]

There are several international taxonomies addressing Green Bond project definitions and acting as guidelines to issuers who wish to advance sustainability while maintaining the credibility and integrity of the Green Bond Market. One of these taxonomies is the GBP, established in 2014 by a consortium of investment banks. Ever since then, ongoing monitoring and development of guidelines has moved to an independent party, the International Capital Markets Association (ICMA).

Following the ICMA (2021) report, the GBP are voluntary process guidelines promoting transparency, disclosure and integrity in the Green Bond Market. The GBP provide clear guidelines for issuers to emit credible Green Bonds by promoting transparency and disclosure, which assist investors in evaluating their exposure to risk and investment impact, while at the same time offering underwriters vital steps that facilitate transactions and preserve the integrity of the Green Bond Market.

The Principles are as follows: Use of Proceeds; Process for Project Evaluation and Selection; Management of Proceeds; and Reporting. A standard, GBP-aligned Green Bond issuance should include the environmental benefits of the green project the bond will finance, followed by how the issuer will identify and manage the potential risks associated with said project, as well as periodic reporting on the use and allocation of the proceeds of the bond.

Another important taxonomy is the European Green Bond Standard (EGBS)[5], announced in early 2020. Similarly, the EGBS aims to create a uniform Green Bond standard to better direct financial and capital flows to credible green investments. It is a voluntary standard, helping companies and public authorities raise funds to finance their environmentally friendly projects, while subjecting them to strong sustainability requirements, and protecting investors from the risk of *greenwashing*.

[4] For more information on each of these taxonomies, and their requirements, see Annex B: Comparison of the different Green Bond Taxonomies.

[5] https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance/european-green-bond-standard_en

There are four key requirements under the EGBS taxonomy: Taxonomy-Alignment; Transparency; External Review; and Supervision by the European Securities Markets Authority (ESMA) of reviewers. A standard, EGBS-aligned Green Bond issuance should allocate all the funds to projects aligned with the EU taxonomy, while fully reporting on the allocation of these proceeds. This issuance should then be followed by an external reviewer, registered and supervised by the ESMA, increasing the reliability and quality of the reporting.

The Climate Bonds Standard (CBS)[6] is another relevant taxonomy, introduced by the CBI, assuring all bond issuances are consistent with the objectives of the Paris Agreement. This standard is the only one recognized and employed internationally. It incorporates the GBP, the EGBS and other taxonomies from China, Japan, India and other countries and regions.

For a Green Bond to be CBS-certified, it must follow a strict process: Prepare the Bond; Engage a Verifier; Get Certified & Issue a Certified Climate Bond; Confirm the Certification Post-Issuance; and Report Annually. Thus, after the issuer sets a Green Bond Framework, defining the use of proceeds for the bond, it must seek an approved Verifier, whose report can get access to the pre-issuance certification, after being submitted to the CBI. Following the issuance of the Green Bond, the issuer must engage with the Verifier and obtain the post-issuance report, to be presented to the CBI and await decision on certification. Following the approval, issuers must then report annually to bondholders and the CBI.

1.1.3 Green Bond Market: Overview

Currently in the Green Bond Market, certification, disclosure and transparency are a major problem, reducing credibility and therefore affecting engagement and overall attractiveness of this market. The CBI lists some of the benefits of certification: besides attracting a more diverse base of investors - potentially bringing pricing advantages to the firm- and enhancing a firm's reputation, certification also allows investors to actively hedge against climate risks and signal to the market and governments their willingness to invest in the low-carbon transition.

Accordingly, several researchers stress the importance of certification and standardisation, in order to reduce the risk of *greenwashing* and, simultaneously, increase participation and improve awareness (Ehlers & Packer, 2017; Kapraun *et al.*, 2021; Nanayakkara & Colombage, 2019; Sartzetakis, 2019). Tuhkanen and Vulturius (2020:19) take a more drastic look into the lack of post-issuance reporting, claiming that unless issuers are able to reduce the existing information asymmetries "it is unlikely that Green Bonds will become a catalyst for sustainable finance".

More broadly, Martin and Moser (2016) discuss the importance of information disclosure by providing evidence that disclosing the societal benefits of investments is valued by investors, more so than the actual cost. Ilhan *et al.* (2021), through a survey to important decision makers at some of the world's largest investors, concluded that climate disclosure is as important as financial disclosures.

[6] https://www.climatebonds.net/certification/get-certified#Process

Respondents believe that more accurate information on climate risks can lead to more efficient pricing. Nevertheless, disclosure also has its costs, namely when confidentiality agreements or competitive considerations come into play.

Pham (2016) provided a detailed study on the volatility of the Green Bond Market, suggesting there is significant *volatility clustering* (see Annex A: Concepts and Definitions). Furthermore, the researcher found an interdependence between the Green Bond Market and the Conventional Bond Market, showing proof of a variable spill-over effect from the former to the latter. Moreover, Pham (2016) data shows that there has been an upward trend in the correlation of volatility of these two markets, which led the researcher to suggest that there is a convergence of returns between the Green Bond Market and the Broader Bond Market. As such, stronger differentiation strategies and certification standardisation should be introduced in the Green Bond Market to increase investors' awareness and reach a broader pool of investors.

Tolliver *et al.* (2019) also request drastic scaling up of the Green Bond Market if we are to address the SDG and the Paris Agreement investment demands. Still, the authors believe the high growth rates of this market mean it is gaining some prominence and that it still can be seen as a viable financing instrument for meeting both agendas.

1.2 Green Bonds

Several researchers compare Green Bonds to Conventional Bonds, stating that they are similar in every way except when it comes to the use of proceeds (Gianfrate & Peri, 2019; Karpf & Mandel, 2018; Löffler *et al.*, 2021; Meyer & Henide, 2020). The ICMA (2021:3) report offers a more complete definition, stating that Green Bonds are "any type of bond instrument where the proceeds or an equivalent amount will be exclusively applied to finance or re-finance, in part or in full, new and/or existing eligible green projects".

1.2.1 Green Bonds: Main Benefits

Why do companies issue Green Bonds? Flammer (2021) tries to tackle this question in her study and concludes that firms issue Green Bonds to signal to the market their commitment towards the environment. The researcher notes that after a Green Bond issuance the companies' stock return is positive, their environmental rating improves and their greenhouse gas emissions decrease. Tang and Zhang (2020) also analyse the benefits of issuing Green Bonds. The results found – greater stock liquidity and an increase in the institutional ownership of the issuer - are consistent with their investor attention argument, meaning firms issue Green Bonds to capitalize on their media exposure, increasing the demand for their shares as well as their investor base.

Meo and Karim (2021) provide evidence that Green Bonds play a part in reducing greenhouse gas emissions. Glomsrød and Wei (2018) add divestment in fossil-based industries as a variable and note that emissions decrease in the same value as the total emissions of the European Union and Japan

together. They also add that this is an underestimate since the increase in investments in renewable energy is not reflected in the divestment variable. Tolliver *et al.* (2019) manage to quantify both the reduction in emissions (108 million tonnes) and the renewable energy capacity (1,500 GW) associated with projects and assets financed through Green Bonds.

A report by Bank of America Merrill Lynch (2014) calls Green Bonds a game changer for unlocking private capital, stating that with the proper development and standardisation Green Bonds could fund most of the investment needs of transitioning to a sustainable energy future. Furthermore, this report says Green Bonds have been less volatile than Conventional Bonds, citing their "perceived safety and longer-term investor base with lower *churn rates*" (Bank of America Merrill Lynch, 2014:4) (see Annex A: Concepts and Definitions).

Another report, by the OECD (2017b), states Green Bonds can facilitate the greening of traditionally brown sectors, implying their environmental impact can be significant. Additionally, besides the clearer advantages to the issuer in terms of reputation and overall environmental strategy, it provides a new source of green financing and a wider range of new green financial products available to investors, facilitating access to capital for green projects.

1.2.2 Green Bonds: Main Limitations

Despite the belief some share that Green Bonds could be able to finance most of the transitioning investment needs, Maltais and Nykvist (2020) believe Green Bonds give the impression to be more impactful than they actually are in terms of shifting capital towards sustainable investments because they are marketed in terms of metrics such as emissions' reduction and renewable energy generated. The authors call this financial tool conservative and unable to unlock new sources of capital for green investment. Tuhkanen and Vulturius (2020) show that firms often do not link Green Bonds and corporate climate targets, failing to make both part of a comprehensive approach to manage their transition into carbon neutrality. The researchers suggest little pressure has been put on issuers to do so.

Additionally, Sartzetakis (2019) states that Green Bonds still have not reached their potential as an instrument to help fund the transition into carbon neutrality. To do so, some barriers need to be overcome, namely allow access to the Green Bond Market of smaller firms and as such reduce the costs of certification, standardisation and reviewing; promote certification and third-party reviewing; and improve the attractiveness of Green Bonds through policies and initiatives.

The Bank of America Merrill Lynch (2014) also stresses the importance of standardising Green Bonds. According to this report, "standardisation reassures buyers of the green credentials behind the bond, thereby increasing comparability, liquidity and investor demand" (Bank of America Merrill Lynch, 2014:20). Furthermore, this report requests an expansion of the issuance of Green Bonds, facilitating accessibility and more accurate rating and pricing of the bonds.

1.2.3 Green Bonds: Is there a Premium?

Although there is still no academic consensus, and results are still mixed, most researchers find that issuing Green Bonds is a cheaper way of financing sustainable operations for firms, when compared to their Conventional counterpart (Baker *et al.*, 2018; Ehlers & Packer, 2017; Fatica *et al.*, 2019; Gianfrate & Peri, 2019; Kapraun *et al.*, 2021; Karpf & Mandel, 2018; Löffler *et al.*, 2021; Meyer & Henide, 2020; Nanayakkara & Colombage, 2019; Preclaw & Bakshi, 2015; Zerbib, 2019). These studies find varying *greeniums* depending on certification, industry and currency.

Zerbib (2019) found a Green Bond premium of -2 basis points (bps), a small although statistically significant premium that is more pronounced for financial and low-rated bonds. According to this scholar's findings, the lower cost of debt for firms with good environmental performance is mainly due to lower financial risk, through intangible asset creation (namely, improvement in the firm's reputation and heightened employee and customer loyalty), and better risk management and mitigation, rather than investor's non-pecuniary preferences. The researcher also adds that "while the amount of this premium indicates investors' preference for Green Bonds, it does not yet reveal any substantial pricing discrepancy between Green and Conventional Bonds" (Zerbib, 2019:51).

Nanayakkara and Colombage (2019) research shows evidence of at least a -63 bps *greenium* in the global capital market, stressing investors' appetite over Green Bonds as a way to diversify their investment portfolio. Löffler *et al.* (2021) show a more conservative premium for Green Bonds, with their results yielding a statistically significant difference between Green and Conventional Bonds' yields of around -15 bps to -20 bps, suggesting that either Green Bonds have fewer underlying risks or investors simply show a pro-environmental preference for Green Bonds. The scholars lean towards the second claim.

Kapraun *et al.* (2021) analysed both the primary and secondary markets and found no significant difference in yields between Green and Conventional Bonds. Nevertheless, the scholars show evidence of a *greenium* of -5 bps to -18 bps for Green Bonds expressed in EUR or that were issued by governments, local governments or supranationals. These researchers also state that for the pricing of corporate Green Bonds, external certification proves to be of utmost importance.

Gianfrate and Peri (2019) focused on the primary market and encountered a -17 bps to -18 bps Green Bond premium, which increases for corporate issuers. Fatica *et al.* (2019) show further proof that the premium depends on issuer type, suggesting financial institutions do not hold a Green Bond premium - versus supranational and corporate issuers. Meyer and Henide (2020) found evidence of a -1.84 bps *greenium*, focusing on EUR-expressed, investment grade, senior corporate issuers. These scholars also find that the premium increases with greenhouse gas emissions, suggesting issuers with higher emissions enjoy a higher premium.

Preclaw and Bakshi (2015) found evidence of an approximately -17 bps Green Bond premium in the secondary market. In trying to justify the presence of a premium in the Green Bond Market, the scholars came up with several suggestions: (1) investor preferences, in particular for non-pecuniary

characteristics – which might be able to offset the lower cash flow; (2) risk and volatility, suggesting that Green Bonds may be less risky/volatile; (3) mismatch between demand and supply, meaning investors are eager to invest in Green Bonds but their supply is limited; and (4) externalities, where investors are willing to accept the lower return because of the externalities offered by the bond.

Zerbib (2019) agrees with the previous researchers, blaming the premium on the limited supply of highly demanded bonds. The author goes on to say that the premium is in accordance with *Stakeholder Theory* (see Annex A: Concepts and Definitions), where better environmental performance leads to a lower cost of capital. Nevertheless, Karpf and Mandel (2018) are not so sure the demand for Green Bonds is high enough to justify a premium, pointing out herding behaviour and reputation externalities as possible explanations.

Ehlers and Packer (2017) documented a -18 bps *greenium* on average, looking at fixed-rate bonds expressed in EUR or USD. This researcher also compares the premium found with the costs of certification and green assessment (0.1 bps and 3-5 bps, respectively), concluding that the premium is enough to compensate. Baker et al. (2018) analysed the municipal bond market in search of a premium, finding one of nearly -6 bps. This premium can increase with certification.

Karpf and Mandel (2018), after a 2017 study where they found evidence of a Green Bond discount, found a premium of approximately -23 bps. The scholars justify this premium looking at the Green Bond issuers, which in general are more creditworthy and have more robust economic fundamentals. In fact, to explain their Green Bond discount encountered in their 2017 study, these researchers state that "following the rise of the credit quality of green bonds on the municipal market, the premium has eventually turned positive" (Karpf & Mandel, 2018:164-165).

On the other hand, there were also those who did not find any premium (Flammer, 2021; Karpf & Mandel, 2017; Larcker & Watts, 2020; Tang & Zhang, 2020). Karpf and Mandel (2017), as mentioned previously, found evidence of a Green Bond discount, indicating that Green Bonds are penalized by the market. Tang and Zhang (2020) found little evidence that Green Bonds are issued at lower yields than Conventional Bonds, suggesting their main benefit is not cheaper debt financing. Flammer (2021) shares this same view, arguing that investors are not willing to accept investments with lower returns just because they are environmentally friendly.

Larcker and Watts (2020) did not find a significant difference in yields, suggesting once more that investors are not willing to let go of return to support eco-friendly projects. Moreover, this study also focused on the cost of underwriting, coming to the conclusion that underwriting is 10% higher for Green Bonds. Although Larcker and Watts (2020) focus on the municipal bond market, they argue that if there was a *greenium*, the municipal market would be where they would most likely observe it since this market has been one of the largest Green Bond issuers to date.

The CBI also studies the pricing of Green Bonds[7], looking for a *greenium* in the primary market in their periodic reports, issued since 2017. That said, this entity looks at a handful of Green Bonds every few months, focusing on their own yield curve and determining there is a *greenium* if Green Bonds are priced inside their own yield curve, suggesting they have lower yields than the firm's existing debt.

Throughout their reports, the CBI states that usually there is evidence of a new issue premium, *i.e.*, to attract investment, firms price their new bonds lower (higher yields). Moreover, this organisation calls the *greenium* counterintuitive "because Green Bonds rank pari passu (on equal footing) with bonds of the same rank from the same issuer" (CBI, 2017a:10). The lack of credit enhancement and additional costs with certification and reviewing are also pointed as reasons to why there should not be a *greenium*.

Overall, in their reports, the CBI rarely found that the majority of Green Bonds displayed a *greenium*, only doing so in their 2020, second semester report (CBI, 2021a). Nevertheless, it is noticeable, as the years go by, that the amount of Green Bonds exhibiting a *greenium* increased, stating that this is evidence of investor support for the *Green Label*. However, in 2021, it appears that the number of Green Bonds exhibiting a *greenium* reduced due to interest rates: "as interest rates rise, bond prices generally fall, and while a lack of supply may temper the magnitude of the impact, a green label is unlikely to offer complete protection from this" (CBI, 2022:9).

Generally speaking, even though Green Bond academic and financial literature is actively growing, it is still at an early stage. With more research on this topic and more time for the market to develop, a consensus will be reached. The benefits will standout, and so will the shortcomings. But meanwhile, combining this study with other research areas may help investors realise the advantages of firms or portfolios focusing on environmental concerns.

1.3 Green Finance

Green Finance, in this master thesis, can be seen as an umbrella term, being often used to refer to any financial initiative that aims to manage the impact of financial investments on the environment and society. Hence, CSR, SRI and any other type of positive environmental behaviour, such as the issuance of Green Bonds, can be fit into this term. By building this bridge we are able to better understand the impact of good environmental management on firms or portfolios. Most of the studies in these areas reveal that good environmental performance brings advantages, via lowering the overall cost of capital and boosting profitability.

1.3.1 Green Finance: Corporate Social Responsibility

The United Nations Industrial Development Organisation (UNIDO) defines CSR as "a management concept whereby companies integrate social and environmental concerns in their business operations

[7] For more information on the reports issued by the CBI between 2017 and 2022, see Annex C: Table summarising the reports issued by the CBI.

and interactions with their stakeholders"[8]. Essentially, it is the way a company can reach a balance of economic, environmental and social imperatives, while at the same time managing shareholders and stakeholders' expectations. UNIDO also mentions the competitive advantages firms can access if they properly implement this concept, such as: increased brand recognition and reputation; enhanced customer loyalty; increased sales and profits, as well as lower operational costs; improved productivity and quality; and easier access to capital and markets.

Flammer (2013) conducted a thorough study on CSR and shareholder reaction. The results pointed towards positive responses from the market to eco-friendly initiatives and negative ones to eco-harmful behaviour, as would be expected. Furthermore, the researcher found that the more institutionalised becoming green is, the worst the effect of eco-harmful behaviour since companies are penalised for not following the norm. On the other hand, the better the environmental CSR of a firm, the less negative the response to eco-harmful behaviour will be because the lower the additional value generated by additional investments on CSR. Therefore, from this perspective, environmental CSR can be seen as insurance against shareholders' negative reaction.

On the other hand, Krueger (2015) focused on the value added by shareholders from CSR investments. The scholar noted that when CSR comes from *agency problems* (see Annex A: Concepts and Definitions) it is detrimental to shareholder value because managers are benefitted at the expense of shareholders. Yet, if CSR is used for value-enhancing purposes then shareholders tend to react positively, mainly when it is used to address problematic stakeholder relations. Martin and Moser (2016) note that potential investors react more positively when CSR investment reports focus more on the societal benefits rather than the cost to the firm. The researchers add that the managers' investment decision cannot be fully explained by the expected investor reaction, it must also reflect the value they put on said benefits.

Lourenço *et al.* (2012) show that firms face pressure and scrutiny from stakeholders to adopt CSR in their business operations. The scholars' results suggest companies are penalized by the market for not adopting such measures, showing proof of large profitable firms who are undervalued for having a low level of CSR. Thus, these researchers consider firms engage in CSR to meet stakeholder expectations. According to them, forming good relationships with stakeholders is imperative to create certain resources and capabilities that are indispensable to developing competitive advantages.

Orlitzky *et al.* (2003) developed research into the complex relationship between Corporate Social Performance (CSP) and Corporate Financial Performance (CFP), which up until then was considered to be inconclusive by several previous studies. Employing meta-analysis, these researchers found a positive relationship between CSP and CFP, implying that companies with better CSP enjoy stronger CFP. Furthermore, these scholars found that reputation is an important mediator of this relationship.

[8] https://www.unido.org/our-focus/advancing-economic-competitiveness/competitive-trade-capacities-and-corporate-responsibility/corporate-social-responsibility-market-integration/what-csr

Kim *et al.* (2015) also found a positive relationship between CSP and CFP. By introducing *competitive action* (see Annex A: Concepts and Definitions), these scholars considered that the effect of CSR on CFP depended on the level of this variable. Hence, when the level of competitive action was high, positive CSR boosted CFP, through positive responses from stakeholders; conversely, negative CSR had a negative, stronger effect on CFP, since stakeholders' expectations were not met, which led to the destruction of stakeholder relationships. Another interesting result these researchers found was that, when the level of competitive action was low, the effect of negative CSR on CFP was mitigated. Nevertheless, continuously employing negative CSR initiatives bears a cost to the firm, in the form of damaged reputation and relationships with stakeholders.

1.3.2 Green Finance: Socially Responsible Investing

S&P Global considers that SRI "puts a premium on positive social change by considering both financial returns and moral values in investment decisions"[9]. Following their definition, investors who use this strategy consider the impact of their investment on society or the environment before accounting for their financial returns. According to the Sustainable Investment Forum (2020) report, climate change and carbon emissions are the most important environmental issues for institutional investors.

When going through this type of investments some previous selection should be made. Kempf and Osthoff (2007), at the portfolio level, describe three different screening techniques: (1) negative screening, where investors exclude investments related to controversial business areas (nuclear power, military, alcohol, tobacco, gambling and firearms); (2) positive screening, which rates investments based on a set of criteria and then selects the ones that have a higher rating; and the (3) best-in-class screening, which is similar to the previous one but makes sure the resulting portfolio is balanced across all industries. The authors found that the best performing portfolio was the one that contained the higher SRI ratings and that was composed using the best-in-class approach.

However, Guerard (1997) found that screened and unscreened portfolios had similar returns and that using the military screen continually cost the investors returns. Statman and Glushkov (2009) admitted that stocks of companies with high SRI ratings outperformed stocks with low ratings, nevertheless shunned stocks' good performance balanced out the first effect, leaving socially responsible indexes with similar returns to those of conventional indexes.

Heinkel, Kraus and Zechner (2001) discuss how SRI, particularly green investment, can impact corporate behaviour. According to their results, 25% of investors in the market should be green to encourage more firms to reform their operations and move on to clean technologies. A report from the Social Investment Forum (2020) states that 33% from the total USA assets under professional

[9] https://www.spglobal.com/en/research-insights/articles/what-is-the-difference-between-esg-investing-and-socially-responsible-investing

management are managed under sustainable investing strategies. In the framework created by these researchers, a third of investors are enough to drive firms to adapt and transform their operations.

Delsen and Lehr (2019) study how beneficiaries have preferences for sustainable pension fund investments. Through a questionnaire the scholars concluded that respondents have strong preferences for sustainability, with roughly three quarters favouring this type of investment even with higher premiums or lower benefits. The authors found that gender, age, educational attainment and employment status are the socio-demographic characteristics that have an effect on SRI. Contrary to previous research, income, home ownership, religion and risk appetite do not play a part.

1.3.3 Green Finance: The effects of good Environmental Performance

Considering firms' environmental management and performance, a number of benefits are listed. Several authors defend that good environmental management and performance can lead to larger stock returns (Flammer, 2021; Kempf & Osthoff, 2007; Klassen & McLaughlin, 1996; Statman & Glushkov, 2009; Tang & Zhang, 2020) while others point out the reduced cost of capital, improved credit quality and lower perceived risk one can have by putting their effort towards environmental and social concerns (Bauer & Hann, 2014; Oikonomou *et al.*, 2014; Sharfman & Fernando, 2008). Sharfman and Fernando (2008) also mention resource efficiencies as an advantage.

Additionally, Konar and Cohen (2001) found a positive relationship between a firms' environmental performance and the value of their intangible assets. The researchers found a 380 million USD reduction in market value attributed to environmental concerns, meaning a worse environmental performance led to lower intangible assets, and vice-versa. This paper made the scholars believe the reason why some major corporations over complied with environmental regulations was because they were rewarded in the marketplace. Also, Earnhart and Lizal (2007) focused on a transition economy to conclude that better environmental performance increased profitability, by driving down costs more than revenues.

Alessi *et al.* (2021) study if there is indeed a *greenium* in the market. According to their results, the *greenium* is negative and statistically significant, meaning investors are willing to forego return in exchange for financing transparent, environmentally friendly projects. The scholars interpret this result as evidence that climate change is a risk and investors finance these greener projects as a hedging strategy against worse environmental outcomes.

In his work, Sartzetakis (2019) describes three types of climate-related financial risks: (1) physical risks, which can arise from weather-related events, such as floods and storms; (2) liability risks, which can arise from parties affected by those events; and (3) transitional risks, related with problems arising from the transition to carbon neutrality, such as technology adaptation or policy changes. If issuers and investors put their effort into managing these risks, by focusing more on the environmental and social impact of their business and investment activities, the previously listed benefits and competitive advantages will be available and ready to generate return.

Overall, as the United Nations (UN) put it, fossil investments will eventually phase out, resulting in abandoned assets and unrealised returns[10]. Green, clean, sustainable investment is the future, leading to cost savings and sustainability improvement. Focusing on this transition, although costly as it may be, will bring several advantages in the form of lower cost of capital, enhanced reputation, boosted profitability, increased stock return and a more diverse investor base to the issuers. To the Planet, accelerating the transition to a carbon-free economy will reduce greenhouse gas emissions and, hopefully, attenuate climate change consequences.

[10] https://www.un.org/en/climatechange/raising-ambition/climate-finance

2 Data

In this chapter we will discuss the data and steps required to build the dataset that will be used to address the main question at hand: do Green Bonds provide a cheaper way for companies to finance their sustainable projects? Moreover, we will study this dataset and provide you the main descriptive statistics, along with a description of its balance, with the help of Microsoft Excel (hereby mentioned simply as Excel).

2.1 Data Collection

Most academic literature associated with the *greenium* uses Bloomberg as its main source of information (Baker *et al.*, 2018; Ehlers & Packer, 2017; Flammer, 2021; Gianfrate & Peri, 2019; Kapraun *et al.*, 2021; Karpf & Mandel, 2017, 2018; Larcker & Watts, 2020; Nanayakkara & Colombage, 2019; Tang & Zhang, 2020; Zerbib, 2018). Other platforms, mainly used as a secondary source, are CBI (CBI, 2017a - 2022; Ehlers & Packer, 2017; Tang & Zhang, 2020), Mergent (Baker *et al.*, 2018; Larcker & Watts, 2020), Refinitiv Eikon (Kapraun *et al.*, 2021; Löffler *et al.*, 2021) and some more specific bond indexes (Meyer & Henide, 2020; Preclaw & Bakshi, 2015).

However, according to Larcker and Watts (2020), Bloomberg is widely considered, among industry professionals, to be the most comprehensive publicly available list of green securities. With that in mind, the present study takes full advantage of Bloomberg's ability to provide reliable data from the financial market. The data collected provides information regarding the bond, particularly its *Issuer Name*, *Issue Date*, *Maturity Date*, *Maturity Type*, *Amount Issued*, *Currency*, *Bloomberg's Composite Credit Rating* (BBG C), *Coupon*, *Coupon Type*, *Yield at Issuance*, *Price at Issuance*, *Seniority*, *Collateral Type* and different levels of *Bloomberg's Classification System* (BCLASS). For more information on each of these fields see Annex D: Table summarising all the Bloomberg fields. Furthermore, we include the *Ticker* and the *International Security Identification Number* (ISIN) in case we need to gather more information about a specific issue later.

The previously listed fields provide information regarding Green Bonds and Conventional Bonds. According to Bloomberg's New Energy Finance (BNEF) (2015) Terminal Guide, Green Bonds are defined in accordance with the GBP, meaning Bloomberg's *Green Instrument Indicator* emphasizes the bond's Use of Proceeds clause, making sure all the proceeds from Green Bonds go towards environmentally friendly projects. Thus, Bloomberg's list of Green Bonds reduces the risk of *greenwashing* through certification and disclosure, meaning issuers must deliver a prospectus with every Green Bond containing information regarding their use of proceeds. Only after presenting this mandatory documentation will issuers be subject to approval by BNEF and, eventually, have their bond labelled as a Green Bond by Bloomberg.

2.2 Data Filtering

To conduct our analysis of the Green Bond Market, we are focusing on corporate bonds. Flammer's (2021) study also looks at this financial instrument, claiming there has been a surge in corporate Green Bond issues ever since 2013, but little is known regarding corporate Green Bonds. Therefore, using a fixed income search function on Bloomberg, we select corporate bonds. Bloomberg then returns information on over 300,000 securities, of which 4,182 are Green Bonds and the remaining are Conventional Bonds, as seen on the table represented below.

Table 2.1: Bloomberg filters used on the dataset.
(Source: Own elaboration)

Field	Boundaries	Criteria		Matches	
		Green Bonds	Conventional Bonds	Green Bonds	Conventional Bonds
Security Status	Include	Corporate Bonds		302,196	
Green Instrument Indicator	--	Yes	No	4,182	298,014
Issue Date	In the range	01/01/2014 - 31/12/2021		3,832	238,083
BBG C	>=	BBB-		931	29,746
Coupon Type	Include	Fixed		813	23,735
Yield at Issue	Has data	--		353	13,286
Seniority	Has data	--		353	13,223
Maturity Type	Exclude	Callable or Convertible		148	4,996

However, we need to apply more filters in order to end up with a more manageable database. Hence, we are focusing on corporate bonds issued between January the 1st, 2014, and December the 31st, 2021, since we only want to focus on Green Bonds issued after the creation of the GBP and before the ending of the last full year. Furthermore, we are only interested in data from *investment grade* issues (Gianfrate & Peri, 2019; Meyer & Henide, 2020; Preclaw & Bakshi, 2015) (see Annex A: Concepts and Definitions). Issues with a lower rating, to attract investors, must compensate them for the degree of risk they are exposed to, meaning the lower the credit rating, the higher the coupon. Getting rid of these issues gets rid of high yield bonds, otherwise known as junk bonds, leaving the database with more "controlled" coupons. These filters reduced the database to around 30,500 securities: 931 Green Bonds and 29,746 Conventional Bonds.

Next, we select only bonds with a fixed coupon (Baker *et al.*, 2018; Ehlers & Packer, 2017; Gianfrate & Peri, 2019; Kapraun *et al.*, 2021; Larcker & Watts, 2020), in order to facilitate computations and reduce uncertainty. Bonds with missing information regarding their yield at issue or their seniority are left out, since the latter is important for matching reasons, which will be discussed on the next chapter, and the former is essential to answer the question at hand, if indeed Green Bonds are issued at a premium or not. These three filters reduced the database to approximately 13,500 securities, of which 353 are Green Bonds and 13,223 are Conventional Bonds.

Finally, following Kapraun *et al.* (2021) we decided to exclude *callable* and *convertible bonds* from the database (see Annex A: Concepts and Definitions). Because they introduce a new level of flexibility

to the issuer or the investor, the coupon of these bonds is affected and, as such, different from that of plain vanilla bonds. The database is then reduced to a final 148 Green Bonds and 4,996 Conventional Bonds.

2.3 Descriptive Statistics and Balance Checking

After constructing our dataset, it is important to run a diagnosis on it, highlighting the main statistics and analysing the distribution of the variables in each group. Thus, our analysis will be split into three. First, we will set our eyes on the 148 Green Bond issues and their main statistics, followed by a similar study of the 4,996 Conventional Bond issues. Afterwards, we will examine the balance between these two groups, checking how the information is distributed in each group.

2.3.1 Descriptive Statistics: Green Bonds[11]

The 148 Green Bonds have an average *Yield at Issue* of 1.953% and a total *Amount Issued* of 92,602.58 million USD, making the average Green Bond emission hold an issuing amount of 625.69 million USD. Throughout the years, Green Bond issuance has increased, going from just 7 corporate, investment grade issuers in 2014 (4.73% of issuers) to a total of 58 issuers in 2021 (39.19% of issuers). Curiously, though, in 2015 we only have record of one Green Bond issuer. This means that in 2015, issuers, or the issues, did not meet our requirements, *i.e.*, they were not corporate, investment-grade issuers, or the bonds were not vanilla.

The average *Yield at Issue*, throughout these years, varied greatly, having started at 2.326% in 2014, until reaching its peak in 2017, at 2.899%. Afterwards, the yield decreased to 1.141% in 2020 and slightly increased in 2021, to 1.476%. As explained previously, 2015 seems to be, again, the odd-one-out, since the one bond that was issued had a 0.514% yield. However, looking at the big picture, it seems that as the Green Bond Market increased in size and gained prominence, the issuing yield began to decrease, and the advantages of Green Bonds began to show.

Taking a look at the main issuing *Currencies*, it is no surprise that both USD and EUR constitute the most liquid portion of the Green Bond Market, with the latter making up for approximately 16% of the issues and the former representing more than half the issues (50.68% of the issuers). Nevertheless, the average amount emitted from EUR-issues is nearly double the average amount of the USD-issues (1,156.69 million USD versus 658.13 million USD). Comparing the average yield of the issues emitted in these currencies, we see major differences too, with EUR-issues holding a yield of 0.767% and USD-issues with an average yield at issue of 2.441%. Thus, even though issues expressed in USD are higher in number when compared to issues expressed in EUR, it seems that they are, at the same time, smaller in size and, overall, more expensive for firms to issue.

[11] For more information on the descriptive statistics of Green Bonds check out Annex E Green Bonds' descriptive statistics.

Another variable interesting to analyse is the *BBG C*, or in other words, the Credit Rating. Most issues have an AAA rating (30.41% of issuers) and thus, as expected, these issuers should enjoy lower financing rates since their default risk is minimal, and investors do not require high yields as compensation. Yet, AAA rated issues have an average yield at issue of 1.806%, which is lower than the overall average of the group, but not the lowest out of the credit ratings. In fact, AA+, AA-, A+ and A rated issuers enjoy lower funding rates, according to our sample (0.395%, 0.987%, 1.563% and 1.533%, respectively). The most likely reason for this problem is the size of our dataset: 148 Green Bond issues are not enough to draw conclusions for the whole Green Bond Market. Furthermore, some of these credit ratings have only 3 observations, corroborating our hypothesis. Still, the fluctuation of interest rates throughout the years could have also contributed to the fact that AAA-rated bonds did not show the lowest funding rates.

Finally, we can also look at *BCLASS* or, in other words, at the sector of activity of these Green Bonds. Most of these issues come from government-related activities (49.32% of issuers), followed by corporate activities (48.65% of issuers) and, at last, securitised activities (2.03% of issuers). If we concentrate on the average yields at issue, we see that securitised Green Bonds, with -0.005%, hold the pricing advantage. On the other hand, corporate and government-related Green Bonds seem to have similar yields at issue (1.990% and 1.997%, respectively). Looking at the second level of corporate activities, we see that Financial Institutions seem to issue more Green Bonds (33 out of 72 issuers) and, at the same time, enjoy the best funding rates (1.494%), on average. Next, comes the Industrial sector, with 25 issuers out of 72 corporate issuers, with an average yield at issue of 2.710%. Finally, the Utilities sector has the lowest number of issuers (14 out of 72 issuers) but has one of the best corporate funding rates (1.875%), on average.

2.3.2 Descriptive Statistics: Conventional Bonds[12]

Turning our attention to the 4,996 Conventional Bonds in our dataset, we document an average *Yield at Issue* of 2.586% and an average *Issuing Amount* of 674.82 million USD, bringing the total amount issued by Conventional Bonds to a staggering 3,368,725.77 million USD or, approximately, 3.369 trillion USD. Comparing these numbers to the ones registered in the Green Bond group, we see a clear difference. The average yield at issue of Conventional Bonds is plainly higher than that of Green Bonds, hinting at a possible *greenium*. Furthermore, the total amount issued by Conventional Bonds is 35 times higher than the amount issued by Green Bonds, supporting the fact that the Green Bond Market is still in its early stages while, simultaneously, denoting the future potential size of the Green Bond Market.

Throughout the years, even though it is not as clear as in the Green Bond Market, the Conventional Bond Market has been increasing, going from 563 issuers in 2014 (11.27% of issuers) to 909 issuers in

[12] For more detailed information on the descriptive statistics of Conventional Bonds see Annex F: Conventional Bonds' descriptive statistics.

2021 (18.19% of issuers). Similarly, there seems to be a decrease in the number of issuers in 2015 (7.57% of issuers), further accentuated in 2016 (6.63% of issuers). It seems that in these years, less plain vanilla bonds were issued by corporate, investment grade issuers. Moreover, throughout these years, the *Yield at Issue* shifted as well. Overall, it looks like it decreased from 3.671% in 2014 to 1.342% in 2021. However, from 2016 to 2018, the decreasing trend halted, showing an increase in yields, from 2.621% in 2016 to 3.554% in 2018.

Looking at the main issuing *Currencies*, once again, the USD and the EUR take the centre stage as the most liquid portion of the bond market (57.91% of issuers and 13.23% of issuers, respectively). Just like previously, issues expressed in EUR are of bigger size (861.12 million USD) and cheaper (1.293%) than issues expressed in USD (828.29 million USD; 2.864%). Nevertheless, the difference in the issuing amount is not as prominent as in the Green Bond Market.

Analysing the *Credit Rating* of the Conventional Bond issuers, A rated issuers are the most common (16.41% of issuers), followed by A+ rated issuers (15.87% of issuers) and A- rated issuers (13.73% of issuers). Similarly to our Green Bond sample, AAA rated bonds do not have the best funding rate (2.438%) when compared to the other credit ratings. This time, AA+, AA, AA-, A+ and A rated issues have lower yields at issue (1.845%, 2.265%, 2.115%, 2.261% and 2.265%, respectively), on average, than AAA rated issues. Again, just like previously, we could attribute this problem to the fact that the number of observations is not large enough to fully reflect market conditions.

Lastly, it is also important to look at the *BCLASS* field. This time, corporate issues hold almost three quarters of issuers (74.96% of issuers), followed by government-related bonds (21.16% of issuers) and securitised Conventional Bonds (3.88% of issuers). Like in the Green Bond sample, securitised activities seem to have the best funding rates (1.297%). Next, corporate issuers enjoy an average yield at issue of 2.537%. Government-related issuers come last with an average yield of 2.995%. Going into more detail on corporate activities, Financial Institutions hold the higher number of issuers (2,245 issuers out of 3,745 issuers) and the best funding rates (2.389%) on average, just like previously. Following this, issuers in the Industrial sector issue more Conventional Bonds (1,345 out of 3,745 issuers) at an average yield of 2.768%. Finally, Utilities issuers seem to emit less Conventional Bonds (155 issuers out of 3,745 issuers) but enjoy better funding rates than their Industrial partners (2.694%).

2.3.3 Balance Checking

When employing matching methods, it is important to check for balance in our sample. If the distribution of the variables between each group is similar, then the only palpable difference between these groups – the *Green Label* – is the most likely cause of the difference in yields and, thus, a simple difference in means should suffice. However, as we will see, this is not always the case. Most of the times, there is imbalance, meaning the distribution of the variables in each group is different and, thus, the variables had some impact in our outcome variable.

To check for balance, we first combine both of our databases into a single one, containing information on both Green and Conventional Bonds. Then, we need to introduce a binary variable (*Green*) to identify our bonds: if the value of this variable is 0, then the bond is Conventional, whereas if the value of this variable is 1, then the bond is Green. Furthermore, we take the *Year of Issue* and the *Time to Maturity* of each bond using Excel functions. After constructing such dataset in Excel, we plot some line charts to check the balance and overlap of our variables.

Taking a look at this first set of line charts (distribution of issues per *Time to Maturity*, per C*urrency*, per C*ollateral Type*, per *Maturity Type* and per *Seniority*), it appears that these variables have similar distributions. The proportion of issues are similar for most categories, and any movement from one field to the next is accompanied in both groups. In fact, at times, the lines overlap and it becomes hard to distinguish one from the other. Balance and data overlap seem fine.

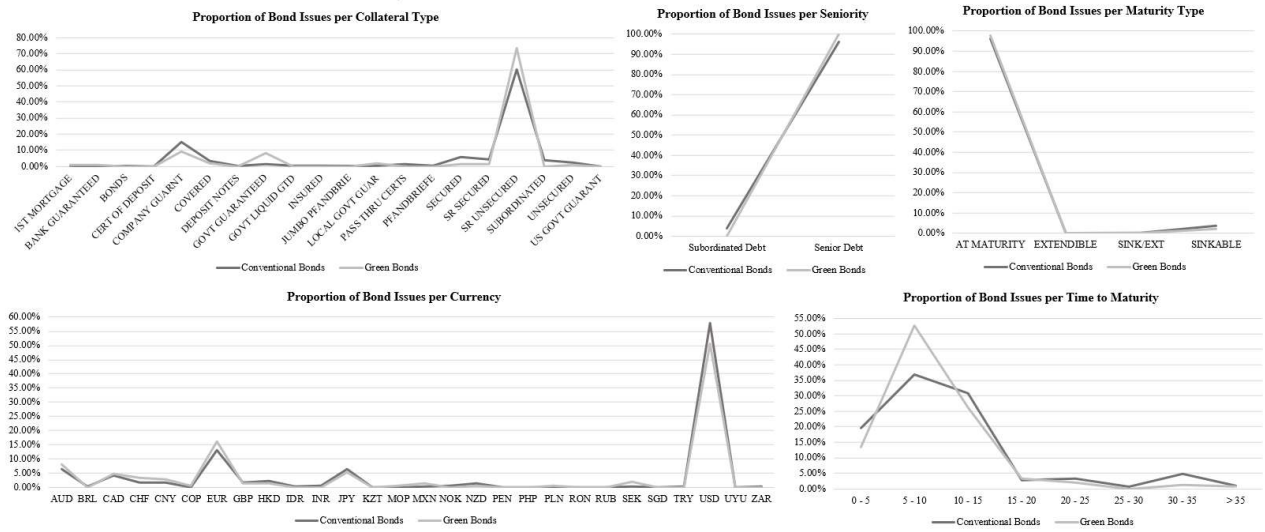

Figure 2.1: Balance check for Collateral Type, Seniority, Maturity Type, Currency and Time to Maturity. In this set of line charts, we included covariates with the best balance, where Green and Conventional Bonds have similar distributions.
(Source: Own elaboration)

Nevertheless, not all variables have similar distributions. If we analyse the line charts of the distribution of issues per *Year of Issue*, per *Amount Issued*, per *BBG C* and per *BCLASS*, we see clear differences. For example, looking more closely at the distribution of issues per *BCLASS*, we see that in the Green Bond group, the proportion of issues is similar for Corporate and Government-related activities, whereas in the Conventional Bond group, this same proportion is totally different, existing a clear issuing advantage of Corporate activities over Government-related activities. Analysing the other two distributions as well, balance seems better but not completely, since in some points the groups move in different directions. Hence, it seems there is a lack of balance.

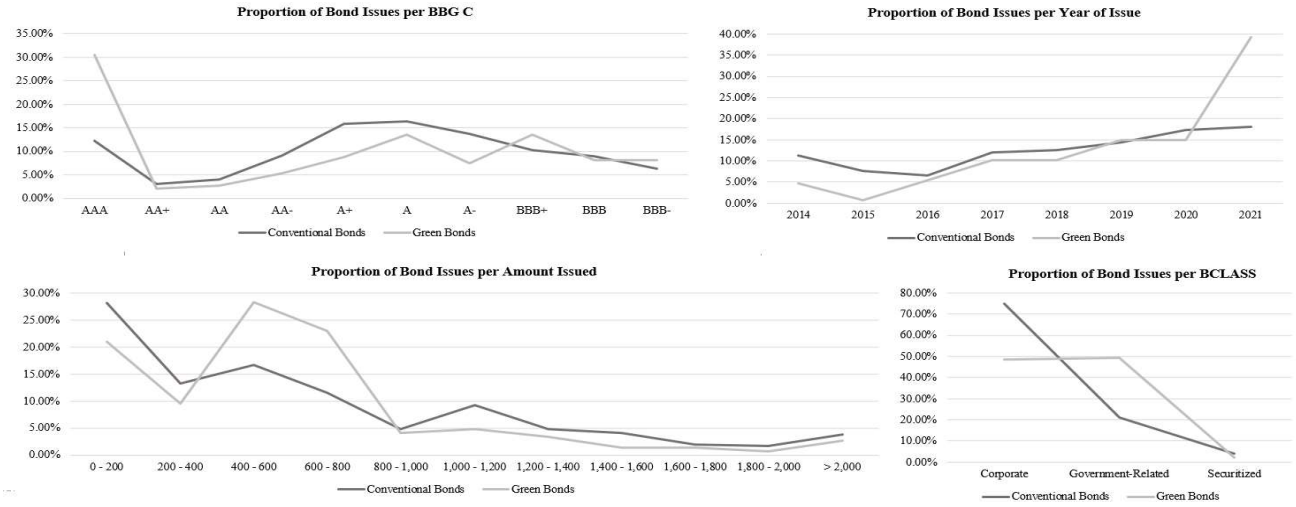

Figure 2.2: Balance check for BBG C, Year of Issue, Amount Issued and BCLASS. In this set of line charts, we included the covariates with the worst balance: Green and Conventional Bonds have different distributions. (Source: Own elaboration)

Overall, using matching methods will improve balance and overlap, creating a sub-dataset composed of only matched observations, or in other words, of similar Green and Conventional Bonds. The more variables we use for the matching, the closer the matching will be to Exact Matching and, thus, the less imbalance there will be. On the next chapter we will dive deeper into matching methods and how they improved balance for each sub-sample.

3 Methodology

In this chapter we will describe the methodology applied in this research to find if there is indeed a *greenium*. Thus, after collecting our data, as described in the previous chapter, we match Green Bonds with Conventional Bonds through different matching methods, which are described in this chapter: PSM, CEM and Direct Matching. Afterwards, we run different regression models on the matched data to determine if there is a Green Bond premium. R Studio was the coding software chosen to conduct our methodology on.

3.1 Matching Methods

Before describing the matching methods used, it is important to clarify what are matching methods and when they should be used. Stuart (2010) gathers information on matching methods in one detailed study, defining matching as any method that aims to balance the distribution of covariates in the treated and control groups. These groups, as one might guess, differ in the treatment, which is the variable whose impact on the outcome variable we are interested in assessing. The covariates are the other variables that can influence the assignment of treatment and/or the outcome variable.

On the other hand, when should these methods be employed? Most matching methods are used to deal with observational data rather than experimental data[13]. The key difference between these concepts is, once again, related with the treatment, *i.e.*, in experimental data treatment is assigned randomly to individuals, whereas in observational data the treatment is selected by the individuals, making treatment dependent from the covariates. Because of this, when forming the treated and control groups, one cannot compare them, since the covariates in each group are likely to be different. Thus, it becomes hard to conclude if a statistically significant difference in the outcome variable between the groups is due to the treatment or to the influence of the covariates. However, in experimental data, the random assignment of treatment makes both groups comparable – the main difference being the treatment. Hence, because both groups are comparable in the absence of treatment, it becomes reasonable to conclude that a statistically significant difference in the outcome variable between the groups is caused by the treatment.

To better understand these concepts, we present an easy-to-understand practical example retrieved from the University of Virginia's Library online page[14] (Ford, 2018). This example involves determining if smoking increases the risk of contracting a dangerous pulmonary disease. To truly answer this question, we would need a time machine. We would need to pick a subject, make them smoke for several years, and study, throughout their lifetime, if they develop said pulmonary disease. Then, we would need to go back in time, study this same subject, not allow them to smoke, and observe if the disease is developed. Moreover, we would need to observe several subjects. This is clearly unethical and impossible. Thus, to answer this question, we use matching methods. We take one subject who received

[13] https://towardsdatascience.com/propensity-score-matching-a0d373863eec
[14] https://data.library.virginia.edu/getting-started-with-matching-methods/

the treatment - for instance, a middle-aged Caucasian man who smokes, weighs 75 kg and went to college - and match him with a similar subject who did not receive treatment – a middle-aged Caucasian man who does not smoke, weighs 75 kg and went to college. By matching similar subjects, with different treatments, we are able to conclude on the effect of the treatment (smoking) on the outcome variable (dangerous pulmonary disease).

Taking this example, and applying it to our study, we clearly understand the roles our variables play. In our case, the *Green Label* is the treatment variable that will split our sample into two groups: the treated group (Green Bonds) and the control group (Conventional Bonds). As stated previously, we want to assess the impact the *Green Label* has on the yield of the bonds. Therefore, we found our outcome variable: the *Yield at Issue*. The remaining variables are the covariates, which will influence and help the matching of our data, bringing balance to the treated and control groups.

Looking into how these methods work, Stuart (2010) describes two stages: the Design Phase and the Outcome Analysis Phase. The first stage aims to approximate the observational study to an experimental study through matching methods. It includes three steps: (1) defining closeness, where we will select which covariates to include in the matching and then translate them into a distance measure; (2) implementing a matching method, where we will select a matching method given the previously chosen closeness measure; and (3) assessing the quality of the resulting matched samples, through numerical analysis or graphical representations (depending on the quality of the match, we may need to repeat the first two steps). After we are satisfied with the matching, we can move on to the second stage and start analysing the outcome and estimating the treatment effect.

Among the Green Bond literature that was previously analysed and studied on greater detail, several studies employ matching methods. Most of them use the Direct Matching technique (Flammer, 2021; Kapraun *et al.*, 2021; Larcker & Watts, 2020; Nanayakkara & Colombage, 2019; Zerbib, 2019), matching Green and Conventional Bonds according to a predefined list of rules. Other studies employ matching methods such as PSM (Gianfrate & Peri, 2019; Löffler *et al.*, 2021), which matches the treated and control groups depending on their propensity score; and CEM (Löffler *et al.*, 2021), matching Green and Conventional Bonds by coarsening covariates.

In our study we apply all three matching methods: PSM, CEM and Direct Matching. By using three different methods of matching the treated and control groups, we hope to reduce model dependence and reach a more robust answer to our question at hand. Hence, next we present a brief description of how each matching method works, along with the amount of matches we were able to achieve by employing each one. The codes we use for matching purposes were retrieved from the online publications of Ford (2018) and Luvsandorj (2021a; 2021b), along with the scientific article by Iacus *et al.* (2009).

3.1.1 Propensity Score Matching

Propensity scores were first introduced by Rosenbaum and Rubin (1983) as a way to translate all the covariates into one scalar: the probability of being treated. Hence, this matching method uses probit or

logit models to estimate the propensity score, defining the treatment variable as the dependent variable – which is always a binary variable - and the covariates we wish to match on as the independent variables, as shown below in equation (4.1):

$$Green_i = Issue_i + Maturity_i + Maturity\,Type_i + log(Amount)_i + Currency_i + BBG\,C_i + Seniority_i + Collateral_i + BCLASS_i \quad (3.1)$$

Annex G: Summary table describing all the variable used throughout the study details each of these, and other additional variables. Note that during matching we leave the outcome variable (*Yield at Issue*) out (King & Nielsen, 2019; Stuart, 2010). This is because we are first trying to achieve balance among the covariates.

The MatchIt function on R Studio allows us to, at the same time, compute the propensity scores and match treated and control units. That said, using equation (4.1) as the argument for this function, R Studio summarises all the covariates into one propensity score for each bond. Afterwards, using Nearest Neighbour matching, R Studio matches 1:1 Green and Conventional Bonds, *i.e.*, for Green Bond *i* the MatchIt function selects Conventional Bond *i* with the closest propensity score.

After running this function in R Studio and observing its summary, we check that we were able to match all the Green Bonds, meaning we managed to get 148 matched pairs. Furthermore, this function shows three more tables: the first two show descriptive statistics of the data before and after matching, respectively, whereas the third table provides an idea of how the balance improved for the data after matching. Analysing the third table more closely we see that only three variables had a negative balance improvement, meaning overall balance improved for the data (see the table and explanation in Annex H: Table representing the percent of balance improvement of applying the PSM method).

Lastly, as suggested by Stuart (2010), we evaluated the quality of the matching. To do so, we decided to graphically represent the matched and unmatched pairs of both treated and control groups. Furthermore, we looked at the balance of the sample before and after matching. After analysing both

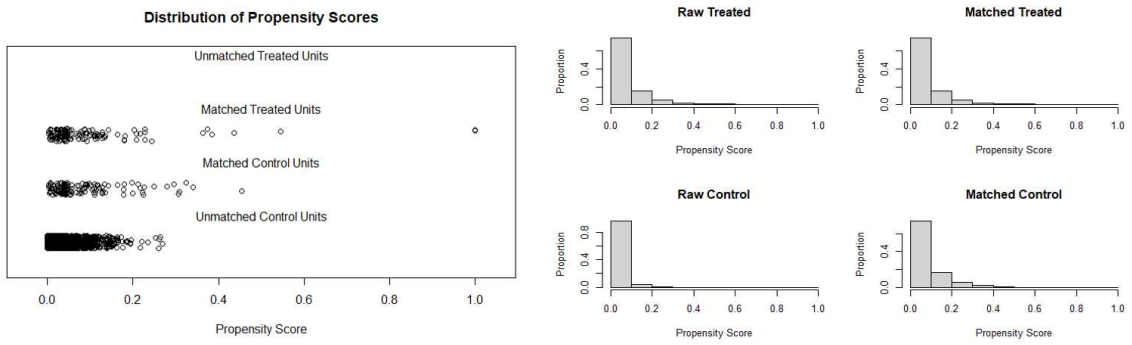

Figure 3.1: Assessment of how the PSM method improved balance in the PSM dataset.
(Source: R Studio)

graphs we decided that the PSM technique improved the overall balance of the sample. Hence, we can move on with the analysis of the impact the *Green Label* has on the *Yield at Issue*.

Nevertheless, we should note that propensity scores have recently been criticised. King and Nielsen (2019) state that, although propensity scores are one of the most commonly used matching methods available, its use actually "increases imbalance, inefficiency, model dependence, research discretion, and statistical bias" (King & Nielsen, 2019:1). These scholars name this effect the PSM Paradox. By employing PSM to a specific database, certain observations are pruned in order to increase the overall balance of the sample. However, continuous pruning after nearly approximating the observational study to a completely randomised experiment, will do more harm than good, degrading inference and increasing imbalance, model dependence and bias.

Still, "the same paradox of matching increasing imbalance can occur with other methods when enough observations have been pruned" (King & Nielsen, 2019:17). Furthermore, if the data we start with is too imbalanced, making causal inference impossible, "the paradox we identify is avoidable and PSM will reduce imbalance" (King & Nielsen, 2019:2). To our understanding, the initial database we start with is imbalanced, as shown in the previous chapter, making PSM a viable matching option.

3.1.2 Coarsened Exact Matching

Coarsened Exact Matching is a more recent matching method made known by Iacus *et al.* (2012). These scholars state that the main idea behind CEM is "to coarsen each variable by recoding so that substantively indistinguishable values are grouped and assigned the same numerical value" (Iacus *et al.*, 2012:8). Afterwards, the matching is made using the Exact Matching algorithm, which, as the name suggests, matches treated and control units whose covariates are equal or belong in the same group created through coarsening.

When matching using CEM, treated and control units are set in strata and are assigned a specific weight, depending on whether the unit belongs to the treated or control group (treated units are assigned a weight equal to one), the number of units and matches per stratum. Then, strata that contains at least one control and one treated unit are kept, while the others are discarded from the sample. As such, even though it is possible, matching for Green and Conventional Bonds will not be 1:1. Usually each stratum has several treated and control units with different weights.

For the outcome analysis stage, CEM retains the original (uncoarsened) data of the coarsened units. This means that the coarsened variables are only used to ease the matching between treated and control units, increasing the number of matched units. Nevertheless, "the more coarsening we allow (…) the larger the bound on model dependence and estimation error" (Iacus *et al.*, 2012:20). Therefore, a fine balance between coarsening must be achieved.

In this study, we decided to introduce coarsening in the following variables: *Maturity*, *Amount* and *BBG C*. *Maturity* is a continuous quantitative variable whose values range from just under a year to a little over one hundred years. Finding exact matches on such a wide interval of values would prove to

be troublesome. That said, using cut points, we decided to divide this group in 3, creating the following intervals:]0.635; 33.9],]33.9; 67.1] and]67.1; 100] according to R Studio.

Similarly, *Amount* is a continuous quantitative variable. However, its range is wider, going from one million USD to nearly 13.5 billion USD. Hence, we decided to divide this group into 5 bins:]-12.5; 2,700],]2,700; 5,390],]5,390; 8,090],]8,090; 10,800] and]10,800; 13,500].

On the other hand, *BBG C* is a qualitative variable ranging from AAA to BBB-. As we know, these numbers represent a hierarchy, where AAA means less risk and BBB- represents more risk. To portray this idea to R Studio, we followed Kapraun *et al.* (2021) and turned the letters into numbers. To coarsen the variable, we did the same as Zerbib (2019) and removed the plus and minus signs next to each credit rating. Thus, we ended up with 4 groups: AAA ratings were given the number 1; AA+, AA and AA- credit ratings received the score of 2; A+, A and A- got the number 3; and, at last, the BBB+, BBB and BBB- credit ratings received the number 4.

Below we represent the equation that was used as the argument of the MatchIt function on R Studio. This time we specified we wanted to use the CEM method, otherwise we would match again using the PSM technique, since it is the default option of this function.

$$\begin{aligned} Green_i = {} & Issue_i + Maturity\ Cut_i + Maturity\ Type_i + Amount\ Cut_i \\ & + Currency_i + BBG\ C\ Cut_i + Seniority_i + Collateral_i \\ & + BCLASS_i \end{aligned} \tag{3.2}$$

After running the code and looking at the summary, we find out we managed to pair 125 Green Bonds with 1,330 Conventional Bonds, over 71 strata. Similarly to before, we also obtain information on three tables: two of them show descriptive statistics before and after matching and the last describes how balance improved after matching. Looking at the third table, we conclude balance improved greatly, with all covariates showing positive change (see table and explanation in Annex I: Table representing the percent of balance improvement of applying the CEM method). This was to be expected as well, since we were employing Exact Matching.

3.1.3 Direct Matching

Direct Matching, as the name suggests, has a more direct approach to matching, requiring the user to define *ex-ante* a list of rules to match on. Similarly to the previously defined matching methods, we are interested in "matching a pair of securities with the same properties except for the one property whose effects we are interested in" (Zerbib, 2019:42). By doing so we avoid having to deal with factors that influence bond pricing such as credit risk, currency risk, maturity risk and other types of risk. Moreover, we also control for liquidity through several of our requirements, just like Kapraun *et al.* (2021) and Zerbib (2019) apply in their studies. Contrary to the prior methods, we opted for a more hands on

approach instead of coding on R Studio. Thus, we ended up matching directly on Excel, choosing for each Green Bond one Conventional Bond whose characteristics followed the following set of rules.

Table 3.1: Set of rules used for the Direct Matching approach.
(Source: Own elaboration)

Bond Characteristics	Requirements
Issue Date *Maturity Date*	+/- 3 years
Issue Size	×/÷ 4
Issuer Name *Maturity Type* *Collateral Type* *Currency* *Credit Rating (BBG C)* *Industry (BCLASS)* *Coupon Type* *Seniority*	Same

When coming up with the rules for matching treated and control units we looked into the other studies that employed Direct Matching (Flammer, 2021; Kapraun *et al.*, 2021; Larcker & Watts, 2020; Nanayakkara & Colombage, 2019; Zerbib, 2019). Hence, just like all those studies, our first rule is that the issuer of the treated and control units must be the same, *i.e.*, to form a matched pair of Green and Conventional Bonds, their issuing company must be the same.

Looking at the issuing date, both Kapraun *et al.* (2021) and Zerbib (2019) give a two-year tolerance, meaning a Green and Conventional Bond could still be matched if their issuing year was, at max, two years apart (earlier or later). Larcker and Watts (2020), on the other hand, only allowed matching if both units were issued on the same day. Looking at our data, to maximise our matched pairs, we decided to increase this tolerance to three years.

Similarly, when it comes to the tolerance of the maturity date, Kapraun *et al.* (2021) and Zerbib (2019) set a two-year tolerance, matching their issue date tolerance. Larcker and Watts (2020), more conservatively, decided to set a one-year tolerance. Considering our data, we decided to follow Kapraun *et al.* (2021) and Zerbib (2019) studies, setting the same three-year tolerance we set for the issue date.

Next, we focused on the amount that was issued by the bonds. Kapraun *et al.* (2021), decided that the issue size of the Conventional Bond should not be larger than two times the amount that was issued by the Green Bond, or lower than half of this amount. On the other hand, Zerbib (2019) allowed the issue size of the Conventional Bond to go up until four times or four quarters of the amount issued by

the Green Bond. Taking into account our limited number of observations, we applied Zerbib (2019) higher tolerance rule.

Lastly, we only considered of forming a pair between Green and Conventional Bonds if the other characteristics of the bond – maturity type, collateral type, currency, credit rating (*BBG C*), industry (*BCLASS*), coupon type and seniority – were identical, just like Kapraun *et al.* (2021), Larcker and Watts (2020) and Zerbib (2019).

Furthermore, if after following all these rules we still had more than one Conventional Bond to pick from, we looked again at their issue and maturity dates. After doing so, we selected the Conventional Bond that was most similar to the Green Bond, *i.e.*, that had the same maturity in years, since its issue date until its maturity date, or that had the closest issue date. At the end we managed to form 61 matched pairs of Conventional and Green Bonds.

When it comes to evaluating the degree of balance improvement, according to King and Nielsen (2019:6), "deviations from exact matching are known as imbalance". Given that we are doing Exact Matching on most of the covariates, except on the issue and maturity dates and on the issuing amount, where some tolerance was applied, we consider balance improved greatly.

3.2 Regression Model

After matching Green and Conventional Bonds, we managed to bring balance to our dataset and approximate our observational study to an experimental study, as was the goal. At this point, generally speaking, some scholars state a simple difference in means of the outcome variable between the treated and control groups is enough to determine the effect of treatment on the outcome variable (Iacus *et al.*, 2012; Stuart, 2010). However, in this study, we apply two different regression methods. As stated by Stuart (2010:2), "matching methods should not be seen in conflict with regression adjustment and, in fact, the two methods are complementary and best used in combination".

Looking at the Green Bond literature previously mentioned, most studies employ some sort of regression model. Most of these studies apply a Fixed-Effects model regression since their data includes observations over time of each issue and, as such, these scholars need to control for time-invariant characteristics (Baker *et al.*, 2018; Fatica *et al.*, 2019; Kapraun *et al.*, 2021; Larcker & Watts, 2020; Löffler *et al.*, 2021; Tang & Zhang, 2020; Zerbib, 2019). Nanayakkara and Colombage (2019) apply a mixed regression model, combining both Fixed-Effects and Random-Effects regression models, feeling as if neither one alone would yield unbiased results. Karpf and Mandel (2017, 2018) employ an Oaxaca-Blinder regression, which is commonly applied to explain differences in any continuous outcome between two groups. Preclaw and Bakshi (2015) apply a simple linear regression on the bonds' credit spreads.

Other studies use different methodologies. Ehlers and Packer (2017) do a simple credit spread comparison to determine if there is a premium. Reports issued by the CBI analyse the *greenium* through yield curves, arguing that there is a *greenium* if the yield of the Green Bond sits inside its own credit

curve. Gianfrate and Peri (2019) use treatment effects to compare the yields of Green and Conventional Bonds. Meyer and Henide (2020) define the *greenium* as the difference between the Z-spread (zero volatility spread) of a green bond and the Z-spread of an implied non-green bond. A negative (tighter) spread means there is a premium.

Nevertheless, as stated previously, in our study we run several regression models. By doing so, we can better understand the statistical significance of the relationship between the treatment and the outcome variable, as well as the relationship of the outcome variable with the covariates. Since we only have information regarding the bonds at issue, it is not necessary to apply a Fixed-Effects model as most scholars did to control for time-invariant variables. Therefore, on R Studio, we run different regression models, with different combinations of explanatory variables, as seen below:

$$Yield_i = \beta_1 + \beta_2 Green_i + \varepsilon \tag{3.3}$$

$$Yield_i = \beta_1 + \beta_2 Green_i + \beta_3 Maturity_i + \beta_4 \log(Amount_i) + \varepsilon \tag{3.4}$$

$$Yield_i = \beta_1 + \beta_2 Green_i + \beta_3 Maturity_i + \beta_4 \log(Amount_i) + \beta_5 BBG\ C_i + \varepsilon \tag{3.5}$$

$$Yield_i = \beta_1 + \beta_2 Green_i + \beta_3 Maturity_i + \beta_4 \log(Amount_i) + \beta_5 BBG\ C_i + \beta_6 Currency_i + \varepsilon \tag{3.6}$$

$$Yield_i = \beta_1 + \beta_2 Green_i + \beta_3 Maturity_i + \beta_4 \log(Amount_i) + \beta_5 BBG\ C_i + \beta_6 Currency_i + \beta_7 BCLASS_i + \varepsilon \tag{3.7}$$

$$Yield_i = \beta_1 + \beta_2 Green_i + \beta_3 Maturity_i + \beta_4 \log(Amount_i) + \beta_5 BBG\ C_i + \beta_6 Currency_i + \beta_7 BCLASS_i + \beta_8 Maturity\ Type_i + \varepsilon \tag{3.8}$$

$$Yield_i = \beta_1 + \beta_2 Green_i + \beta_3 Maturity_i + \beta_4 \log(Amount_i) + \beta_5 BBG\ C_i + \beta_6 Currency_i + \beta_7 BCLASS_i + \beta_8 Maturity\ Type_i + \beta_9 Collateral_i + \varepsilon \tag{3.9}$$

Notice that for each dataset originated by the three matching methods we apply all these equations. However, when it comes to Direct Matching, since *Maturity Type* only has one unique value, it does not make sense to include this variable in the regression. Therefore, for Direct Matching, we only apply the

first five equations as they are. The sixth equation (4.8) suffers a little transformation, switching *Maturity Type* with *Collateral*. The seventh, and last equation (4.9), is not applied for the dataset generated through Direct Matching.

Furthermore, as explained previously, CEM uses weights during matching. Stuart (2010), in her detailed study, states that weights should be used directly in regression models when weighting matching methods are used. Thus, the matched data deriving directly from CEM will go through a weighted regression model, more specifically, the Weighted Least Squares (WLS) method. The remaining databases, resulting from PSM and Direct Matching, will go through a multiple linear regression model, more precisely the Ordinary Least Squares (OLS) method.

Nevertheless, to employ such models there are assumptions that need to be met so that the estimates are BLUE (Best Linear Unbiased Estimator), in particular, assumptions related with the variances and correlation of the variables in the study. In the previously mentioned regression models, we found problems with the homoscedasticity and autocorrelation assumptions through the use of the Breusch-Pagan and Durbin-Watson tests, respectively. According to Curto (2020), estimators under heteroscedasticity and autocorrelation are still unbiased and consistent, but no longer the most efficient, meaning there are other estimators with smaller variances, and thus they are not BLUE anymore. Consequently, the standard errors are affected, impacting the values of the t and F statistics, which ultimately affects statistical significance and overall statistical inference.

Thus, to address these issues, we decided to employ a HAC (Heteroscedasticity and Autocorrelation Consistent) estimator, namely, the Newey-West estimator[15], capable of estimating a more efficient variance-covariance matrix. Therefore, for all the regression models applied to the three databases originated through the three matching methods, we use the HAC procedure and, by doing so, we improve statistical inference by looking at the true statistical significance of each variable.

Lastly, Stuart (2010) cites Austin (2007) regarding a "debate about whether the analysis needs to account for the matched pair nature of the data" (Stuart, 2010:13). However, the scholar cites two further studies (Schafer & Kang, 2008; Stuart, 2008) as reasons for why it is not necessary to use the matched pairs: conditioning on the covariates used in the matching process (for instance through a regression model) is sufficient; and PSM only groups observations based on their propensity scores, instead of on the full set of covariates, which does not guarantee that each pair is well-matched. Thus, "it is more common to simply pool all the matches into matched treated and control groups and run analyses using the groups as a whole, rather than using the individual matched pairs" (Stuart, 2010:13).

[15] https://www.econometrics-with-r.org/15-4-hac-standard-errors.html

4 Results and Discussion

In this chapter we highlight the main results obtained from applying the previous regression models to each of our datasets (originated from different matching methods – PSM, CEM and Direct Matching). Moreover, these results are interpreted and discussed in the context of the Green Bond Market, providing recommendations and implications for this market and its participants.

4.1 Results

The main goal of this dissertation is to explore if there is a premium in the Green Bond Market. To do so, besides comparing the average *Yield at Issue* of each group, we run the previous regressions to obtain an answer. In fact, it is important to introduce other explanatory variables into the analysis and to assess whether our results are statistically significant, indicating a relationship between the treatment (*Green Label*) and the outcome variable (*Yield at Issue*), or not, demonstrating there is no such relationship, and the results are simply by chance.

4.1.1 Propensity Score Matching

First, we start with the dataset that resulted from applying PSM to our initial sample. As aforementioned, this dataset contained information regarding 148 Green Bond issues (total number of Green Bonds) and as many Conventional Bond issues since we did 1:1 matching. Overall, our total number of observations ranks up to 296 issues. When computing the average *Yield at Issue* for each group, we found that the treated group had an average of approximately 1.9530% whereas the control group showed an average yield of around 1.9360%. Thus, there seems to be a Green Bond discount of roughly 1.7 bps, contrary to what was expected based on the majority of Green Bond literature studied earlier.

Since PSM is not a weighted matching method, we continue our analysis with the OLS regression method, after which we apply the HAC estimator. Hence, according to the following table, the first three equations (4.3, 4.4 and 4.5) show that the *Green Label* increases the *Yield at Issue* of bonds (1.7 bps, 3.4 bps and 3.7 bps, respectively). However, we see that their corresponding p-values are too high to be considered statistically significant and, as such, it seems that the *Green Label* has no effect on the *Yield at Issue*. The other equations (4.6, 4.7, 4.8 and 4.9), nevertheless, suggest the opposite, showing that the treatment has a negative effect on the outcome (-4.2 bps, -3.5 bps, -2.9 bps and -2.6 bps, respectively). This happened in the sequence of adding more explanatory variables and, consequently, increasing the R square of the regression, going from 0.2079 in equation 4.5 to 0.6471 in equation 4.6. However, similarly to before, the corresponding p-values are too high to be considered statistically significant and, thus, we continue to not find any evidence that the *Green Label* has any effect on the *Yield at Issue*.

Table 4.1: Results of the HAC estimator applied to the OLS regression model in the dataset generated through PSM. Note: "." p-value < 0.1; "*" p-value < 0.05; "**" p-value < 0.01; "***" p-value < 0.001. (Source: R Studio)

	(4.3)	(4.4)	(4.5)	(4.6)	(4.7)	(4.8)	(4.9)
Intercept	1.9361***	2.30350***	1.69877***	1.112928**	0.400042	-0.06514	0.31318
	(<2e-16)	(1.890e-06)	(0.000919)	(0.002322)	(0.3113376)	(0.87999)	(0.5296103)
Green	0.0170	0.03404	0.03667	-0.041634	-0.034904	-0.02902	-0.02559
	(0.9315)	(0.85545)	(0.832349)	(0.708375)	(0.7507834)	(0.78800)	(0.8131873)
Maturity		0.07042***	0.06287***	0.087222***	0.082978***	0.07728***	0.07785***
		(5.524e-05)	(6.521e-05)	(5.759e-14)	(2.080e-13)	(2.969e-09)	(1.737e-09)
log(Amount)		-0.15478*	-0.17769*	0.065956	0.051878	0.05822	0.05548
		(0.02716)	(0.011208)	(0.200597)	(0.3107149)	(0.26102)	(0.2692974)
BBG C			0.15848***	0.193934***	0.228886***	0.22886***	0.22756***
			(1.783e-08)	(4.080e-16)	(<2.2e-16)	(<2.2e-16)	(<2.2e-16)
Currency							
[EUR]				-2.356265***	-2.406941***	-2.41558***	-2.44915***
				(<2.2e-16)	(<2.2e-16)	(<2.2e-16)	(<2.2e-16)
[USD]				-0.981060***	-0.939792***	-0.97138***	-0.97210***
				(1.598e-06)	(1.836e-06)	(1.337e-06)	(1.458e-06)
BCLASS					0.410583***	0.42078***	0.38662***
					(0.0001551)	(5.304e-05)	(0.0004727)
Maturity Type						0.45956	0.49504
						(0.17404)	(0.1451650)
Collateral							-0.02343
							(0.1470666)
Green Bonds	148	148	148	148	148	148	148
Observations	296	296	296	296	296	296	296
R Squared	3.396e-05	0.1002	0.2079	0.6471	0.6631	0.6651	0.6702

Looking at the other explanatory variables, we see that *Maturity* increases the yield of bonds on average by 7.6 bps. This means that if we increase the maturity of a bond by one year, its yield will increase by 7.6 bps on average. Furthermore, we see that all of the estimates for each regression are statistically significant, *i.e.*, there is a positive relationship between *Maturity* and *Yield at Issue*. *BBG C*, *Currency* (in particular, EUR and USD) and *BCLASS* all have statistically significant estimates in all of the regressions too, showing some kind of relationship between *Yield at Issue* and each of these covariates. On average, it seems that *BBG C* has a positive relationship of around 20 bps; *Currency*[EUR] has a negative relationship of nearly -2.4 percentage points (pps); *Currency*[USD] has a negative relationship of approximately -96 bps; and *BCLASS* has a positive relationship of around 40 bps.

On the other hand, *Amount*, *Maturity Type* and *Collateral* do not seem to have any relationship with the *Yield at Issue*. The first is only statistically significant in equations 4.4 and 4.5, suggesting a negative relationship of around -16 bps. The last two are not significant in any regression, indicating *Maturity Type* and *Collateral* have no effect on the yield of bonds. Overall, these variables, along with the *Green Label*, do not seem to influence in any way the outcome variable.

4.1.2 Coarsened Exact Matching

Next in line to interpret is the dataset that originated from employing CEM to our initial sample. As referenced previously, this dataset contains information on around 125 Green Bonds and 1,330 Conventional Bonds, spread out through different strata and each with its own weight. If we look at the average *Yield at Issue* of each group, we see a different story than before and more in line with what we have researched in earlier chapters. In the CEM dataset, Green Bonds hold an average yield of 1.9825% versus an average yield of 2.1478% for Conventional Bonds, suggesting there might be a *greenium*. However, we have seen before that we should consider weights, when the applied matching method uses them (Stuart, 2010). Doing so, we obtain an average weighted yield at issue of 1.98% for Green Bonds and an average weighted yield of 1.99% for Conventional Bonds, which still supports our Green Bond premium hypothesis.

As stated beforehand, from now on we use the WLS regression method, with the application of the Newey-West estimator. Thus, looking at the next table, we see that, curiously, only the first equation estimates a small *greenium* in the Green Bond Market (-0.62 bps). Still, just like previously, it is not a statistically significant estimate and, as such, it does not support our Green Bond premium hypothesis. The following regressions show evidence of a positive relationship between the *Green Label* and the *Yield at Issue* of a bond (2.6 bps, 2.2 bps, 2.9 bps, 2.7 bps, 2.8 bps and 2.7 bps, respectively), suggesting

Table 4.2: Results of the WLS model with the application of the Newey-West estimator in the CEM dataset. Note: "." p-value < 0.1; "*" p-value < 0.05; "**" p-value < 0.01; "***" p-value < 0.001. (Source: R Studio)

	(4.3)	(4.4)	(4.5)	(4.6)	(4.7)	(4.8)	(4.9)
Intercept	1.988767***	1.730376**	1.282211.	1.250531***	0.879555**	1.137190***	1.767216***
	(<2e-16)	(0.005684)	(0.0717)	(9.490e-07)	(0.001194)	(0.0002019)	(7.717e-06)
Green	-0.006239	0.025678	0.022039	0.028502	0.026724	0.027502	0.027154
	(0.9722)	(0.875242)	(0.8868)	(0.7816)	(0.796869)	(0.7932449)	(0.7928957)
Maturity		0.091696***	0.083687***	0.107618***	0.102900***	0.105330***	0.103683***
		(1.433e-09)	(9.683e-13)	(<2.2e-16)	(<2.2e-16)	(<2.2e-16)	(<2.2e-16)
log(Amount)		-0.078693	-0.101120	-0.011323	-0.013678	-0.012726	-0.026548
		(0.400923)	(0.3138)	(0.7714)	(0.717722)	(0.7341511)	(0.4867397)
BBG C			0.121532***	0.174157***	0.195707***	0.198788***	0.194775***
			(5.342e-08)	(<2.2e-16)	(<2.2e-16)	(<2.2e-16)	(<2.2e-16)
Currency [EUR]				-2.004728***	-2.039838***	-2.053129***	-2.123925***
				(<2.2e-16)	(<2.2e-16)	(<2.2e-16)	(<2.2e-16)
[USD]				-0.805568***	-0.820831***	-0.818014***	-0.797897***
				(5.799e-10)	(2.415e-10)	(3.060e-10)	(4.445e-08)
BCLASS					0.217096*	0.233023*	0.207696*
					(0.013816)	(0.0129681)	(0.0275007)
Maturity Type						-0.317038	-0.18374
						(0.1938211)	(0.4287905)
Collateral							-0.040734***
							(0.0003783)
Green Bonds	125	125	125	125	125	125	125
Observations	1455	1455	1455	1455	1455	1455	1455
R Squared	1.502e-06	0.1791	0.2584	0.6104	0.6142	0.6148	0.628

that there is a Green Bond discount in the Green Bond Market. Nevertheless, once more, we notice that these estimates are not statistically significant and, thus, should not be considered proof that there is any relationship between the treatment and the outcome variable.

Taking a look at the other explanatory variables, we see that *Maturity*, *BBG C*, *Currency* (particularly, EUR and USD), *BCLASS* and *Collateral* all show signs of having a statistically significant relationship with the *Yield at Issue*. *Maturity* seems to have a positive relationship of approximately 9.9 bps; *BBG C* appears to also have a positive relationship of roughly 17.7 bps; *Currency*[EUR] has a negative relationship of around -2 pps; *Currency*[USD] has a negative relationship of about -81 bps; *BCLASS* seems to have a positive relationship of 22 bps on average; and *Collateral* a negative relationship of nearly -4 bps. Comparing these estimates to the ones obtained in the PSM dataset, we see that they are roughly similar but, generally, they seem to be more conservative.

The other explanatory variables seem to not have any relationship with the yield of bonds at all. *Maturity Type* and *Amount* show p-values that are above 0.05 in all the regression models, meaning they are not statistically significant, and as such do not seem to have any relationship with the outcome variable.

4.1.3 Direct Matching

Lastly, we have reached the Direct Matching dataset. This dataset, as it employs the most similar matching method to Exact Matching, has the least amount of information, only having observations of 61 Green Bond issues and the same number of Conventional Bond issues since we did 1:1 matching. Nevertheless, as it is one of the most employed matching methods found in our Green Bond premium literature, we will proceed with the analysis. First, similarly to before, we will take a look at the average *Yield at Issue* of each group: Green Bonds have an average yield of 1.7727% and Conventional Bonds hold an average yield of about 2.0698%. Thus, there seems to be a Green Bond premium according to this dataset (-29.7 bps).

Just like the PSM method, Direct Matching is not a weighted matching technique and, as such, we will continue our analysis employing the OLS regression method, followed by the application of the HAC estimator. Following the table presented, the *Green Label* has a negative relationship with the *Yield at Issue*, showing negative estimates for all the regression models (-29.7 bps, -26.3 bps, -26.1 bps, -24.8 bps, -24.6 bps and -24.8 bps, respectively). Furthermore, all the estimates are statistically significant at the 10% level, *i.e.*, the *Green Label* has a negative impact of on average -26 bps on the *Yield at Issue*. Nevertheless, most of the studies analysed thus far employ a significance level of either 1% or 5%, with one of these studies calling a 10% significance level “marginally significant” (Larcker & Watts, 2020:30). Hence, looking at our results, only the regression with the lowest explicative power, equation (4.3), seems to hold for a 5% significance level.

Table 4.3: Results of the HAC estimator applied to the Direct Matching OLS regression model. Note: "." p-value < 0.1; "*" p-value < 0.05; "**" p-value < 0.01; "***" p-value < 0.001.

(Source: R Studio)

	(4.3)	**(4.4)**	**(4.5)**	**(4.6)**	**(4.7)**	**(4.8')**
Intercept	2.0698***	0.39238	-0.34049	0.26147	0.37673	0.02787
	(<2e-16)	(0.65854)	(0.7091121)	(0.7428090)	(0.648114)	(0.973071)
Green	-0.2971*	-0.26316.	-0.26128.	-0.24797.	-0.24606.	-0.24833.
	(0.04422)	(0.07878)	(0.0847786)	(0.0673790)	(0.071314)	(0.067412)
Maturity		0.06613***	0.05588***	0.07549**	0.07927**	0.07814**
		(6.598e-06)	(0.0008007)	(0.0016192)	(0.001049)	(0.001429)
log(Amount)		0.1822	0.21060	0.29037*	0.30057*	0.28407*
		(0.18318)	(0.1077858)	(0.0134902)	(0.011175)	(0.017474)
BBG C			0.13977**	0.13778***	0.12965**	0.13207**
			(0.0045009)	(0.0005863)	(0.008904)	(0.007337)
Currency [EUR]				-2.73483***	-2.71998***	-2.61405***
				(<2.2e-16)	(<2.2e-16)	(<2.2e-16)
[USD]				-1.00439***	-1.01510***	-1.00429***
				(4.021e-05)	(1.299e-05)	(9.157e-06)
BCLASS					-0.10599	-0.05705
					(0.680249)	(0.830781)
Collateral						0.02295
						(0.222396)
Green Bonds	61	61	61	61	61	61
Observations	122	122	122	122	122	122
R Squared	0.01295	0.09286	0.1856	0.6284	0.6295	0.6329

Looking at the other explanatory variables, *Maturity*, *BBG C* and *Currency* (EUR and USD) all have some sort of relationship with *Yield at Issue*, showing signs that their estimates are all statistically significant in any regression. *Maturity* has a positive relationship of on average 7.1 bps; *BBG C* also has a positive relationship of roughly 13.5 bps; *Currency*[EUR] has a negative relationship of about -2.7 pps; and *Currency*[USD] has a negative relationship of approximately -1 pps. All in all, these four explanatory variables seem to be statistically significant in all of the regression models and datasets, meaning their relationship with *Yield at Issue* is strong and noticeable.

Looking at the other explanatory variables, their impact on the outcome variable is inconsistent, showing at times statistically significant estimates. *Amount*, in this case, is statistically significant in the regressions with the higher R squared, showing on average a positive relationship with the *Yield at Issue* of nearly 29 bps, contradicting previous results. Furthermore, *BCLASS* and *Collateral* are both not statistically significant, showing p-values above 0.05 in every regression.

4.2 Results Discussion

After looking at the results each matching method yielded, it is important to understand and discuss them in the context of the Green Bond Market. Is there a Green Bond Premium? If there is none, does that mean firms should not issue Green Bonds? What about investors, should they invest in Green Bonds? And what about the other covariates, how do they affect the yield of bonds? Next, we will try to answer these, and other questions.

4.2.1 Is there a Green Bond Premium?

Our results are mixed. Overall, we found evidence of both a Green Bond premium and a Green Bond discount, depending on the dataset and regression we were working with. Nevertheless, most of these results were not statistically significant, meaning there appears to not exist any relationship between the *Green Label* and the *Yield at Issue*. Even though the Direct Matching dataset revealed statistically significant estimates, these do not hold for the 5% significance level most of the articles studied used to consider their estimates significant. Furthermore, although regression (4.3) of this dataset holds for a 5% significance level, it has little to no explicative power as seen through the R Squared, making it harder to consider this estimate as evidence of any relationship between these two variables.

That said, it does not look like any pricing difference between Green and Conventional Bonds exists in our sample, beyond what is considered normal. As such, our study stands with the piece of Green Bond literature that did not find evidence of any statistically significant Green Bond premium or discount (Flammer, 2021; Larcker & Watts, 2020; Tang & Zhang, 2020).

It is important to bear in mind that our answer is dependent on the small sample of Green and Conventional Bonds we collected from Bloomberg. This is due to some challenges we faced during the data collection stage. Moreover, we only examined if there was a *greenium* in the primary Green Bond Market and, thus, only collected information regarding the yield of the bonds at issue. The fact that we did not collect information about the evolution of the yields, which would have given us some insight into the secondary market, as other studies did, might have limited our results too. This time, Bloomberg export problems and other layout issues prevented us from doing so.

Furthermore, the fact that the Green Bond Market is still fairly recent, and we only collected information on bonds that were issued from 2014 onward, so as to avoid Green Bonds issued before the introduction of the GBP, further limited the amount of information we had available. The fact that the Green Bond Market is still in its early stages means things can change from here on out. With the introduction of better standardisation and certification, Green Bonds' issuing volume may increase dramatically, along with interest and demand in this financial instrument, affecting pricing and other characteristics. Hence, our results will probably hold for a limited amount of time. As time goes on, Green Bond issuance will stabilise and conclusions will be sturdier.

In the meantime, looking at our results, it looks like investors are not willing to forego return in exchange for endorsing environmentally friendly projects and, as such, firms are not able to issue

cheaper debt to fund such projects. This looks worrisome. Theoretically, without any incentives for companies to issue Green Bonds, they will undoubtedly prefer to issue Conventional Bonds because they come without the Use of Proceeds clause. Bonds without this clause give the company more power in how they employ their proceeds, since there is no independent third party whose job is to control and manage this allocation.

Nevertheless, by issuing Green Debt, firms are targeting a particular set of investors, who engage in SRI and introduce moral values into their investment decisions, screening and selecting investment opportunities that align best with their ethical views. With an ever-increasing audience (Social Investment Forum, 2020), as the number of environmentally conscious investors grows alongside the number of environmental issues that need addressing, emitting Green Bonds is of utmost importance to tackle these issues and, simultaneously, a good opportunity for companies to finance their environmentally friendly projects.

Furthermore, there are other benefits that companies should bear in mind when issuing Green Bonds. Increasing the institutional ownership of the firm, the demand for one's shares and its reputation seem to be competitive advantages, improving media exposure and the public outlook on the issuing company (Tang & Zhang, 2020). In fact, sustainable literature and research is at an all-time high as people are becoming more aware of the ongoing environmental problems, existing a social pressure (Lourenço *et al.*, 2012) for firms to enter and explore the Green Debt Markets as a way to reduce their greenhouse gas emissions and adapt their operations.

However, as we have seen previously, there is the risk of *greenwashing*, *i.e.*, companies may issue Green Bonds under false pretences to enjoy all the benefits of issuing without actually allocating the proceeds correctly and, thus, trick investors into buying bonds that do not contribute to a Greener World. This is the main challenge the Green Bond Market is facing, lack of standardisation and certification (Bank of America Merrill Lynch, 2014; Ehlers & Packer, 2017; Kapraun *et al.*, 2021; Nanayakkara & Colombage, 2019; Sartzetakis, 2019), with most of its guidelines being voluntary instead of mandatory. This not only introduces doubt and mistrust in the market and issuers, but also prevents investors from participating in the Green Bond Market and signal to the responsible concerned parties the changes they want to see and implement in the response to climate change.

The fact that there are no universally agreed guidelines and definition for Green Bonds only gets in the way of the expansion and growth of the Green Bond Market. Governments, local authorities, investment banks and other policymakers should push for more clear and mandatory procedures in the Green Bond Market. In the grand scheme of things, looking at climate change repercussions, the dire need of taking action against them and the massive price tag of these plans, Green Bonds are a great financial instrument to use as a response (Bank of America Merrill Lynch, 2014; OECD, 2017b; Tolliver *et al.*, 2019). Just one look at the sheer size of the Global Bond Markets in August 2020 (128.3 trillion

USD)[16] gives an idea of the growth potential of the Green Bond Market, and the amount of money that could be allocated to dealing with the current environmental problems. Securing that all issuers are certified and standardised, signalling to the investors that their Green Bonds are regulated and periodically reviewed, will further this agenda and get us close to a carbon-free economy.

Now is the right time to realise the benefits associated with Green Bonds and participate in the Green Bond Market. Now is the right time to help overturn the consequences of climate change by helping firms reform and adapt their operations, reducing greenhouse gas emissions and allocating their resources more efficiently. Now is the right time to analyse the current Green Bond Market regulations and make the much-needed adjustments to improve confidence and participation in the market.

4.2.2 Do the other Bond Characteristics affect the Yield at Issue?

Throughout our analysis of the *greenium* in the Green Bond Market, we found some statistically significant covariates affecting the bonds' *Yield at Issue*. In particular, *Maturity*, *BBG C* and *Currency* (EUR and USD) are bond characteristics whose estimates were statistically significant in every regression model and matching method we employed. Thus, we can conclude that the relationship between these covariates and the *Yield at Issue* of bonds is strong in our sample.

Maturity, as described previously, is the covariate returning the time to maturity, in years, of a certain bond, since its issue date until its maturity date. Our results show that this variable has a positive relationship with the *Yield at Issue* of bonds. Looking at financial theory, this result makes sense since investors generally prefer short term bonds, so they can realise their gains faster and not be as exposed to volatility, *i.e.*, the risk of market conditions changing, whether in favour of the investor or against it, affecting the return and price of the bond, as well as the risk of the issuer defaulting (not meeting coupon or principal repayments). Thus, the longer the maturity of a bond, the higher the return the investor will require to hold on to it as compensation for these risks. Taking the average of our results, spread in diverse regression models applied to different datasets resulting from different matching methods, we obtain, approximately, an 8.2 bps penalty for each extra year of the bond's lifetime.

BBG C, as formerly introduced, is the variable that captures the credit rating of the issuer. Similarly to what we did when we were applying the CEM method, we converted this categorical variable into a continuous numerical variable in order to better translate the hierarchy of the credit ratings and to facilitate the way the results of each regression model were shown. Thus, the AAA rating was replaced with the number 1, AA+ with the number 2, and so on until the BBB- rating, which was replaced by the number 10. Overall, our results indicate a positive relationship between *BBG C* and *Yield at Issue*, meaning the lower the rating, the higher the number assigned and, as such, the higher the yield of that bond. Comparing this with financial theory, it seems the results are in accordance. As presented earlier, we know that the lower the credit rating of a company, the higher the risk of said company defaulting,

[16] https://www.icmagroup.org/market-practice-and-regulatory-policy/secondary-markets/bond-market-size/

leaving investors with unrealised returns. To compensate for such risk, lower rated firms tend to increase the return their bonds offer to investors. In our sample, the average effect of the *BBG C* on *Yield at Issue* is of nearly 17.3 bps, meaning there is a 17.3 bps impact on the *Yield at Issue* as the credit rating lowers (or as the number assigned to each credit rating increases one unit).

Looking at *Currency*, mainly at EUR and USD, our results point towards a negative relationship with the *Yield at Issue* of bonds. Financial theory does not seem to have the answer to such a direct relationship between these two variables. Our explanation is related with the currency market. It is known that these two markets are the most liquid and traded markets out of all the currencies and, as such, bonds expressed in these currencies are more likely to attract investors and trade faster. In other words, there is a higher amount of exposure and demand for bonds expressed in EUR and USD than other currencies. Knowing this, firms take advantage and issue their bonds at higher prices (lower yields). On average, the effect of currency on the yields of bonds is -2.4 pps and -92.8 bps for bonds expressed in EUR and USD, respectively.

Notice that a 2.4 pps drop in yield just because a bond is expressed in EUR seems exaggerated. However, if we contextualise this result by looking at our descriptive statistics, in the Data chapter, it becomes understandable. Our sample of investment grade, corporate, plain vanilla bonds says the Green Bonds expressed in EUR have an average yield of 0.767%, and the EUR-Conventional Bonds have a 1.293% average yield. If we look at each group's average yield, we see a clear difference: 1.953% and 2.586% for Green and Conventional Bonds, respectively. Giving some tolerance and introducing other effects we can begin to understand this exaggerated estimate. Nevertheless, one should have in mind that this estimate holds for our sample and databases. Most likely, introducing more information and broadening our sample, we would not obtain such a large estimate but a more conservative one.

Looking at the other covariates present in our regression models, their relationship with *Yield at Issue* were not as unanimous as the aforementioned ones. *BCLASS* returned statistically significant estimates in the PSM and CEM regression models, establishing a positive relationship with the *Yield at Issue* of, on average, 31.3 bps. *Collateral Type* only yielded statistically significant estimates for the CEM regression model, indicating a negative average relationship with the bonds' yield of nearly -4.1 bps. On the other hand, *Amount* generated mixed results, only having statistically significant estimates in the PSM regression models with the lower R Square value or in the Direct Matching regression models with the higher R Square value. Furthermore, these estimates represented both a negative and positive relationship with the *Yield at Issue*, putting things more confusing. In the end, the average effect of *Amount* on the *Yield at Issue* is around 6.2 bps. *Maturity Type* never returned any statistically significant estimate, pointing towards no relationship between this covariate and *Yield at Issue*. Finally, the *Green Label*, the focus of this project, only showed statistically significant estimates in the Direct Matching database, showing an average negative relationship with the *Yield at Issue* of bonds of around -26 bps. However, as mentioned previously, most of these estimates only held for a 90% confidence interval, instead of the more usual 95% confidence interval adopted by most statisticians.

Table 4.4: Table representing the average of all the statistically significant estimates each regression method yielded, per matching method.
(Source: Own elaboration)

	PSM	CEM	DM	Average
Green	--	--	-0.2607	-0.2607
Maturity	0.0764	0.0992	0.0710	0.0822
BBG C	0.2075	0.1770	0.1348	0.1731
Currency[EUR]	-2.4070	-2.0554	-2.6896	-2.3840
Currency[USD]	-0.9661	-0.8106	-1.0079	-0.9282
Amount	-0.1662	--	0.2917	0.0627
BCLASS	0.4060	0.2193	--	0.3126
Collateral Type	--	-0.0407	--	-0.0407

Conclusion and Recommendations

Throughout this study the advantages of Green Bonds were highlighted so firms could see beyond the potential lower debt financing rate they could get access to through the issuance of this financial instrument. In fact, our research did not yield statistically significant estimates at the desired confidence interval for the *Green Label*, suggesting there is no linear relationship between the *Green Label* and the *Yield at Issue*, or in other words there is no *greenium*. Thus, these other benefits needed to be named and stressed so sustainability could have a future and, consequently, help further the 2015 Paris Agreement and the 2030 Agenda for Sustainable Development, putting the World on track for a low emission economy.

This transition to a carbon-free economy, however, does not come without a hefty cost, which the public sector can only finance so much, making the engagement of the private sector one of the main goals. Looking at the Conventional Bond Market, and its massive size of over 125 trillion USD as of August 2020, one can see the potential the private sector brings to the Green Bond Market. Thus, focusing on minimizing the risks underlying the still recent Green Bond Market – lack of standardisation, certification and reviewing – should be the focus of governments and other policymakers. Only by addressing such limitations can the confidence in the Green Bond Market increase, leading to more frequent participation and, consequently, signalling to the entities in charge the importance of advancing sustainability.

Several studies look at the benefits of Green Bonds, citing boosted media exposure, reputation, stock interest and return, broadening the investor base of the firm (Flammer, 2021; Tang & Zhang, 2020). Furthermore, the environmental rating of the issuing company improves, reducing greenhouse gas emissions and contributing to a cleaner World (Gløsmrod & Wei, 2018; Meo & Karim, 2021; OECD, 2017b; Tolliver *et al.*, 2019). Lourenço *et al.* (2012) in their study detail the social pressure firms are currently facing to join more sustainable initiatives, describing examples of large firms who are undervalued for not doing so. In other words, by engaging in greener projects, firms can improve relationships with their stakeholders, developing certain resources and capabilities that can lead to competitive advantages.

As Green Bonds are still recent, and literature on this subject is still increasing, one can look at the benefits of Green Finance and build the bridge between these similar concepts, whose main goal is to manage and improve the impact financial initiatives have on the environment and society. Studies on these environmentally conscious firms show they can have access to resource efficiencies, larger stock returns, reduced cost of capital, improved credit rating and lower perceived risk (Bauer & Hann, 2014; Kempf & Osthoff, 2007; Klassen & McLaughlin, 1996; Oikonomou *et al.*, 2014; Sharfman & Fernando, 2008; Statman & Glushkov, 2009). Other studies investigate the relationship between CSR and CFP, noting that, in general, there is a positive relationship between the two (Kim *et al.*, 2015; Orlitzky *et al.*; 2003), depending on reputation and the level of competitive action.

Overall, our dissertation aimed to study the relationship between the *Green Label* and the *Yield at Issue* of bonds, which up to this date there has not been a consensus among studies. This research question is important to determine whether investors as a whole value the *Green Label*. The answer will then impact resulting policies. In this study, it does not seem investors, in general, are willing to forego return in exchange for backing green projects. Resulting policies should focus on increasing the attraction of Green Bonds through, for instance, compensation or tax deductions policies. Governments and policymakers, after addressing the main risks facing the Green Bond Market, should focus on differentiating Green Bonds from Conventional Bonds, making them more attractive for the general public, boosting the engagement of the private sector and putting us one step closer to the carbon-free economy.

Through this study, we also managed to identify and quantify which bond characteristics can affect the return of any given bond. According to our sample, *Maturity*, *BBG C* and *Currency* (particularly, EUR and USD) affect the pricing of bonds: (1) *Maturity* has a positive relationship with the *Yield at Issue* (on average of 8.2 bps), indicating the longer the maturity of a bond, the higher their offered return will be; (2) *BBG C* also establishes a positive relationship with the *Yield at Issue* (on average of 17.3 bps), suggesting that lower-rated bonds should offer higher return rates; (3) *Currency*, on the other hand, constitutes a negative relationship with the *Yield at Issue* (on average of -2.4 pps for EUR-expressed bonds and -92.8 bps for USD bonds), hinting that bonds expressed in either EUR or USD can be issued at lower yields.

Further analysing these results, we concluded they were in accordance with what financial theory predicts. Overall, we know that risk plays a part in determining the return of a security, *i.e.*, investors only expose themselves to risk if the return is enough to compensate them for this exposure. Hence, the *Maturity* and *BBG C* results can be interpreted under this light: firms issuing bonds with a longer maturity or lower credit rating must set their returns high enough to attract investors and compensate them for holding on to their bonds. On the other hand, the *Currency* results were not as clear to analyse. In the end, we came to the conclusion that it could be opportunistic pricing: knowing the market for bonds expressed in EUR and USD is generally bigger and more liquid, firms offer bonds in these currencies at lower return rates.

In summary, studying the Green Bond Market allowed us to research other topics of interest, such as sustainability, CSR and SRI, as well as get a sense of how the World is doing in adapting and advancing such concepts. In general, it seems we are doing a poor job, as several barriers still need to be overcome to unlock the full potential of these concepts: (1) the lack of universally-defined mandatory guidelines allows firms to engage in *greenwashing*, tricking investors into believing their investments are contributing to green the industry; (2) the amount of costs firms must cover to issue Green Bonds seem excessive, as it includes, at least, certification, reviewing and underwriting; (3) some firms and investors still believe in more traditional management styles, ignoring the benefits sustainability can introduce in their business, looking at it as nothing more than added costs; and (4) governments and

other responsible entities need to become more active and vocal in their response to climate change, urging all countries and firms to adapt their policies and operations to fit the carbon-free agenda.

Nevertheless, our research also yielded some positive omens. The fact that the Green Bond Market is still able to operate and continuously increase its audience year after year, means the environment is starting to occupy a bigger slice in the pie charts of firms and investors, signalling to the entities in charge that there is a market for sustainability, which policies and initiatives can help grow. Furthermore, we also learned that more and more investors are starting to introduce ethical values in their decision making. Even though the proportion of these type of investors is only around one third, it is still growing and capable of introducing some much-needed changes in financial markets. Still, fossil-based investments are starting to phase out, as public incentives start to dwindle (as incentives to cleaner alternatives start to increase) and public opinion begins to shift against it. The advantages and benefits highlighted in this dissertation also hope to make a difference and signal to firms that there is an audience for greener projects and researching them, costly as it may be, it also comes with a handful of other benefits and payoffs.

Besides the added knowledge, this research also has its limitations. As stated throughout the study, the Green Bond Market is still fairly recent and has a massive growth potential. As more policies and initiatives come into place, changes will be made that will affect this market and, as such, our results. Therefore, we believe our results will not hold for a long period of time. With more time to grow and implement certain policies, the Green Bond Market will most certainly alter and, potentially, exhibit a Green Bond premium or discount, depending on what is implemented. Moreover, during our data collection stage, we ended up introducing a lot more filters than we initially intended, which might have restricted our results. However, to work around this issue, we made sure to justify every filter according to the available Green Bond literature.

Furthermore, our results may have been hindered by our choice to focus solely on the primary market and the yields at issue of the bonds, due to Bloomberg's exporting problems and other layout issues. Nonetheless, as before, by using different references and grounding ourselves on the Green Bond literature researched, we believe we worked it through.

For future research, as mentioned initially, we believe there are other areas within the Green Bond Market that might need assistance, namely the volatility and impact of Green Bonds, as we have found mixed results. Other areas, such as the relationship between CFP and CSR, or other environmentally conscious concept, can prove to be fruitful as well, since it seems there are not as many studies regarding this relationship, and most end up yielding inconclusive results. Expanding the literature regarding other green financial instruments and the benefits they bring to the table can be productive too, as more studies start to pressure regulatory entities to implement changes and show firms how advantageous issuing such instruments can prove to be.

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Annexes

Annex A: Concepts and Definitions.**Error! Bookmark not defined.**

- **Agency Problem**[17]**:** An agency problem is a conflict of interest inherent in any relationship where one party is supposed to act in another's best interest. Typically, in corporate finance, this term is used to refer to a conflict of interests between the firm's management team and its shareholders. Management, acting as the agent for the firm's shareholders, is supposed to work towards maximising overall shareholder wealth. Nevertheless, it is in the manager's best interest to maximise their own wealth.
- **Callable Bond**[18]**:** Sometimes known as redeemable bond, a callable bond is a bond embedded with a call option, giving the issuer "the right, but not the obligation, to redeem the bond before its maturity date". These bonds can be considered high risk for investors and, as such, they tend to come with a premium as compensation for the risk exposure.
- **Churn Rate**[19]**:** Churn rates are used to measure "the number of individuals or units leaving a group over a specified time period". A high churn rate can be harmful to a firm's profitability and limit its growth potential. Conversely, a lower churn rate indicates stronger loyalty.
- **Competitive Action:** Under Kim *et al.*'s (2015) study, competitive action is a term that includes diverse competitive moves, such as new product introduction, marketing and capacity expansion, that firms use to enhance their competitive position. Thus, strong and active competitive action enhances a firm's competitive position and increases CFP. In particular, competitive action "reflects a firm's effort to fulfil its economic responsibility", emphasizing "that a firm must bring value to customers by continuously striving to introduce new products, methods and initiatives" (Kim et al., 2015:2).
- **Convertible Bonds**[20]**:** A convertible bond is a hybrid security, possessing traits of both debt and equity. This security provides the investor with the right, but not the obligation, to, at certain times during the bond's lifetime, exchange the bond for a predetermined number of shares in the issuing firm. Due to this added flexibility to the investor, investors are often willing to accept lower interest payments.
- **Greenwashing:** Flammer (2021) defines greenwashing as "the practice of making unsubstantiated or misleading claims about the company's environmental commitment" (Flammer, 2021:2). According to the scholar, greenwashing originates from the lack of universal guidelines regarding Green Bonds, stating that the Green Bond Market "relies on private governance regimes such as the

[17] https://www.investopedia.com/terms/a/agencyproblem.asp
[18] https://corporatefinanceinstitute.com/resources/knowledge/trading-investing/callable-bond/
[19] https://corporatefinanceinstitute.com/resources/knowledge/ecommerce-saas/churn-rate/
[20] https://corporatefinanceinstitute.com/resources/knowledge/trading-investing/convertible-bond/

certification standards", which "do not have the same enforcement mechanisms as public regulation" (Flammer, 2021:5).

- **Investment Grade[21]:** Investment grade is a bond classification system used to denote bonds that carry a relatively lower risk compared to other bonds (known as High Yield Bonds or Junk Bonds). The minimum credit rating an issue can have to still be considered investment grade is "BBB-" (Fitch, S&P and DBRS) or "Baa3" (Moody's).
- **Stakeholder Theory[22]:** A stakeholder is a party that has interest in the company and can either affect or be affected by the company's decisions. Typical stakeholders include employees, investors, customers and other individuals. With the increasing attention on CSR, communities, governments and the environment started to be considered as stakeholders. That said, stakeholder theory looks at an organization as a collection of these various individuals with different interests. Together, these interests represent the will of the organization. Business decisions should consider these interests and advance overall cooperation, developing certain intangible assets along the way, that are useful to unlock competitive advantages.
- **Volatility Clustering:** According to Pham (2016), volatility clustering is when "periods of high volatility are often followed by further periods of high volatility and periods of low volatility are followed by periods of low volatility" (Pham, 2016:2-3), meaning current volatility is affected by previous volatility.

[21] https://corporatefinanceinstitute.com/resources/knowledge/trading-investing/investment-grade-bonds/

[22] https://www.investopedia.com/ask/answers/031615/whats-difference-between-agency-theory-and-stakeholder-theory.asp

Annex B: Comparison of the different Green Bond Taxonomies.

Green Bond Principles	European Green Bond Standard	Climate Bonds Standard
Use of Proceeds Eligible Green Projects should be appropriately described in legal documentation, clearly providing the environmental benefits.	*Taxonomy-Alignment* Funds raised through the bond issuance should be fully allocated to projects aligned with the EU taxonomy.	*Prepare the Bond* Issuers should create a Green Bond Framework, setting out the use of proceeds for the bond.
Process for Project Evaluation and Selection Green Bond issuers should clearly communicate to investors the environmental sustainability objectives of the Green Project, how the projects fit the eligible Green Projects categories, as well as information on how the issuer will identify and manage potential risks associated with the relevant project.	*Transparency* Full transparency on how the bond proceeds are allocated, through detailed reporting requirements.	*Engage a Verifier* Engage an approved verifier for pre- and post-issuance certification. The verifier should then provide a report assuring that the Climate Bonds Standard requirements are met. *Get Certified & Issue a Certified Climate Bond* Issuers must submit the Verifier's report and information form to the CBI and await the decision on pre-issuance certification.
Management of Proceeds The net proceeds of the Green Bond, or an amount equal to these net proceeds, should be tracked and attested by the issuer in a formal internal process.	*External Review* All European Green Bonds must be checked by an external reviewer to ensure compliance with regulation and taxonomy alignment of the funded projects.	*Confirm the Certification Post-Issuance* Within 12 months of issuance, issuers must submit the Verifier's post-issuance report and await the decision of post-issuance certification.
Reporting Issuers should provide up to date information on the use of proceeds annually, until full allocation. This annual report should include a list of the projects to which Green Bond proceeds have been allocated, along with a brief description of the projects, the amounts allocated and their expected impact.	*Supervision by the ESMA of reviewers* The external reviewers providing services to the issuers of European Green Bonds must be registered and supervised by the ESMA, ensuring service quality and the reliability of their reviews to protect investors and ensure market integrity.	*Report Annually* Issuers must prepare annually a report for term of the bond to the bond holders and the CBI.

Annex C: Table summarising the reports issued by the CBI.

Reference	Time Period	Amount of Green Bonds analysed	*Greenium*
CBI (2017a)	January 2016 - March 2017	14 Green Bonds	*6 of the 14 Green Bonds* are priced inside their own yield curve, suggesting there is a *greenium* (higher price, lower yield). The remaining 8 Green Bonds do not show signs of a *greenium*.
CBI (2017b)	April 2017 - June 2017	10 Green Bonds	Only *2 out of the 10 Green Bonds* show signs of a *greenium*. The remaining 8 Green Bonds are either priced on or outside their own yield curve, suggesting there is no *greenium*.
CBI (2018a)	July 2017 - September 2017	12 Green Bonds	*2 out of the 12 Green Bonds* are priced inside their own yield curve, showing signs of a *greenium*. The remaining 10 Green Bonds do not have a *greenium*.
CBI (2018b)	October 2017 - December 2017	6 Green Bonds	*3 out of the 6 Green Bonds* analysed showed signs of a *greenium*. The other 3 Green Bonds did not show evidence of having a lower yield than existing debt.
CBI (2018c)	January 2018 - June 2018	18 Green Bonds	*None of the Green Bonds* exhibited a *greenium*. All 18 Green Bonds, expressed in EUR ou USD, were priced either on or outside its own credit curve.
CBI (2019a)	July 2018 - December 2018	21 Green Bonds	*2 out of the 21 Green Bonds* showed signs of a *greenium* (both expressed in EUR). The remaining 19 Green Bonds did not show evidence of having a *greenium*.
CBI (2019b)	January 2019 - June 2019	32 Green Bonds	*6 out of the 32 Green Bonds* exhibited a *greenium*. The remaining 26 Green Bonds were priced either on or outside their own yield curves.
CBI (2020a)	July 2019 - December 2019	19 Green Bonds	*7 out of the 19 Green Bonds* showed signs of having a *greenium*. The remaining 12 Green Bonds did not show proof of holding a *greenium*.
CBI (2020b)	January 2020 - June 2020	21 Green Bonds	*5 out of 21 Green Bonds* were priced inside their own credit curves, suggesting there is a *greenium*. The remaining 16 Green Bonds did not show signs of such a *greenium*.
CBI (2021a)	July 2020 - December 2020	33 Green Bonds	*19 out of the 33 analysed Green Bonds* showed signs of a *greenium*. The remaining 14 Green Bonds were either priced on or outside their own yield curves, suggesting there is no *greenium*.
CBI (2021b)	January 2021 - June 2021	33 Green Bonds	*11 out of the 33 Green Bonds* showed signs of having a *greenium*. The remaining Green Bonds did not show signs of having lower yields than existing debt and, as such, of having a *greenium*.
CBI (2022)	July 2021 - December 2021	34 Green Bonds	*9 out of the 34 Green Bonds* exhibited a *greenium*. The remaining 25 Green Bonds were either priced on or outside their own yield curve, suggesting there is no premium.

Annex D: Table summarising all the Bloomberg fields.**Error! Bookmark not defined.**

Variable	Type	Unit	Description
Issuer Name	Qualitative		Variable returning the issuer name of the bond.
Issue Date	Quantitative	Year	Variable returning the date that the bond was issued.
Maturity Date	Quantitative	Year	Variable that gives information on the maturity date of the bond.
Maturity Type	Qualitative		Covariate that determines the maturity type of the bond, returning either "sinkable", "extendible", "at maturity" or "sink/ext", which can affect principal repayment and/or coupon payments.
Amount Issued	Quantitative	Million USD	Variable that gives information on the amount issued by the bond.
Currency	Qualitative		Covariate determining the currency of the bond issued.
BBG C	Qualitative		Variable that returns the credit rating of the issue. It is an equally weighted blend of the ratings of a security provided by Moody's, S&P, Fitch and DBRS. In case a security is between two ratings, Bloomberg rounds down to the lower rating.
Coupon	Quantitative	Percentage	Variable returning the coupon of the bond, determining the periodic coupon payments.
Coupon Type	Qualitative		This variable returns the coupon type of the bond, affecting interest payments (fixed *versus* floating rate).
Yield at Issue	Quantitative	Percentage	Covariate that returns the yield of each bond at issuance. Contrary to coupons, this variable determines the rate of return the bond generates.
Price at Issue	Quantitative		Variable that returns the price at issuance of the bond. Bonds can be priced at a premium, at a discount or at par, depending on market conditions.
Seniority	Qualitative		Covariate determining the seniority of the bond, returning either "subordinated debt" or "senior debt", which affects the priority of the bond being repaid in case of bankruptcy or liquidation of the issuing firm.
Collateral Type	Qualitative		This variable returns the collateral type of the bond, determining if the bond is backed by other financial assets or not, which can affect the security and repayment of the bond.
BCLASS	Qualitative		This variable returns the sector of activity of the bond. *BCLASS* organises securities into peer groups according to their risk and activity. Bloomberg Barclays Methodology (2020) details this classification scheme greatly, dividing it into four pillars: "Treasury", which includes debt issued by central governments; "Government-Related", which includes government affiliated issuers; "Corporate", including issuers from the Industrial, Financial Institution or Utilities sectors; and "Securitized", which captures fixed income securities whose payments are backed from a pool of assets protected from the credit of the issuer.

Annex E: Green Bonds' descriptive statistics.

Total Amount of Green Bonds	Average Yield at Issue	Average Amount Issued (Million USD)	Cumulative Amount Issued (Million USD)
148	1.9530 %	625.69	92,602.58

Year of Issue	Number of Issues	Proportion of Issues	Average Yield at Issue
2014	07	04.73 %	2.326 %
2015	01	00.68 %	0.514 %
2016	08	05.41 %	2.655 %
2017	15	10.14 %	2.899 %
2018	15	10.14 %	2.454 %
2019	22	14.86 %	2.729 %
2020	22	14.86 %	1.141 %
2021	58	39.19 %	1.476 %

Currency of Issue	Proportion of Issues	Average Amount Issued (Million USD)	Average Yield at Issue
AUD	08.11 %	0472.01	2.402 %
CAD	04.73 %	0640.27	1.405 %
CHF	03.38 %	0244.10	0.269 %
CNY	02.70 %	0125.02	2.788 %
COP	00.68 %	0010.61	5.200 %
EUR	16.22 %	1,156.69	0.767 %
GBP	01.35 %	0514.02	1.720 %
HKD	01.35 %	0057.76	1.580 %
JPY	05.41 %	0183.84	0.756 %
MOP	00.68 %	0124.83	0.600 %
MXN	01.35 %	0050.14	4.700 %
NZD	00.68 %	0091.53	3.865 %
PLN	00.68 %	0100.90	2.060 %
SEK	02.03 %	0190.99	0.890 %
USD	50.68 %	0658.13	2.441 %

Credit Rating of Issue	Proportion of Issues	Average Amount Issued (Million USD)	Average Yield at Issue
AAA	30.41 %	814.92	1.806 %
AA+	02.03 %	567.50	0.395 %
AA	02.70 %	422.87	2.167 %
AA-	05.41 %	464.51	0.987 %
A+	08.78 %	451.73	1.563 %
A	13.51 %	450.56	1.533 %
A-	07.43 %	492.56	2.082 %
BBB+	13.51 %	586.76	2.080 %
BBB	08.11 %	694.52	2.216 %
BBB-	08.11 %	704.17	3.998 %

BCLASS1 & BCLASS2 of Issue	Number of Issues	Proportion of Issues	Average Amount Issued (Million USD)	Average Yield at Issue
Corporate	72	48.65 %	0559.94	1.990 %
Financial Institutions	*33*	*22.30 %*	*0547.57*	*1.494 %*
Industrial	*25*	*16.89 %*	*0545.73*	*2.710 %*
Utility	*14*	*09.46 %*	*0614.48*	*1.875 %*
Government-Related	73	49.32 %	0666.23	1.997 %
Agency	*30*	*20.27 %*	*0645.08*	*1.916 %*
Local Authority	*04*	*02.70 %*	*0588.19*	*0.677 %*
Sovereign	*06*	*04.05 %*	*0750.00*	*3.250 %*
Supranational	*33*	*22.30 %*	*0679.69*	*2.002 %*
Securitized	03	02.03 %	1,217.27	-0.005 %
Covered	*03*	*02.03 %*	*1,217.27*	*-0.005 %*

Annex F: Conventional Bonds' descriptive statistics.

Total Amount of Conventional Bonds	Average Yield at Issue	Average Amount Issued (Million USD)	Cumulative Amount Issued (Million USD)
4,996	2.5861 %	674.82	3,368,725.77

Year of Issue	Number of Issues	Proportion of Issues	Average Yield at Issue
2014	563	11.27 %	3.671 %
2015	378	07.57 %	2.975 %
2016	331	06.63 %	2.621 %
2017	603	12.07 %	2.880 %
2018	632	12.65 %	3.554 %
2019	719	14.39 %	2.754 %
2020	861	17.23 %	1.949 %
2021	909	18.19 %	1.342 %

Currency of Issue	Proportion of Issues	Average Amount Issued (Million USD)	Average Yield at Issue
AUD	06.39 %	237.99	3.370 %
BRL	00.32 %	142.37	7.548 %
CAD	04.28 %	638.32	2.424 %
CHF	01.58 %	223.56	0.401 %
CNY	01.68 %	047.95	3.776 %
COP	00.02 %	009.18	6.250 %
EUR	13.23 %	861.12	1.293 %
GBP	01.62 %	632.38	2.593 %
HKD	02.12 %	057.22	2.154 %
IDR	00.30 %	133.31	4.758 %
INR	00.50 %	036.93	6.610 %
JPY	06.37 %	237.20	0.709 %
KZT	00.10 %	248.11	10.290 %
MXN	00.28 %	148.90	6.442 %
NOK	00.48 %	266.91	2.662 %
NZD	01.50 %	211.29	2.710 %
PEN	00.10 %	208.95	3.960 %
PHP	00.02 %	020.66	2.750 %
RON	00.02 %	032.79	3.538 %
RUB	00.04 %	168.06	6.303 %
SEK	00.36 %	095.05	1.304 %
SGD	00.14 %	216.22	2.750 %
TRY	00.26 %	101.64	12.824 %
USD	57.91 %	828.29	2.864 %
UYU	00.02 %	103.05	10.400 %
ZAR	00.36 %	117.88	7.928 %

Credit Rating of Issue	Proportion of Issues	Average Amount Issued (Million USD)	Average Yield at Issue
AAA	12.23 %	924.23	2.438 %
AA+	03.00 %	919.36	1.845 %
AA	04.02 %	752.49	2.265 %
AA-	09.13 %	466.90	2.115 %
A+	15.87 %	570.29	2.261 %
A	16.41 %	625.82	2.265 %
A-	13.73 %	625.50	2.489 %
BBB+	10.31 %	720.73	2.912 %
BBB	08.99 %	700.14	3.662 %
BBB-	06.31 %	711.95	3.912 %

BCLASS1 & BCLASS2 of Issue	Number of Issues	Proportion of Issues	Average Amount Issued (Million USD)	Average Yield at Issue
Corporate	3,745	74.96 %	0626.84	2.537 %
Financial Institutions	*2,245*	*44.94 %*	*0616.77*	*2.389 %*
Industrial	*1,345*	*26.92 %*	*0665.03*	*2.768 %*
Utility	*0155*	*03.10 %*	*0440.91*	*2.694 %*
Government-Related	1,057	21.16 %	0805.61	2.995 %
Agency	*0497*	*09.95 %*	*0754.09*	*3.489 %*
Local Authority	*0150*	*03.00 %*	*0229.74*	*1.545 %*
Sovereign	*0015*	*00.30 %*	*1,200.00*	*3.409 %*
Supranational	*0395*	*07.91 %*	*1,074.13*	*2.909 %*
Securitized	0194	03.88 %	0887.66	1.297 %
ABS	*0003*	*00.06 %*	*0361.92*	*4.245 %*
Covered	*0191*	*03.82 %*	*0895.92*	*1.251 %*

Annex G: Summary table describing all the variables used throughout the study.

Variable	Type	Unit	Description
Green	Binary		Variable determining if the bond is Green (*Green* = 1) or Conventional (*Green* = 0).
Issue	Quantitative	Year	Variable returning the year that the bond was issued. ***Example:*** *A bond issued on the 29th of July 2017, returns the year 2017.*
Issue Cut	Bin/Intervals		Variable created for the sole use of matching using the CEM procedure. It is composed by several intervals of time.
Maturity	Quantitative	Years	Variable that gives information on the number of years the bond has. ***Example:*** *A bond issued on the 29th of July 2017, and maturing on the 29th of July 2021, returns the number 4, indicating the bond has 4 years of maturity.*
Maturity Type	Qualitative/ Quantitative		Variable that returns the maturity type of the bond. While matching, we used the qualitative variable. On the other hand, during the regression stage, we turned this variable into a quantitative covariate, by attributing a number to each maturity type. By choosing to do so, the regression results are presented in a cleaner way.
Amount	Quantitative	Million USD	Variable that gives information on the amount issued by the bond.
Amount Cut	Bin/Intervals		Variable created to be used solely for the CEM matching technique. It is composed of different intervals.
Currency	Qualitative		This variable determines the currency of the bond issued.
BBG C	Quantitative		Variable returning the credit rating of the issue. Originally, this variable is qualitative. Nevertheless, following Kapraun *et al.*, 2021, we decided to turn it into a quantitative variable, turning "AAA" to the number 1, "AA+" to the number 2, and so on until the rating "BBB-" which takes up the number 10. We used the quantitative version during matching and during the regression stage.
BBG C Cut	Quantitative		This covariate was created specifically to use during the matching stage of the CEM technique. Thus, we turned each credit rating into a number, nonetheless we decided to remove the "+" and "-" signs in order to coarsen the variable (Zerbib, 2019). As such "AAA" turns into the number 1; "AA+", "AA" and "AA-" get the number 2; "A+", "A" and "A-" receive the number 3; and "BBB+", "BBB" and "BBB-" turn into the number 4.
Seniority	Qualitative		This variable returns the seniority of the bond.
Collateral	Qualitative/ Quantitative		This covariate returns the collateral type of each bond. Similarly to previous variables, as it is used in most regression models, we ended up attributing a number to each collateral type. Hence, the qualitative form was used during matching and the quantitative version was employed during the regression stage.
BCLASS	Qualitative/ Quantitative		Just like previous covariates, we ended up turning this variable into a quantitative one, attributing to each BCLASS a number, to be used solely during the regression stage. During the matching procedure, we employ the qualitative version of this variable.

Annex H: Table representing the percent of balance improvement of applying the PSM method.

Percent Balance Improvement:

	Std. Mean Diff.	Var. Ratio	eCDF Mean	eCDF Max
distance	80.5	61.6	99.9	91.3
Year_Iss	97.5	77.5	84	74.3
Time_Mty_Years	77.6	51.9	52.6	45.4
Mty_Type[AT MATURITY]	29.6	.	29.6	29.6
Mty_Type[EXTENDIBLE]	100	.	100	100
Mty_Type[SINK/EXT]	100	.	100	100
Mty_Type[SINKABLE]	23.1	.	23.1	23.1
log(Amt_Iss_MM)	80.3	22.8	46.5	-40.6
Currency[AUD]	21.4	.	21.4	21.4
Currency[BRL]	100	.	100	100
Currency[CAD]	100	.	100	100
Currency[CHF]	62.4	.	62.4	62.4
Currency[CNY]	33.8	.	33.8	33.8
Currency[COP]	100	.	100	100
Currency[EUR]	54.6	.	54.6	54.6
Currency[GBP]	-648.2	.	-648.2	-648.2
Currency[HKD]	100	.	100	100
Currency[IDR]	100	.	100	100
Currency[INR]	100	.	100	100
Currency[JPY]	29.9	.	29.9	29.9
Currency[KZT]	100	.	100	100
Currency[MOP]	0	.	0	0
Currency[MXN]	38.1	.	38.1	38.1
Currency[NOK]	100	.	100	100
Currency[NZD]	100	.	100	100
Currency[PEN]	100	.	100	100
Currency[PHP]	100	.	100	100
Currency[PLN]	0	.	0	0
Currency[RON]	100	.	100	100
Currency[RUB]	100	.	100	100
Currency[SEK]	100	.	100	100
Currency[SGD]	100	.	100	100
Currency[TRY]	100	.	100	100
Currency[USD]	90.6	.	90.6	90.6
Currency[UYU]	100	.	100	100
Currency[ZAR]	100	.	100	100
BBG_C	79.4	46.7	37.2	55.4
Seniority[SBOD]	100	.	100	100
Seniority[SNDB]	100	.	100	100
Collat_Type[1ST MORTGAGE]	-26.2	.	-26.2	-26.2
Collat_Type[BANK GUARANTEED]	-6.3	.	-6.3	-6.3
Collat_Type[BONDS]	100	.	100	100
Collat_Type[CERT OF DEPOSITE]	100	.	100	100
Collat_Type[COMPANY GUARNT]	76.9	.	76.9	76.9
Collat_Type[COVERED]	6	.	6	6
Collat_Type[DEPOSIT NOTES]	100	.	100	100
Collat_Type[GOVT GUARANTEED]	89.8	.	89.8	89.8
Collat_Type[GOVT LIQUID GTD]	100	.	100	100
Collat_Type[INSURED]	100	.	100	100
Collat_Type[JUMBO PFANDBRIE]	100	.	100	100
Collat_Type[LOCAL GOVT GUAR]	55.7	.	55.7	55.7
Collat_Type[PASS THRU CERTS]	100	.	100	100
Collat_Type[PFANDBRIEFE]	100	.	100	100
Collat_Type[SECURED]	84.8	.	84.8	84.8
Collat_Type[SR SECURED]	57.2	.	57.2	57.2
Collat_Type[SR UNSECURED]	89.8	.	89.8	89.8
Collat_Type[SUBORDINATED]	100	.	100	100
Collat_Type[UNSECURED]	54	.	54	54
Collat_Type[US GOVT GUARANT]	100	.	100	100
BCLASS[Corporate]	97.4	.	97.4	97.4
BCLASS[Government-Related]	92.8	.	92.8	92.8
BCLASS[Securitized]	27.3	.	27.3	27.3

Looking at the previous table, we are interested in the Std. Mean Diff. column, which gives us an idea of how overall balance improved for that particular variable. The previous two tables (not pictured in this report but that can be shown upon request), show, among other information, the mean of the treated and control groups, before and after matching respectively. Depending on how these means were affected by the matching, the Std. Mean Diff. column displays either a positive number, indicating that balance improved, or a negative one, indicating that balance got worse for that variable in particular.

A practical example may help understand this. Looking at the Currency[EUR] variable before matching, we have a treated mean of 16.22% and a control mean of 13.24% (notice that these percentages are the likelihood of the bond issued being expressed in EUR). After matching, the treated mean remains the same, since we include all the treated observations in the PSM dataset, but the control mean changes to 17.57%, since now we do not have all of the 4,996 control observations in the PSM dataset (we only have 148 Conventional Bonds in this dataset). Looking at the Currency[EUR] variable, in the Std. Mean Diff. column of the table formerly presented, we see the number 54.6 presented, indicating that there was balance improvement (we went from a 2.98% difference to a 1.35% absolute difference).

On the other hand, looking at Currency[GBP], we find the most negative balance improvement in the entire table (-648.2). If we analyse the means before and after matching, we find out why. Before matching, the probability of a Green Bond being expressed in GBP was 1.35%, and the probability of a Conventional Bond being expressed in the same currency was of 1.62%. After matching, however, balance worsened, since the control mean increased to 3.38%, meaning that in the matched PSM dataset, it was more likely that Conventional Bonds were expressed in GBP than in the initial sample. Therefore, we went from an absolute difference in means of 0.27% to a 2.03%, worsening the overall balance of the sample.

Furthermore, the numbers 100 and 0 are the most common in this table. Variables that have a 100 in the Std. Mean Diff. column, have the same mean after matching, *i.e.*, treated and control mean after matching is the same, which indicates balance improvement. When variables have a 0 in the Std. Mean Diff. column, it means that one of the groups (treated or control) does not have a bond with that characteristic, for example, in the matched sample, the treated group has a bond expressed in MOP, however the control group does not.

Overall, we can say that balance improved since most numbers in the Std. Mean Diff. column are positive.

Annex I: Table representing the percent of balance improvement of applying the CEM method.

Percent Balance Improvement:

	Std. Mean Diff.	Var. Ratio	eCDF Mean	eCDF Max
Year_Iss	100	98.2	100	100
Time_Mty_Years_Cut]0.635; 33.9]	100	.	100	100
Time_Mty_Years_Cut]33.9; 67.1]	100	.	100	100
Time_Mty_Years_Cut]67.1; 100]	100	.	100	100
Mty_Type[AT MATURITY]	100	.	100	100
Mty_Type[EXTENDIBLE]	100	.	100	100
Mty_Type[SINK/EXT]	100	.	100	100
Mty_Type[SINKABLE]	100	.	100	100
Amt_Iss_MM_Cut]-12.5; 2,700]	100	.	100	100
Amt_Iss_MM_Cut]2,700; 5,390]	100	.	100	100
Amt_Iss_MM_Cut]5,390;8,090]	100	.	100	100
Amt_Iss_MM_Cut]8,090; 10,800]	100	.	100	100
Amt_Iss_MM_Cut]10,800; 13,500]	100	.	100	100
Currency[AUD]	100	.	100	100
Currency[BRL]	100	.	100	100
Currency[CAD]	100	.	100	100
Currency[CHF]	100	.	100	100
Currency[CNY]	100	.	100	100
Currency[COP]	100	.	100	100
Currency[EUR]	100	.	100	100
Currency[GBP]	100	.	100	100
Currency[HKD]	100	.	100	100
Currency[IDR]	100	.	100	100
Currency[INR]	100	.	100	100
Currency[JPY]	100	.	100	100
Currency[KZT]	100	.	100	100
Currency[MOP]	100	.	100	100
Currency[MXN]	100	.	100	100
Currency[NOK]	100	.	100	100
Currency[NZD]	100	.	100	100
Currency[PEN]	100	.	100	100
Currency[PHP]	100	.	100	100
Currency[PLN]	100	.	100	100
Currency[RON]	100	.	100	100
Currency[RUB]	100	.	100	100
Currency[SEK]	100	.	100	100
Currency[SGD]	100	.	100	100
Currency[TRY]	100	.	100	100
Currency[USD]	100	.	100	100
Currency[UYU]	100	.	100	100
Currency[ZAR]	100	.	100	100
BBG_C_Cut	100	98.9	100	100
Seniority[SBOD]	100	.	100	100
Seniority[SNDB]	100	.	100	100
Collat_Type[1ST MORTGAGE]	100	.	100	100
Collat_Type[BANK GUARANTEED]	100	.	100	100
Collat_Type[BONDS]	100	.	100	100
Collat_Type[CERT OF DEPOSITE]	100	.	100	100
Collat_Type[COMPANY GUARNT]	100	.	100	100
Collat_Type[COVERED]	100	.	100	100
Collat_Type[DEPOSIT NOTES]	100	.	100	100
Collat_Type[GOVT GUARANTEED]	100	.	100	100
Collat_Type[GOVT LIQUID GTD]	100	.	100	100
Collat_Type[INSURED]	100	.	100	100
Collat_Type[JUMBO PFANDBRIE]	100	.	100	100
Collat_Type[LOCAL GOVT GUAR]	100	.	100	100
Collat_Type[PASS THRU CERTS]	100	.	100	100
Collat_Type[PFANDBRIEFE]	100	.	100	100
Collat_Type[SECURED]	100	.	100	100
Collat_Type[SR SECURED]	100	.	100	100
Collat_Type[SR UNSECURED]	100	.	100	100
Collat_Type[SUBORDINATED]	100	.	100	100
Collat_Type[UNSECURED]	100	.	100	100
Collat_Type[US GOVT GUARANT]	100	.	100	100
BCLASS[Corporate]	100	.	100	100
BCLASS[Government-Related]	100	.	100	100
BCLASS[Securitized]	100	.	100	100

Once again, just like earlier, we are interested in analysing the Std. Mean Diff. column of the table presented previously. This time, however, we only see the number 100, indicating that both the treated and control groups, in the matched CEM sample, have the same means. This is to be expected, since the CEM method uses the Exact Matching technique, that is, bonds are only put in the same stratum if their characteristics are the same or in the same bin that was created through coarsening. Thus, overall, we can say that balance improved.