UNIVERSIDADE CATÓLICA PORTUGUESA

The pricing of Green Bonds:

An Empirical Analysis of Spread Determinants

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Católica Porto Business School

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Dissertation presented to the Universidade Católica Portuguesa to obtain the Master's degree in Finance

by

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Resumo

Green Finance é ainda um tema muito recente no panorama económico-financeiro atual. Esta dissertação tem como objetivo contribuir para a literatura teórica e empírica existente sobre teste tema, mais especificamente ao nível das *green bonds*. Esta tese procura fazer uma análise aos determinantes do *spread* das *green bonds* e compará-los aos das *corporate bonds* convencionais, e a partir daí extrair conclusões.

Para realizar esta análise, investigámos de forma empírica quais as principais variáveis contratuais, macroeconómicas e específicas das empresas (contabilísticas e financeiras) que explicam o spread destas obrigações.

Executamos uma comparação entre as *green bonds* e as *corporate bonds* entre os anos 2013 e 2020. A nossa amostra conta com 14,592 tranches, das quais 607 correspondem a *green bonds* e 13,985 a *corporate bonds*. Concluiu-se que o facto de ser g*reen bond* não tem impacto significativo no *spread* da obrigação; i.e., controlando por fatores contratuais, macroeconómicos e específicos das empresas, o spread das *green bonds* não difere significativamente do spread das *corporate bonds*.

Para além disso, foi possível concluir que as *green bonds* e as *corporate bonds* convencionais são influenciadas de forma diferente por fatores de *pricing* semelhantes. Finalmente, as empresas que escolhem *green bonds* são menos rentáveis, menos alavancadas e com melhor rating.

Palavras-chave: Green finance; Green Bonds; Spread; Corporate Bonds

Abstract

Green finance is still a very recent topic when we look at the financial and economical scene. This dissertation has as main goal the contribution to the existent theoretical and empirical literature on this topic, more specifically on green bonds. This work intends to perform an analysis of spread determinants of green bonds and compare them to conventional corporate bonds.

Thus, we empirically investigate empirically which are the main contractual, macroeconomic, and firms' accounting and market factors that affect bond spreads.

We established a comparison between green bonds and corporate bonds between 2013 and 2020. Our sample includes 14,592 tranches, from which 607 correspond to green bonds and 13,985 to corporate bonds. We conclude that spreads do not differ significantly between green bonds and corporate bonds.

Furthermore, we also find that green bonds and conventional corporate bonds are differently influenced by common pricing factors. Finally, we find that less profitable firms and those with lower leverage and higher credit rating choose green bonds over corporate bonds.

Keywords: Green finance; Green Bonds; Spread; Corporate Bonds

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Introduction

"The power of population is indefinitely greater than the power in the earth to produce subsistence for man." (Malthus, 1798). This impactful quote has been stated over 200 years ago, and yet it could have been said today. More than ever, humans start to see how their actions have real consequences on the planet, and how it can actually affect the way we live to the worse, with global warming being a daily concern in our lives, animals going extinct and the climate getting more and more volatile. NASA/NOAA (2019) reports that since this quote mentioned above until today, the global average temperature on our planet has increased above one degree Celsius, mainly caused by greenhouse gases emissions.

Acknowledging this issue, countries started to take action, with the Paris Agreement in 2015 symbolising a move from the big players to diminish the devastating impact that the planet is suffering. The European Green Deal also translates into another intention from nations to promote the green label, helping to sustain green, sustainable projects, as for example a green bond standard (European Commission, 2019).

Given that the economic and financial system is the machine that sustains the worldwide activities, it is crucial that there is a change in this machine, to include concerns with the above-mentioned problem. There are signs that the paradigm may be changing as, for instance, investors pay now more attention for portfolio's exposure to carbon dioxide (CO2) emissions, and they have a growing concern about companies environmental and climate principles. As investors seem to be more concerned with these problems, Liston-Heyes and Brust (2016) find out that investors' pressure pushes companies to a more environmentally friendly set of

actions. Muhammad et al. (2015), Eccles et al. (2016) and Carney (2015) also argue that there are advantages for companies when they opt for green practices.

Acknowledging this increasing interest in environmentally conscious principles, it is important to notice the increase in importance of green finance. Green finance is a very recent topic, and therefore there is not one exact definition of what it conveys (Zhang et al., 2019). Additionally, it is important to not confuse it with climate finance or even ESG (environmental, social and governance).

There are many proposed definitions for green finance (Lindenberg, 2014; Wang and Zhi, 2016; Zadek and Flynn, 2013; Höhne et al., 2012; Zhang et al., 2019), but the most common definition is that it corresponds to investments that have a positive externality for the environment, which allows for sustainable development, including a decrease in the greenhouse gases emissions and therefore pollution, as well as a decrease on the climate risks that the economy and financial system are exposed to (Bergedieck et al,, 2017).

Green finance functions as a platform to the development of new ideas and instruments that can be a vehicle to execute this mission, from which green bonds stand out. The academic literature focused on green bonds is incomplete (Gianfrate and Perri, 2019), and therefore this poses an interesting topic to study and add to the literature. A definition for this instrument is that "green bonds are serviced from the cash flows of the entire operations of the issuer – not just the green project" (Ehlers and Packer, 2017). Similar definitions are presented by Anderson (2016), International Capital Market Association (2018) and Gianfrate and Peri (2019).

There still is a lack of transparency for these instruments, which is why there has been an effort to reduce the information asymmetries[1]. For a bond to be classified as a green bond, there are a set of principles that have to be followed:

[1] There still is a lack of transparency about this type of information, which means that investors could be deceived into thinking they are investing on a green project when in reality they are not.

the proceeds must finance green projects (i.e., with environmental and climate benefits), and they must be subject to third-party authentication, which includes costs (Flammer, 2019). This is why the International Capital Market Association created the Green Bond Principles (GBP), which are utilized to check if a bond is green or not (Reboredo, 2018).

The literature on corporate bonds is very extensive and many authors (Pinto and Marques, 2019; Longstaff et al., 2005; Collin-Dufresne, 2001; Elton et al., 2001; Gabbi and Sironi, 2005; Campbell and Taksler, 2003; Oikonomou et al., 2011; Dorfleitner et al., 2019; Chen et al., 2011) study the relationship between the spread and various pricing determinants (where credit rating is the main explanatory variable), to understand how spreads react to variables capturing contractual, macroeconomic and firm-level variables.

On the other hand, some authors (Wulandari et al., 2018; Zerbib, 2019; Karpf and Mandel, 2017) already took the initiative to study green bonds, but there has not been a consensus or a conclusive idea about the relation between spread and the other explanatory variables. This is in part justified by the fact that green bonds are very recent, and therefore the sample size is somewhat limited. The first green bond in our sample was issued in 2013 by "Electricite de France SA – EDF" located in France, with a total deal amount of 1,881,460,000 US Dolllars.

We begin our analysis with a sample of 14,592 tranches, from which 607 correspond to green bonds and 13,985 to corporate bonds. The first research question is "Are green bond spreads lower than the spreads of similarly rated corporate bonds?" We find out that green bonds do not have a significantly lower spread that conventional corporate bonds. The second research question is "Are green bonds and standard corporate bonds similarly priced?". We find that there is a difference between how these factors (e.g., the currency risk, the rating discordance and maturity) influence the spread of each type of bond. Finally, the last research question is "What the determinants of firms' choice between green

bonds and standard corporate bonds?". We show that less profitable firms and those with lower leverage and higher credit rating choose green bonds over corporate bonds.

This work is organized as follows. Chapter 1 reviews literature on climate change, its association with the financial system, sustainable development, and then green finance. In this chapter, determinants of green bonds and corporate bonds is also discussed. Chapter 2 presents the research questions and hypotheses. Chapter 3 describes the sample selection and presents univariate analysis. Chapter 4 presents a comparative analysis of green bonds and corporate bonds financial characteristics. Chapter 5 presents regression results, while Chapter 6 presents robustness tests. Finally, a conclusion finalizes this work.

1. Literature Review

1.1 Climate change

To gain a deeper knowledge in the main topic of green finance, it is necessary to contextualize it in a broader one that is climate change. Nasir et. al (2019) studies the ASEAN-5 countries (Indonesia, Malaysia, the Philippines, Singapore, and Thailand) and concludes that economic and financial growth is responsible for the degradation of the environment. They mention the Environmental Kuznets Curve, which shows that even though in the short-term there is a deterioration of the environment caused by economic growth, on the long run the same economic growth can be responsible for the environmental improvement. Malthus (1798) points out that "… the power of population is indefinitely greater than the power in the earth to produce subsistence for man. Population, when unchecked, increases in a geometrical ratio. Subsistence increases only in an arithmetical ratio. By that law of our nature which makes food necessary to the life of man, the effects of these two unequal powers must be kept equal".

Climate change and global warming are a present, prevalent, and predominant challenge that humanity faces and must confront. According to NASA/NOAA (2019), in the past two centuries the global temperature has increased around 1 degree Celsius, primarily due to greenhouse gases emissions caused by human actions. Still as mentioned by NASA/NOAA (2020), the models utilized to forecast and predict the global temperature (i.e., models to understand the past, present and future of the world's climate changes) in the past fifty years have proven to be fairly accurate, which sustains and reinforces the idea that global warming is a real issue. Cook et al. (2013) study the scientific consensus about anthropogenic global warming (AGW), and through an examination of 11

944 climate abstracts, between 1991 and 2011, conclude that "… 66.4% of abstracts expressed no position on AGW, 32.6% endorsed AGW, 0.7% rejected AGW and 0.3% were uncertain about the cause of global warming", which corroborates that almost no one refuses global warming amongst the scientific community.

To underline the belief that global climate changes are real, there are already big movements involving nations to fight these problems.

The Paris Agreement was settled on 12 December 2015, where the parties that constitute the United Nations Framework Convention on Climate Change (UNFCCC) agreed to start acting to fight the climate changes, with the goal of hastening the measures and investments to secure a sustainable low carbon future (Boermans and Galema, 2019). Integrated with the objective of diminishing poverty, the Paris Agreements seeks action from all the parties to fight the global threat that climate change poses. The goals are to "make finance flows consistent with a pathway towards low greenhouse gas emissions and climate resilient development", in order to hold "the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels". This would limit the effects of climate change. Sustaining the 2 degrees Celsius threshold is an expensive task, requiring 53 trillion dollars in energy-related investments by 2035 (Batten et al., 2017). Finally, this agreement also proposes to increase "the ability to adapt to the adverse impacts of climate change and to foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production" and to make the financial world compatible with lower greenhouse gas emissions and an environmental-friendly growth and progress. The Intergovernmental Panel on Climate Change (IPCC) is a Nobel Peace Prize winner (won in 2007, on account of its contribution for climate change awareness) that supports the Paris Agreement's statement to

maintain the global average temperature below 2 degrees Celsius and limited to 1.5 degrees Celsius (Masson-Delmotte et al., 2018).

The European Green Deal started in the end of 2019, and is, therefore, a very recent answer from the European Union to the climate and environmental challenges that the world is facing. As it was also settled in the Paris Agreement, it is compulsory that the biggest nations come together and organize to propose a solution. The European Green Deal will offer investors a chance to ensure that the investments are indeed green, sustainable, and trustworthy, through the creation of, for example, a European Union green bond standard (European Commission, 2019).

1.2 Climate change and the financial system

In this chapter, we discuss how is the financial system being affected by these environmental changes. As analysed by Braun et al. (2019), in the case of the insurance industry, which is worth 25 trillion dollars worldwide, partially disinvesting in carbon-intensive assets would help reducing the global warming. Boermans and Galema (2019) stress that since the Paris Agreement, investors pay more attention for portfolio's exposure to carbon dioxide (CO2) emissions. These types of investments (i.e., carbon-intensive) are exposed to regulatory and environmental risks, which is also something that is increasingly important for investors and financial institutions (Battiston et al., 2017). Environmental changes influence investment portfolios, since there are, according to Ilhan et al. (2019), physical risks (e.g., global warming); regulatory risks (e.g., taxes to control the carbon emissions); and technological climate risks which consist in innovations related to environmental-friendly practices that replace the conventional products (e.g., electric vehicles replacing diesel or gasoline cars). The investors also consider climate risk reporting as an important aspect of a company's data disclosure, and that these reports should be standardized and compulsory. Investors, as mentioned previously, are more concerned about the climate

change than a decade ago, and how it affects their portfolios. According to Krueger et al. (2020), investors believe that climate risks have financial repercussions for their portfolios. It is also important to mention that 479 worldwide investors including firms and local authorities guaranteed their commitment to act on environmental changes through NAZCA (Non-State Actor Zone for Climate Action).

However, regulators and the investors still consider that the current degree of disclosure is not sufficient (Ilhan et al., 2019). Investors also mention that the shortage of firm's disclosure regarding climate matters requires them to count on private reporting channels of firms to get hold of this information (Solomon et al., 2011). The financial markets depend on precise and transparent information about firms' risk exposure, which include increasing climate change's risks, either from rules imposed by regulators or natural occurrences (Krueger et al., 2020). Considering this requirement for accurate data, it becomes clear that the financial system is exposed and vulnerable to negligence on climate issues (Batten et al., 2016; Breitenstein et al., 2019).

According to Breitenstein et al. (2019), a company's climate risks are inversely (i.e., negatively) related to its financial performance. Besides that, companies that show climate responsibility display smaller market risk traits. There is an increasing awareness and eagerness to recognize these environmental risks, which is easily observed when comparing the lack of acknowledgement in 2011 about these issues, and the more sophisticated knowledge and recognition nowadays. According to Bergedieck et al. (2017), "there is a positive correlation between investments managed according to sustainability criteria and their financial performance".

These inferences may lead us to believe than in fact investors worry about climate matters, which by itself would influence firms to change their practices. Liston-Heyes and Brust (2016) using a sample of 536 Argentinian firms, use a

"multi-stage model of corporate environmental behaviour" to comprehend how does investors' pressure affect the firm's environmental performance. Authors conclude that investor's pressure can have a positive effect in the creation and promotion of pro-climate attitudes. Furthermore, Muhammad et al. (2015), using an ordinary least squares (OLS) regression with fixed effects, find that there is a negative relation between environmental performance and firm volatility and downside risk. Likewise, Eccles et al. (2016) show a negative relation between the market risk of a firm and its corporate environmental performance (i.e., when the firm's environmental performance is higher, its market risk decreases). According to Carney (2015), climate change is not only a persistent and undeniable problem, but also a potential tragedy at economic levels, since the majority of market participants do not consider the risks they take, as they only occur in the long run. Finally, Hong et al. (2019) point out that investors do not price correctly the climate and environmental risks.

1.3 Sustainable Development

Sustainable Development consists in Humanity's practices and decisions that "ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brutland, 1987). Kuhlman (2010) states that "sustainability is concerned with the well-being of future generations and in particular with irreplaceable natural resources—as opposed to the gratification of present needs which we call well-being". For the author, there is a trade-off between the resources that are totally consumed and therefore extinct, and the increased capital that compensates this loss. Therefore, guarantying a sustainable life for the next generations demands that the current generation sacrifices its welfare.

Pearce et al (2013) states that "the next generation should inherit a stock of wealth, comprising man-made assets and environmental assets, no less than the stock inherited by the previous generation".

Lagoarde-Segot (2018) distinguishes weak sustainability and strong sustainability. According to the author, weak sustainability is characterized by the aggregate stock of capital being the sum of natural, human, and manufactured capital. When there is a reduction in, for example, natural capital, it can be offset by an increase in human and manufactured capital. As the natural resources diminish, their price increases leading to innovation, to produce without using natural resources. Strong sustainability, on the other hand states that a reduction in natural resources cannot be offset by an increase in manufactured or human resources. Instead of being substitutes, they are seen as complements.

In accordance with Merton (1973), economic agents maximize the potential value they can attain from an investment, taking into consideration the risk. Similarly, Statman (2006) points out that one of the main points that affects the decision of investors to allocate their capital is the social responsibility of the firm. Moskowitz (1972) reinforces this idea by stating that the social responsibility will be a deciding factor for investors, but still not as relevant as the returns.

Being aware of Moskowitz's analysis, it is important to understand if socially responsible firms are also the ones that yield higher returns. De and Clayman (2015) conclude that firms that have better environmental, social and governance scores will have higher financial returns, and lower correlation with market volatility. Kempf and Osthoff (2007) show that buying stocks that are socially responsible and selling the ones that were not, would lead "to high abnormal returns of up to 8.7% per year". McGuire et al. (1988) argues that firms which are socially responsible end up with less lawsuits as well as fines. In accordance with Clark et al. (2014), "90% of the studies on the cost of capital show that sound

sustainability standards lower the cost of capital of companies. 88% of the research shows that solid ESG (environmental, social and governance) practices result in better operational performance of firms". Additionally, firm's stock prices increase when the company is environmentally responsible, whereas it decreases when the firm behaves negligently towards climate issues (Flammer, 2013). Goss and Roberts (2011) point out that firms that lack social responsibility have higher costs of borrowing (by paying higher interest rates on their loans). Eccles et al. (2012) establish a comparison between 180 sustainable firms and non-sustainable companies, and find that on the long-term, the high sustainable firms outperform the companies that do not adopt these measures.

On the other hand, Fabozzi (2008) shows that a portfolio constituted by sin stocks (tobacco, alcohol, gambling, among others) "produced an annual return of 19%". Kacperczyk and Hong (2011) also find that sin stocks produce higher returns than comparable stocks, since these stocks have a negative view from investors, and therefore are less held by financial institutions, which causes their returns to be higher than conventional stocks. Belghitar (2014) similarly notices that shorting socially responsible investment (SRI) funds and using that money to fund an investment in conventional indexes creates better returns and reduces the variance of the portfolio.

Statman (2006), after comparing four socially responsible indexes and comparing their returns with S&P500's, he reaches the conclusion that socially responsible investments do not perform worse or better than conventional investments. It is therefore possible to infer that it is yet unknown and ambiguous if being socially responsible and conscious when making investment decisions pays off.

Cornel and Damodaran (2020) state that in the short-term being socially responsible will generate mainly expenses, but that in the long-term, since the firm adapts its cost structure, it will be able to invest more effectively when

compared with firms that are not socially responsible. For example, the firm may spend more on employees, but those same employees will most likely be more productive and motivated. The discount rate would also decrease since investors would choose responsible firms, driving the equity cost down, lenders would offer better loans' terms and governments could offer subsidies due to the firms' positive externalities. The firm would also decrease the probability of being involved on a scandal that could harm their business.

Since ESG is nonetheless recent, the market prices are still adjusting. The discount rate for high rated ESG stocks is expected to fall with time, and the discount rate for low rated ESG stocks is expected to increase. This leads to an increase in the high rated ESG stocks, which will outperform the lower rated ESG stocks, since their price will decrease. This, though, is just a onetime adjustment, ever since when the market is in equilibrium, the value of a high rated ESG stock will be higher and therefore its expected returns will be lower (Cornel and Damodaran, 2020).

1.4 What is green finance?

Green Finance is a very recent topic and, therefore, its definition is still ambiguous and subjective (Zhang et al., 2019). Taking this issue into consideration, it becomes harder to define other ideas and concepts that derive from green finance, as, for example, green bonds, which turns into a challenge for investors and other individuals interested in these matters (Lindenberg, 2014; Wang and Zhi, 2016).

However, green finance's relevance and importance have been growing exponentially in the last few years. As Zadek and Flynn (2013) mention, there is a lack of clarification of definitions, leading to the confusion and wrong interpretation between terms as "green finance" and "climate finance". Whilst they are correlated, it is important to grasp that they do not have the same

meaning. Bergedieck et al. (2017) also defends that green finance is different from climate finance, referring that it has the objective of decreasing greenhouse gases emissions and "reduce the vulnerability of human and ecological systems to negative climate change". According to Lindenberg (2014), climate finance is a piece of what constitutes green finance, with a focus on the decline of greenhouse gas emissions. In accordance with Höhne et al. (2012), "green finance is a broad term that can refer to financial investments flowing into sustainable development projects and initiatives, environmental products, and policies that encourage the development of a more sustainable economy."

Furthermore, it is important to differentiate green finance from the term ESG (Environmental, Social and Governance). ESG only focuses on the firm's performance in these matters (Bergedieck et al., 2017).

From Wang and Zhi (2016) perspective, green finance distinguishes itself from the traditional finance because it focuses on environmental issues. There are also various types of financial products with a special emphasis on environmental concerns, like biodiversity funds, weather derivatives, green investment funds and green bonds. According to Bergedieck et al. (2017), these instruments are capable of leveraging sustainable growth, with investments in renewable energies and technologies, improved and efficient water and waste usage, amongst others.

The United Nations Framework Convention on Climate Change (UNFCCC) defines green finance as "local, national or transnational financing-drawn from public, private and alternative sources of financing-that seeks to support mitigation and adaption actions that will address climate change". (Zhang et al., 2019). PriceWaterhouseCoopers (2013) also propose a definition for green finance, which is stated as "financial products and services, under the consideration of environmental factors throughout the lending decision making, ex-post monitoring and risk management processes, provided to promote

environmentally responsible investments and stimulate low-carbon technologies, projects, industries and businesses."

Lindenberg (2016) also defines green finance as including the policies which promote the creation and development of green projects that are environmentally friendly. Besides, it also comprises green investments in projects that counteract and diminish dangers to the natural environment (e.g., dams), promoting a better and more efficient use of energy. These green investments also include services as water management and environmental protection of the ecosystems. Finally, Lindenberg (2016) proposes that green finance also incorporates parts of the financial system that lead with green investments such as financial instruments that are used for these investments, as, for example, green bonds.

To finalize the suggested definitions, green finance is explained by Bergedieck et al. (2017) as the "financing of investments that provide environmental benefits in the broader context of environmentally sustainable development", including a decrease in pollution and greenhouse gases emissions, complemented by a better and more effective use of energy. According to Bergedieck et al. (2017), it also encompasses the management of climate and environmental risks which the financial system is exposed to.

Green finance faces several challenges as (i) the mismatch in long-term project maturities; (ii) information asymmetry between the beneficiaries and the investors; (iii) the difficulty in finding a definition for green finance; and (iv) obstacles in internalizing environmental externalities. Taking in consideration these issues, and with the objective of developing green finance, countries have embraced solutions to attenuate the problems, such as subsidies, regulations, and taxes. (G20 Green Finance Synthesis Report, 2016).

The Bergedieck et al. (2017) claims that financial institutions' investments are influenced negatively by global climate change and water, land, and air pollution. Therefore, these risks should be evaluated and managed.

Besides the typical climatic benefits that green finance can offer, it may also create development opportunities, with the acceleration of high-potential green industries and stimulation of innovative technologies. Additionally, it can generate opportunities for the financial industry. (G20 Green Finance Synthesis Report, 2016).

1.5 What are green bonds?

The academic literature focused on green bonds is scant and incomplete (Gianfrate and Perri, 2019). As mentioned previously, green bonds are an instrument of growing importance (Flammer, 2019) and might be very useful to lead the economy towards a more environmentally friendly world, since bonds are long-term sources of financing for companies, and companies need some time (for example, to build infrastructure) to create eco-friendly and green projects. As stated by Wang and Zhi (2016), "the bonds can raise a larger scale of funds whose terms are relatively long, so bonds are very suitable for those investment projects of large-scale infrastructure construction which demands huge capital and returns investment for a longer period." According to Flammer (2019), it is in industries that directly depend on natural resources (as for example the energy sector) that we can easily find companies issuing green bonds. These bonds are also more common in Europe, the United States of America and China. Green bonds, as mentioned previously, are a very recent topic, and therefore all the results obtained in studies come from a somewhat small number of observations. Obviously, as time passes, there will be more observations, which can lead to a better understanding of green bonds (Flammer, 2019). The average green bond deal size, according to the Climate Bonds Initiative (2019) was 144 million dollars in 2019, increasing from 108 million dollars in the previous year. This growth in deal size offers liquidity to the market, which can facilitate the introduction of

green bonds in an index and attract more investors, which would create more funds for green projects ran by these companies.

The European Investment Bank (EIB), in 2007, issued the world's first green bond, under the name of Climate Awareness Bond. The concern with longevity of our planet started to get more serious during the last decade, and presently is interpreted as a serious matter. Since then, green bonds have been quickly growing and expanding, and they can play a role in the transition for a climate aware and environmentally friendly economy. (Wang and Zhi, 2016).

Under these circumstances, the European Union (EU) on December 11, 2019, presented the European Green Deal, which proposes the transformation of the EU into an efficient society, promoting an environmentally friendly economic development. It is important to note that the European Green Deal states the following: "increased opportunities will be provided for investors and companies by making it easier for them to identify sustainable investments and ensuring that they are credible. This could be done via clear labels for retail investment products and by developing an EU green bond standard that facilitates sustainable investment in the most convenient way" (European Commission, 2019). This can also be interpreted as an indication that green bonds could play a major role in this transition into a sustainable Europe. For the G20 Green Finance Study Group (2016), green bonds are a component of green finance, and they have the goal of expanding and grow climate and environmentally friendly investments.

To study green bonds and to advance for the research question, it is necessary to define the concept of green bonds, understand their characteristics and development throughout the years, and distinguish them from standard corporate bonds. Green bonds, in the last years, have been growing and being utilized as instruments to finance investments. These bonds are fundamental for environmental projects, and therefore they are usually conditional on

environmentally related credit risks. The proceeds that come from the green bonds are allocated to green projects, and the "green bonds are serviced from the cash flows of the entire operations of the issuer – not just the green project". This has an effect on green bonds' pricing and how investors perceive them. When we compare green bonds with standard bonds, we must look at the premium. If the green bonds are at premium at the issuance date it means that investors value the green label and find it appealing (whilst still concerned with the bond's performance), which would motivate and entice issuers to keep issuing these types of bonds (Ehlers and Packer, 2017).

According to Anderson (2016), green bonds are an instrument which popularity has increased in the capital markets, and they are utilized to finance ventures that are climate and environmentally friendly. Green bonds are used to support climate friendly projects, since they have the ability to match those projects and its owners with investors that are looking to invest their money in projects that focus on sustainability, energy efficiency and green projects. Companies convincingly indicate their promise to support environmental projects when they issue green bonds, using the funds invested to finance these same projects (Flammer, 2019). For the International Capital Market Association (2018), a bond is considered green when its proceeds are utilized to fund a green project, which provides benefits for the environment. As said by Gianfrate and Peri (2019), "green bonds are conventional bonds and public debt issued by corporate, municipalities and other governmental entities with a distinguishing feature: proceeds are used for environment-friendly projects, primarily related to climate change mitigation and adaptation".

The International Capital Market Association (2018) also defends that green bonds are instruments used to fund green projects. For a bond to be categorized as a green bond, the proceeds must finance green projects (i.e., with

environmental and climate benefits), and they must be subject to third-party authentication, which includes costs (Flammer, 2019).

International Capital Market Association created in 2014 the Green Bond Principles (GBP), which are used to confirm whether a bond is green or not (Reboredo, 2018). Green bonds have conditions (the firm that is being funded must spend the money on green investments) that they have to fulfil in order to have that label, as opposed to traditional bonds (Yang and Zhi, 2016, Ehlers and Packer, 2017). These principles (Green Bond Principles) consist in guidelines that endorse a transparent process and full disclosure of the green bond, to clarify investors about their choices. Ehlers and Packer (2017) refer that the green certification would be helpful for investors, with the purpose of making it simpler for them, and also for the asset managers. According to Gianfrate and Perri (2019), when compared to regular bonds, green bonds have extra transactional costs since issuers have to worry with the certification of the green bonds, as well as supervising and reporting the use of the proceeds, to ensure they are used in green projects. Although, according to the authors, the savings in interest paid for the issuers surpasses the costs involved in getting the green certification. The Green Bond Principals allow the green bond investments to grow and expand, since the investors and asset managers can be sure that the investment is being used on green projects with climate and environmental advantages (Ehlers and Packer, 2017). According to the Climate Bonds Initiative (2019), 86% of the green bonds issued in 2019 were externally reviewed, which is highly valued by the market.

In Flammer's (2019) perspective, there may be more than one reason for a company for the issuance of green bonds. Firstly, one reason is that investors can interpret the green bonds' issuance as a sign that informs them that the firm is committed to the saving and preserving of the environment, as well as battling the climate problems. Secondly, this interpretation from the investors might be

naïve, which happens when the firms try to create an environmental conscious image, even though they do not really worry about these matters (this is dubbed by Flammer (2019) as greenwashing). Finally, the green bonds may provide less expensive financing, lowering the overall cost of capital.

According to the International Capital Market Association (2018), we can divide green bonds in four different categories. The first one is the standard green use of proceeds bond, which consists of "a standard recourse-to-the-issuer debt obligation aligned with the Green Bond Principles". Oppositely, green revenue bonds are "a non-recourse-to-the-issuer debt obligation aligned with the Green Bond Principles in which the credit exposure in the bond is to the pledged cash flows of the revenue streams, fees, taxes etc., and whose use of proceeds go to related or unrelated green project(s)". Green project bonds fund one or more green projects, and the investor is exposed to the risk of these projects, and with a possible recourse to the issuer (and aligned with the Green Bond Principle). Finally, green securitised bonds are collateralised by the cashflows of one or more green projects (covered bonds, asset-backed securities, mortgage-backed securities, amongst others), and they are also aligned with the Green Bond Principle. The standard bonds are very similar to "normal" bonds, although they have requirements to be considered green. The first condition is also the most obvious one, which is the need to invest the money from the bonds into a sustainable and green project. They can also be used to hedge environmental and climate risks (just like weather derivatives). It is also important to take into consideration the possibility of government intervention, such as lowering taxes for these bonds or a lower investment threshold. These interventions would be inviting for investors since these bonds would be treated favourably when compared to "normal" bonds.

This segmentation between the different type of green bonds brought some light over the topic and helped this market to rapidly grow from 3 billion dollars

in 2012 to 11 billion dollars in the following year. In 2016, the green bond market was valued in 81 billion dollars. In 2019, "global green bond and green loan issuance reached USD257.7bn" (Climate Bonds Initiative, 2019). It becomes clear that these bonds have a growing importance, although they still correspond to less than one percent of the total bond market (Reboredo, 2018). It is possible for retail investors to have access to these types of bonds, either by buying them directly or through a Green Bond Fund (Anderson, 2016). Ehlers and Packer (2017) mention that Green Bond indices (compiled by Barclays, Bank of America Merrill Lynch, Standard & Poor's, Barclays MSCI or Solactive) grant investors the possibility of diversifying risks by investing in a portfolio.

Analysing the literature that compares regular bonds with green bonds, although this is a recent topic, we can already find some dichotomies between them. Gianfrate and Peri (2019) analyse 121 European green bonds issued between 2013 and 2017 and concluded that green bonds are more suitable than regular bonds, especially for corporate issuers, including in the secondary market. They argue that green bonds can be a key to transform the economy into a more environmental and climate friendly one, without harming financially the issuers. Still according to the same authors, as mentioned above, issuers benefit when the bond is considered green, paying on average less 18 basis point annually in interests to investors. This means that even though there may be costs associated with the attainment of a green bond certificate, these bonds still produce benefits that can pay off the costs, benefiting not only the society and planet as a whole, but also the corporation.

Menz (2010) studies European corporate bonds and finds out that, even though only slightly significant, the "risk premium for socially responsible firms was, ceteris paribus, higher than for non-socially responsible companies". Conversely, Zerbib (2019) makes an "analysis on 110 green bonds on the secondary market between July 2013 and December 2017" and finds a negative

premium of 2 basis points for green bonds, which indicates "that the price impact of pro-environmental motives on bond prices is still limited". Although, according to the same author, the negative 2 basis point should not be a disincentive to invest in green bonds, and according to their study, the premium is mostly influenced by the type of issuer and its rating. Gianfrate and Peri (2019) mentioned that the evidence about a green bond advantage in the primary and secondary market is ambiguous, which is why there is a necessity to investigate more to have a clearer perception of this subject.

As per Flammer (2019), when there is an announcement of a green bond issuance, the stock market responds favourably (the cumulative abnormal return is 0,49% according to the findings). These cumulative abnormal returns should be even higher shall the green bonds be certified by a third party and issued by a first-time issuer.

In accordance with Krueger (2015) investors respond "strongly negatively to negative news" on corporate social responsibility (which includes environmental concerns), and only "weakly negatively to positive events". Flammer (2013), stated that the stock market responds positively to an environmental and climate friendly conduct from firms. For Flammer (2019), this happens because green bonds issuances provide an indication that firms are committed to climate and environmental causes.

Larcker and Watts (2020) match green bonds to quasi-identical standard bonds from the same issuer in the municipal bonds market. They noticed that there is not a pricing difference between green and regular bonds, which stands consistent with Flammer (2019) findings, that states that there is no significant difference between the yields of a standard bond and a green bond. Larcker and Watts (2020) justify finding that the green bond premium is zero by stating that green projects are competitive and therefore provide enough income to create competitive returns. Flammer (2019) states that it should be expected that

investors would be willing to pay a premium and exchange financial returns for positive externalities for society and the environment. Although, based on the studies mentioned above, this is not what occurs. Chiang (2017) claims that the investors do not invest in green bonds if their returns are not considered competitive. After conducting a survey by the State Treasure Office of California, Chiang found that firms were not willing to take on a "lower yield for a green bond". Larcker and Watts (2020) and Flammer (2019) also organized interviews with investors that ended up confirming the findings stated above (i.e., they will not invest in a bond that has lower returns, even if it is green).

Karpf and Mandel (2017) studied and compared green bonds with standard bonds and concluded that green bonds give the impression of being penalized by the market (they found that there is a positive yield differential for green bonds, and that these bonds trade at a discount of 8 basis points). Ehlers and Packer (2017) defend that green bonds "have been priced at issuance at a premium on average relative to conventional bonds, but their performance in the secondary market over time has been similar".

Gianfrate and Perri (2019) mention that green bonds end up being more convenient than regular bonds. Ehlers and Packer (2017) examine a cross-section of a sample of 21 green bonds issued between 2014 and 2017, comparing their spread (at issuance) with similar bonds (e.g., standard bonds from the same issuer, and therefore eliminating other risk factors as the credit risk, and with the nearest issue date and maturity) to study the impact of a green label on bond's prices. The results suggest that "green bond issuers on average have borrowed at lower spreads than they have through conventional bonds", which also confirm that investors may have a preference for green bonds. This is also consistent with the Climate Bonds Initiative which claims that investors' interest in green bonds can be observed through the number of oversubscriptions of

green bonds compared with non-green issuances (Climate Bonds Initiative, 2016).

As mentioned by Flammer (2019), the evidence is mixed. Zerbib (2019) finds that a green bond has a negative premium of 2 basis points, and Karpf and Mandel (2017) show that a green bond has a discount of 8 basis points. Larcker and Watts (2020) claim that Karpf and Mandel (2017) compare between taxable and non-taxable bonds, producing a bias in the final results into the finding of a discount for green bonds.

When comparing regular (conventional) bonds and green bonds from the same issuer, their risk characteristics are very similar. As stated by Ehlers and Packer (2017), "while the proceeds from the issuance of a green bond are earmarked for environmentally friendly projects, green bonds are serviced from the cash flows of the entire operations of the issuer – not just the green project.". Flammer (2019) shows that when firms issue green bonds, they tend to "improve their environmental performance (i.e., higher environmental ratings and lower CO2 emissions) and experience an increase in ownership by long-term and green investors."

1.6 What factors determine corporate bond spreads?

To gather a better understanding on the determinants of green bonds' spread, extant literature on corporate bonds' spread will be discussed next. Corporate bonds are fixed income instruments issued by a private or public entity, where the borrower (the issuer of the bond) pays the investor (the bondholder) a predetermined coupon through a specified period of time, and the nominal amount when it is due. Firstly, to comprehend clearer what is going to be discussed below, it is necessary to define spread. According to Pinto and Marques (2019), the spread "corresponds to the price for the risk associated with the bond at closing, defined as the margin yielded by the security at issue above a corresponding currency treasury benchmark with a comparable maturity".

Many authors have already studied what influences the spread of a bond, providing a number of suggestions that sometimes are opposed to each other.

Longstaff et al. (2005) point out that the main variable that explains corporate bonds spreads is the default risk. They state that "the default component represents 51% of the spread for AAA/AA-rated bonds, 56% for A-rated bonds, 71% for BBB-rated bonds, and 83% for BB-rated bonds". Collin-Dufresne (2001) presents the same argument.

Elton et al. (2001) claim that corporate bond prices have a risk premium that goes beyond the expected default loss, but that those risks have been neglected by past studies. In accordance with the authors, expected default is responsible for a smaller fraction (no more than 25 percent) of the corporate bonds' premium than what would be typically expected. Accordingly, the spreads on corporate bonds in relation to government bonds vary depending on the rating class, and is always positive, mainly due to three components. Firstly, the already mentioned expected default loss, which represents companies' default risk, which must reward the risk investors are facing. Secondly, the tax premium since the interest payments on corporate bonds are taxed at a state level and government bonds are not, which justifies corporate bonds offering a higher pre-tax yield. Finally, the risk premium: because corporate bonds are riskier than government bonds, investors should demand a risk premium. Still according to the authors, a big portion of these risks are systematic, and therefore non diversifiable. Elton et al. (2001) show that the lower the rating, the higher the risk premium. This happens not only due to the obvious higher credit risk, but also because when the debt has a lower rating, the coupons are higher, and therefore the tax payments will be higher. Using Fama-French factors, the authors claimed that 85 percent of "the spread that is not accounted for by taxes and expected default can be explained as a reward for bearing systematic risk."

In accordance with Cornaggia et al. (2017), credit ratings "serve as a point of reference and common language of credit that is used by financial market professionals worldwide to compare risk across jurisdictions, industries and asset classes, thereby facilitating the efficient flow of capital worldwide".

Gabbi and Sironi (2005) studied Eurobonds (mainly their spread) between 1991 and 2001 and find that the bonds' ratings are the main factor that influences the bonds' spread. Besides that, during the period of the study, the authors observed that investors were increasingly trusting more and more the rating agencies assessments about the credit risk of each firm.

They also argue that taxes play an important role explaining the bonds' spread, but that liquidity does not, neither on the primary market nor on the secondary market. Finally, they show that the subordination of a bond is an important variable that explains the spread. When a bond is subordinated, it will pay a higher spread than a senior one.

Using data from 1995 to 1999, Campbell and Taksler (2003) show that equity volatility is one of the main reasons (just like credit ratings) for the variation in corporate bonds spreads. The authors show that equity volatility and credit ratings are each responsible for one third of the changes in yield spreads. "Using Moody's and Standard and Poor's corporate bonds yield indexes between 1963 and 1999", the authors present evidence that the spreads widen when the idiosyncratic risk in the market (i.e., non diversifiable risk) increases.

Helwege and Turner (1999) point out that "among firms with the same credit rating the safer ones tend to issue longer dated bond", which "causes the average spread to decline with maturity, even though for an individual firm the spread typically might increase with maturity". When a bond is issued and it is considered of good quality, its probability of default at issuance is very low, and the room for an increase in the probability of repayment is minimal since it is already perceived as a good bond. Although, the room for downward moves is

big, which means there is always the possibility that with time, the bond will lose its quality. Therefore, the credit yield curve for good and secure firms has a positive slope. On the contrary, speculative bonds are very risky when they are issued, having a big spread, but with time, the probability of getting better is high, since it has room for improvement compared to little space for getting worse. This makes the slope of the credit yield spread for high yield bonds negative.

Besides the default risk, Collin-Dufresne et al. (2001) show that the expected future leverage of a company will have an influence in the bonds' spread. Flannery et al. (2012) point out that spreads are influenced by the issuer's risk and by the expectations that investors have about these risks in the future. They came to the conclusion that the expectations investors create about the future firm's leverage and its changes will influence the spread of the bonds.

According to Oikonomou et al. (2011), another variable may influence the spread of a bond is the corporate social performance of a company. According to the authors, when firms have a good corporate social performance, their ratings are higher, and their spreads are lower.

Dorfleitner et al. (2019) also focus on corporate social performance as a variable that can explain the credit rating and therefore the bonds' spreads, since a good corporate social performance will decrease the firm's risk. According to the authors, this also depends on the social and cultural aspects of the country or region where the firm is located. They compared Europe and North America and concluded that in North America there is a positive relationship between the corporate social performance and credit ratings, whilst in Europe only the social component has influence (and the environmental performance variable has not).

Collin-Dufresn et al. (2001), Campbell and Taksler (2003) and Chen et al. (2011) argue that when bonds are more liquid, their yield spread tightens.

Chen et al. (2011) analyse over 4000 corporate bonds, including high yield and investment grade bonds, and show that liquidity influences significantly the spread of corporate bonds. When bonds are less liquid, their yield spreads tend to be higher, and vice-versa (i.e., bonds that are more liquid will have a smaller yield spread). Bonds that have less liquidity logically trade with less frequency, and for the same cashflow will realize lower prices, and have a higher spread. Therefore, the authors are also advocate that bonds' spread cannot be fully explained by only default related variables. For Bao et al. (2011), the credit risk component of a corporate bond spread is overshadowed by changes in market illiquidity.

Considering green bonds, Wulandari et al. (2018) state that this bond typology is more propense to the illiquidity risk because of the additional costs with the green labelling of the bond. They state that the issuance of green bonds may be less appealing for issuers when comparing to normal bonds because there is not a consensus in the definition of green bonds, which leads companies to have additional transaction costs by hiring external reviewers to confirm that the bond is indeed green. This causes the supply of green bonds to be insufficient, which is aggravated by the fact that there are not enough tax incentives for green investments, as mentioned by Zerbib (2019). Besides, if the supply of green bonds is not enough, the market volume will be low and therefore there will be less liquidity. According to Wulandari et al. (2018), the demand for green bonds is increasing because investors feel the urge to diversify their portfolios against climate and environmental risk, and green bonds are seen as a tool to do that. Zerbib (2019), as mentioned previously, refers that green bonds have a negative premium compared to conventional bonds, which can be seen as a proof that the demand for green bonds is way higher than their supply. Contrary to these findings, Karpf and Mandel (2017) find a positive premium for green bonds, which could be justified by the illiquidity in this market, as suggested by

Wulandari et al. (2018). They show that green bonds are actually more liquid than conventional bonds, at least during the 2014-2016 period.

Several authors also show that, despite credit ratings being the most important pricing determinant, there are also other contractual, macro and firm-level variables that influence bond spreads. Pinto and Marques (2019) analysed 24 525 European bonds between 2000 and 2016 and find that ratings are the most important factor when pricing corporate bonds (in line with Colin-Dufresne et al., 2001; Longstaff et al., 2005; Elton et al., 2001), but investors also value other variables as the market volatility (Campbell and Taksler, 2003), maturity (bonds that have longer maturities are deemed as riskier than bonds with shorter maturities, and therefore investors will ask for a higher premium for longer maturities), number of banks and their reputation (having more banks and with good reputation helps diminishing the information asymmetries, which decreases the spreads), deal size (as mentioned by Gabbi and Sironi (2005), the issue size of corporate bonds has a positive relationship with liquidity), legal aspects and country risk (investors demand a premium for firms that are bases on countries with low creditor protection, as mentioned by Boubakri and Ghouma (2010)). Besides these variables, Pinto and Marques (2019) also find that the higher the number of tranches, the lower the spread on a corporate bond issue (only for financial firms). The financial crisis also affects spreads, which increased for corporate bonds issues, and the "the slope of the Euro swap curve, EUSA5y-Libor3M, are significantly negatively related for corporate bonds, meaning a steeper Euro swap curve is associated with lower credit spreads".

2. Research Questions and Hypotheses

The financial system is deeply related to climate changes, not only because it is affected by such changes, but also because the financial system can work as a vehicle to help fixing the environmental threat upon the world.

Green finance, as formerly mentioned, is still a very recent topic, and consequently there is still a lack of studies due to the small samples' sizes, along with a difficulty to define the term itself. It has also become evident that green bonds, being such a recent instrument, are far from being fully understood. We intend to fill this gap in the literature by (i) comparing spreads between green bonds and corporate bonds; and (ii) study what determines firms choosing green bonds over corporate bonds.

The best way to study green bonds is to contrast them with conventional corporate bonds and compare them so we can find the main differences in their pricing. As it has been mentioned, bonds spreads depend on a multitude of factors, and their relative importance comparing to other factors is yet not fully known, as some authors findings differ. Nevertheless, it is commonly accepted that the default risk is a major variable that influences the bond spread, alongside with the bond maturity, market volatility, the number of banks and their quality, deal size, liquidity, legal risk, currency risk, bank reputation, country risk and number of tranches.

So, this raises the question about the green bonds spread. The literature has not yet reached a clear conclusion about green bonds spreads, as there are different studies that reach different inferences. Menz (2010) finds that the socially responsible bonds have a higher premium than non-socially responsible bonds, whilst Zerbib (2019) shows evidence that there is a negative bond premium of 2 basis points. Flammer (2019) and Larcker and Watts (2020) find

that there is not a pricing difference between green bonds and corporate bonds. Regarding this uncertainty, this raises the question if green bonds have a lower spread than similar conventional bonds, which would reduce the financing cost for the issuers. We thus point out:

Hypothesis 1 (H1): Green bonds have lower spreads than similarly rated corporate bonds.

Longstaff et al. (2005) and Collin-Dufresne (2001) point out that the default risk is the main variable that explains corporate bonds spreads. Gabbi and Sironi (2005) add the subordination level of a bond as a component that influences the spread, Campbell and Taksler (2003) point out the volatility, and Collin-Dufresne et al. (2001) the expected future leverage. Oikonomou et al. (2011) and Dorfleitner et al. (2019) find that corporate social performance influences the bond's spread. Acknowledging this raises the question whether green bonds and corporate bonds are similarly priced or not. This raises a second hypothesis:

Hypothesis 2 (H2): Green bonds and standard corporate bonds are influenced differently by common pricing factors.

Oikonomou et al. (2011) find that when firms have a good corporate social performance, their ratings are higher, and their spreads are lower. Considering this, we will study what are the determinants of a firms' choice between green bonds and standard corporate bonds. We thus argue that:

Hypothesis 3 (H3): Firms with higher creditworthiness prefer green bonds over traditional corporate bonds.

3. Data, Methodology and Descriptive Statistics

3.1 Sample Selection

Data on bond offerings was extracted from DCM Analytics, which provides a large diversity of data and information regarding debt instruments, more specifically bond securities. Information on macroeconomic variables as well as firms' characteristics was extracted from Datastream.

We compare green bonds with corporate bonds' spreads for the 2013-2020 period, since the first record of a green bond issuance in DCM Analytics database was 2013. We only include investment grade corporate bonds and high yield corporate bonds. We intend to understand and comprehend how are green bonds priced when compared with corporate bonds, and if their spread is higher or lower than the counterpart on issuance. Given this, we also removed bonds which general industry was either "Insurance" or "Finance". We use DCM Analytics classification to identify which investment grade and high yield corporate bonds were in fact green bonds.

After filtering the data to remove outliers, missing information, and to achieve the cleanest possible sample, we ended up with 14,592 tranches, from which 607 are green bonds and 13,985 are corporate bonds. The data is in US Dollars and the spread in basis points.

The first panel (Panel A) presents the geographical distribution of the green bonds in the world. We can observe that whilst North America (United States of America and Canada) was responsible for almost two thirds of corporate bonds deal value in our sample between 2013 and 2020, when it comes to green bonds its percentage in total value is 32%. On the other hand, Europe is responsible for over half of the green bonds value in our sample, and "only" for a little bit over

a quarter of corporate bonds. It is important to mention that the same logic applies to Asian countries, which represent 12% of green bonds value and no more than 5.1% of corporate bonds total value.

Panel B encompasses the industrial distribution of green bonds and corporate bonds in our sample. For green bonds, the sector Utilities leads in number of tranches and in deal value (almost half of the total value), followed by Real Estate, Machinery and Equipment and then Transportation. For corporate bonds, the distribution has a less concentrated distribution pattern. Services have the highest percentage in deal value (12.98%), immediately followed by Utilities and Machinery and Equipment, both with approximately 12.1%. Nevertheless, other sectors as Communications, Construction/Heavy Engineering, Oil and Gas and Real Estate are all around the 10% mark. This shows that whilst corporate bonds have an even distribution on deal value by industry, the same does not apply to green bonds, where some sectors stick out.

On the third table (Panel C) it is presented the top issuers of each type of bond. Apple leads both ranks, as it is responsible for the largest percentage of deal value (representing over 5% in green bonds). The top ten green bond issuers are responsible for 27.5% of the total value on these bonds, whilst the corporate bonds top ten issuers are only responsible for 6.9% of the total value of this type of bonds.

Panel D includes the top ten switchers between the 2013 and 2020 period. We consider a switcher a company that has issued both green bonds and corporate bonds during the sampling period. Once again, Apple leads the rank in terms of Deal Value, followed by Verizon Communications Inc and PepsiCo Inc.

Finally, Panel E discriminates the bonds by year of issuance. It is possible to verify that the number of green bonds issued each year increased consistently from one single green bond in 2013, to 213 bonds in 2020, as well as their deal value (with exception to 2018, where it slightly decreased when compared to the

previous year). Corporate bonds also increased their deal value between 2013 and 2020 in our sample, although not as consistently as their counterparts.

Table 1 - Geographic and industrial distribution, top issuers and switchers, and bonds by year, from DCM Analytics.

Panel A: Geographic distribution

Geographic location of originator/issuer	Green Bonds			Corporate Bonds		
	Number of tranches	Total value [$ Million]	Percent of total value	Number of tranches	Total value [$ Million]	Percent of total value
North America	159	92999.71	32.29%	8794	5022165.30	64.91%
Canada	17	3925.06	1.36%	1053	367157.68	4.75%
United States	142	89074.65	30.92%	7741	4655007.62	60.17%
Europe	318	146405.66	50.83%	3988	2038059.17	26.34%
France	40	32283.38	11.21%	583	397108.74	5.13%
Germany	26	19539.14	6.78%	551	403330.33	5.21%
Italy	18	13048.55	4.53%	170	128097.96	1.66%
United Kingdom	26	13274.67	4.61%	844	414869.46	5.36%
Portugal	6	4992.23	1.73%	28	11060.53	0.14%
Spain	24	16754.36	5.82%	114	76701.45	0.99%
Netherlands	36	21744.64	7.55%	226	141999.45	1.84%
Sweden	78	7676.33	2.67%	437	71110.17	0.92%
Switzerland	1	539.75	0.19%	210	133784.12	1.73%
Luxembourg	1	208.82	0.07%	34	19525.58	0.25%
Belgium	2	1310.87	0.46%	78	62229.17	0.80%
Others	60	15032.93	5.22%	713	178242.21	2.30%
Latin America	18	10882.53	3.78%	346	148842.13	1.92%
Asia	130	34396.28	11.94%	727	392302.11	5.07%
Australia and Pacific	9	2063.47	0.72%	276	98014.01	1.27%
Africa	3	92.06	0.03%	43	11852.00	0.15%
Middle East	2	1199.25	0.42%	37	25662.78	0.33%
Total	**639**	**288,039**	**100%**	**14,211**	**7,736,897**	**100%**

Panel B: Industrial distribution

Industrial category of originator/issuer	Green Bonds			Corporate Bonds		
	Number of tranches	Total value [$ Million]	Percent of total value	Number of tranches	Total value [$ Million]	Percent of total value
Commercial and Industrial						
Agriculture, Forestry and Fishing	12	4,446.91	1.54%	156	56,816.39	0.73%
Communications	8	6,526.06	2.27%	917	739,106.17	9.55%
Construction/Heavy Engineering	43	13,056.17	4.53%	1,312	761,782.94	9.85%
Manufacturing						
Chemicals, Plastic and Rubber	9	4,281.59	1.49%	426	221,870.38	2.87%
Food and Beverages	7	3,398.61	1.18%	703	443,885.21	5.74%
Machinery and Equipment	34	31,088.66	10.79%	1,203	935,039.40	12.09%
Steel, Aluminum and other Metals	7	2,803.77	0.97%	210	99,675.11	1.29%
Other	15	7,175.70	2.49%	553	308,103.37	3.98%
Mining and Natural Resources	4	442.68	0.15%	206	124,517.09	1.61%
Oil and Gas	2	589.12	0.21%	1,268	850,325.51	10.99%
Real Estate	173	49,796.52	17.29%	1,819	663,318.18	8.57%
Retail Trade	5	1,551.63	0.54%	395	225,693.41	2.92%
Services	15	5,790.57	2.01%	1,858	1,004,173.74	12.98%
Wholesale Trade						
Utilities	240	130,142.01	45.18%	2,324	934,962.94	12.08%
Financial Institutions						
Transportation	65	26,948.98	9.36%	861	367,627.65	4.75%
Public Administration/Government						
Other						
Total	**639**	**288,039**	**100%**	**14,211**	**7,736,897**	**1**

Panel C: Top originators/issuers					
	Green Bonds			Corporate Bonds	
Company	By value of deals	By number of deals	Company	By value of deals	By number of deals
Apple Inc	5.26%	0.61%	Apple Inc	0.96%	0.11%
ENGIE SA	3.48%	1.02%	Petroleos Mexicanos - PEMEX	0.80%	0.29%
Alphabet Inc	3.47%	0.20%	Verizon Communications Inc	0.77%	0.15%
Electricite de France SA - EDF	3.27%	0.61%	Oracle Corp	0.74%	0.05%
TenneT Holding BV	2.91%	1.43%	Daimler Finance North America LLC	0.65%	0.20%
E.ON SE	2.48%	0.82%	Coca-Cola Co	0.63%	0.14%
Mexico City Airport Trust	2.08%	0.41%	International Business Machines Corp	0.61%	0.18%
ENEL Finance International NV	1.60%	0.82%	PepsiCo Inc	0.60%	0.21%
Iberdrola Finanzas SAU	1.54%	1.02%	Microsoft Corp	0.60%	0.06%
MidAmerican Energy Co	1.36%	0.82%	Comcast Corp	0.58%	0.14%

Panel D: Top 10 switchers in the 2013-2020 period			
Issuer/issuer parent	Number of switches | GB *versus* CB *	Number of deals	Deal amount [$ Million]
Apple Inc	3	14	89,549
Verizon Communications Inc	1	16	60,477
PepsiCo Inc	1	22	47,881
Pfizer Inc	1	9	38,888
Daimler AG	1	23	31,547
Volkswagen International Finance NV	1	10	28,865
Telefonica Emisiones SAU	1	17	24,674
Electricite de France SA - EDF	3	9	22,442
ENEL Finance International NV	4	9	20,883
Vodafone Group plc	1	8	19,726

Panel E: Bonds by year						
Year	Green Bonds			Corporate Bonds		
	Number of tranches	Total value [$ Million]	Percent of total value	Number of tranches	Total value [$ Million]	Percent of total value
2013	1	1,881.46	0.65%	1,716	877,441.55	11.3%
2014	21	10,186.36	3.54%	1,704	839,351.03	10.8%
2015	22	11,437.11	3.97%	1,439	776,355.38	10.0%
2016	48	30,879.80	10.72%	1,445	779,110.76	10.1%
2017	64	33,203.63	11.53%	2,000	1,040,356.83	13.4%
2018	84	27,624.99	9.59%	1,498	733,784.94	9.5%
2019	186	67,824.79	23.55%	1,825	994,818.09	12.9%
2020	213	105,000.84	36.45%	2,584	1,695,678.90	21.9%
Total	**639**	**288,039**	**100%**	**14,211**	**7,736,897**	**100%**

3.2 Methodology and Description of Variables

As we intend to determine the main drivers of green bonds spreads, we used the model presented on the equation (1). The dependent variable is the spread (in basis points). We make use of an OLS regression and adjust it for heteroskedasticity. Taking into consideration the varying risk premia and cross-country differences, we estimate standard errors clustered by year and country.

$$\begin{aligned} Spread_{i,t} = {} & \alpha_0 + \beta_1 Green\ Bond_{i,t} + \beta_2 Rated_{i,t} \\ & + \sum_{n=2}^{21} \beta_n\, Rating\ dummy_{n,i,t} + \beta_{23}\, rating\ discordance_{i,t} \\ & + \gamma\, Contractual\ characteristics_{i,t} + \varphi\, Macroeconomic\ factors_t \\ & + \varepsilon_{i,t} \end{aligned} \tag{1}$$

Appendix B has a complete description of each independent variable to help their interpretation, as well as the expected impact of this explanatory variables on the depend variable (spread).

3.2.1 Spread

The spread, as previously mentioned, is the "price for the risk associated with the bond at closing, defined as the margin yielded by the security at issue above a corresponding currency treasury benchmark with a comparable maturity" (Marques and Pinto, 2020). Given that there is a possibility that there can be fixed-rate and floating-rate bonds in the same deal, we include a dummy for a fixed rate to control this effect.

3.2.2 Credit Rating

The credit ratings are one key variable that affects the spread of a corporate bond (e.g., Collin-Dufresne et al., 2001; Elton et al., 2001; Hull et al., 2004; Titman et al., 2004; Longstaff et al., 2005, Pinto et al., 2019). All the tranches in this analysis have at least one credit rating assigned by Moody's, S&P or Fitch, which is later converted into a numerical scale, which works in this manner: AAA=Aaa=1, AA+=Aa1=2, and so on until D=21 (Gabbi and Sironi, 2005; Cornaggia et al., 2017).

If a tranche has two or three credit ratings, we use the average of this ratings. As presented on the explanation above, the higher the number of the rating, the worst the actual rating is, which means that the higher this number is, the higher will also be the spread. As some bonds in this sample may not be rated, we used a dummy variable that would take the value of 1 in case S&P, Moody's or Fitch assigned a rating, and 0 otherwise. We also use a dummy variable that takes the value of 1 when at least two rating agencies assign different ratings to the same tranche. This allows us to examine if a different rating assigned from the rating

agencies has any statistical significance on spreads (it is expected that the rating discordance increases the credit risk).

3.3.3 Contractual Characteristics

As mentioned before, there are other variables beyond the credit rating that can explain the pricing of corporate bonds, as the deal size, maturity, the number of banks and number of tranches, the currency risk, subordination level, whether it is callable or not, whether the company switches between green bonds and corporate bonds, and if it switches in the same year.

According to Gabbi and Sironi (2005), Chen et al. (2007) and Sorge and Gadanecz (2008), the deal size of a corporate bond indicates a higher liquidity and lower uncertainty.

Regarding the maturity of a bond, the longer it is, the riskier it is when compared with a bond with a shorter maturity. We also use a subordinated dummy variable, that takes the value of 1 when the tranche is subordinated, and 0 otherwise (this helps to control for differences in risk between tranches in the same deal). It is expected that these bonds have a higher spread than senior bonds.

We also have a dummy variable to control the currency risk (this variable takes the value of 1 if there is currency risk, and 0 otherwise), which we expect to increase the spread compared to tranches that do not have this risk associated (Vink and Thibeault, 2008). Another dummy variable included takes the value of 1 if the bond is backed by fixed assets, and 0 if the bond is backed by current assets.

We control the number of banks involved in a transaction, and it is expected that there is an inverse relationship between the spread and the number of banks (Pinto et al., 2019). Still regarding banks, we created a variable for bank

reputation, given that banks with a higher reputation may diminish the information asymmetry and therefore it is expected that these banks will be responsible for lowering the spread (Kara et al., 2016).

We also control the number of tranches in a transaction, and we expect it has the same effect as the number of banks in the spread (negative relation between the two variables). We include a dummy variable regarding switchers, that takes the value of 1 if the issuer has issued both corporate bonds and green bonds on the same year.

3.3.4 Macroeconomic Factors

We use the EUSA5y-Libor3M (computed by the difference between the five-year Euro swap rate and the 3-month Libor rate) to analyse the influence of macroeconomic factors on the spreads. We also take into account the market volatility, measured by the Chicago Board Options Exchange Volatility Index.

It is expected that an increase in the yield curve's slope has a negative impact on the spread, whilst volatility is expected to have a positive relation with the slope of the yield curve, so when volatility increases, the spread also increases (Campbell and Taksler, 2003, Titman et al., 2004; Cuchra, 2005; Krishnan et al., 2005; Cremers et al., 2008).

According to Boubakri and Ghouma (2010), investors demand higher yields on corporate bonds to firms that are in countries where there is a lack of creditors' rights protection. Therefore, we created a variable that controls the impact of creditors rights on the spread. Finally, we also created a variable that controls the country risk, taking the rating of a company and turning it into a numerical scale, as previously mentioned.

We additionally use year and industry dummy variables to control for unobserved macroeconomic trends and possible industry-specific variation (Pinto el al., 2019).

3.3.5 Firm specific characteristics

To control for firm specific characteristics, and has done by other studies (Chen et al., 2007; Landsman et al., 2008; Flannery et al., 2012; Riachi and Schwienbacher, 2013, 2015; Lemmon et al., 2014, Pinto et al. 2019), we have proxies for issuing firm's size, using the log total assets (we expect this to have a negative relationship with the spread), asset tangibility, using the fixed assets to total assets (we also expect a negative relation with the spread), financial leverage by using the total debt to total assets (we expect a positive relation with the spread), the profitability measured by the return on assets (expected negative relation), and the growth opportunities using market to book value (also expected a negative relationship with the spread).

Given that DCM Analytics does not provide this information, we use Datastream to get this data. In addition, considering that DCM Analytics does not have an identification symbol that we could automatically match with Datastream, we hand-matched the information in the two databases by using the issuer's names.

4. Univariate Analysis

We start this analysis by comparing the pricing characteristics of green bonds and corporate bonds (Appendix A details the statistics of these variables). Table 2 includes Wilcoxon z-tests for the continuous variables and Fisher's exact tests for the discrete variables.

Regarding the pricing of corporate bonds and green bonds, Table 2 shows that the spread (in basis points - bps) of green bonds is, on average, lower (171.3 bps) than corporate bond spreads (219.4 bps), with a 1% level significance. The deal size is also lower for green bonds, with an average amount of $ 958 million versus $ 1,277.9 million for corporate bonds.

The number of banks, on average, is also significantly lower for green bonds than for corporate bonds (6.7 banks on average for green bonds and 8.4 banks for corporate bonds). The average number of tranches on green bonds is significantly higher (on average, 9.9 tranches) than corporate bonds' 2.1. The same applies for maturity, with corporate bonds maturing, on average, in 11 years, while green bonds mature in 9.9 years, which is surprising given that green bonds are expected to have a longer maturity since the projects they fund are usually long-term projects.

The ratings are significantly better for green bonds at the 1% level, with an average rating of 4.8 (approximately A+) vis-à-vis 7.1 (approximately A-) for corporate bonds. The bank reputation is significantly higher for green bonds, with a value of 16.1 on a scale of 1 to 25, compared to corporate bonds with an average of 10.2.

The average country risk is significantly higher at the 1% level for green bonds (2.9) than for corporate bonds (1.8). The creditors rights are higher on green bonds, with a statistically significant average value of 1.8 on a scale between 1 and 4, compared to corporate bonds (1.4).

Moving on to firms' specific characteristics, the total assets are higher for firms that issue green bonds l, with an average value of $ 1,992.4 million. The corporate bonds issuers total assets average is $ 406.9 million, way lower than their counterpart. This may be used as one justification to why we see the spread of green bonds being lower than corporate bonds. The market to book is, on average, higher for green bond issuers (4.1%) versus corporate bond issuers (-1.1%). The return on assets is slightly higher for corporate bond issuers, with an average value of 6%, compared to the 5.2% of green bond issuers. The total debt to total assets, which has a positive impact on the spread, is higher for corporate bond issuers (39.6%) than for green bond issuers (37.9%). Finally, the fixed assets to total assets ratio is higher for green bond issuers, with an average value of 6.2%, compared to the corporate bond issuers with an average of 4.5%.

The majority of corporate bonds and green bonds are rated, 87.8% and 73.5%, respectively. 21.4% of the green bonds are exposed to currency risk, which is lower than the corporate bonds exposed to currency risk, with a percentage of 25.4%. The tranche rating discordance, which is expected to affect the spread significantly, is significantly lower for green bonds (23.4%) than for corporate bonds (40.8%). More corporate bonds are callable (75.4%) than green bonds (60.8%), as well as collateralized (13.3% and 9.1%, respectively). Finally, only 1.3% of the green bonds are subordinated, while 4.7% of the corporate bonds are subordinated.

Table 2 - Univariate Analysis

Variable of interest	Green Bonds		Corporate bonds		Variable of interest	Green Bonds		Corporate bonds	
Univariate analysis - continuous variables									
Spread (bps)					**Maturity (years)**				
Number	607		13,985		Number	607		13,985	
Mean	171.3	***	219.4	***	Mean	9.9	***	11.0	***
Median	128.0		158.0		Median	7.0		8.0	
Deal Value ($M)					**Rating [1-22 weak]**				
Number	607		13,985		Number	607		13,985	
Mean	958.0	***	1,277.9	***	Mean	4.8	***	7.1	***
Median	518.5		646.8		Median	6.0		8.0	
Number of Banks					**Bank Reputation**				
Number	607		13,985		Number	607		13,985	
Mean	6.7	***	8.4	***	Mean	16.1	***	10.2	***
Median	5.0		7.0		Median	18.0		4.0	
Country Risk					**Creditor rights**				
Number	607		13,985		Number	607		13,985	
Mean	2.9	***	1.8	***	Mean	1.8	***	1.4	***
Median	1.0		1.0		Median	2.0		1.0	
Number of tranches					**Total Assets ($M)**				
Number	607		13,985		Number	177		4,610	
Mean	9.9	***	2.1	***	Mean	1,992.4	***	406.9	***
Median	7.0		1.0		Median	69.9		36.2	
Market to Book					**Return on Assets**				
Number	177		4,610		Number	177		4,610	
Mean	4.1%	*	-1.1%	*	Mean	5.2%	***	6.0%	***
Median	1.8%		2.4%		Median	4.5%		5.4%	
Total debt to Total assets					**Fixed assets to Total assets**				
Number	177		4,610		Number	177		4,610	
Mean	37.9%		39.6%		Mean	6.2%	***	4.5%	***
Median	35.8%		38.6%		Median	4.4%		3.4%	
Univariate analysis - dummy variables									
Rated Tranches					**Currency risk**				
Nr. of tranches	607		13,985		Nr. of tranches	607		13,985	
Nr. of tranches with d=1	446	***	12,278	***	Nr. of tranches with d=1	130	**	3,548	**
% of total	73.5%		87.8%		% of total	21.4%		25.4%	
Tranche Rating Discordance					**Collateralized**				
Nr. of tranches	607		13,985		Nr. of tranches	607		13,985	
Nr. of tranches with d=1	142	***	5,704	***	Nr. of tranches with d=1	55	***	1,864	***
% of total	23.4%		40.8%		% of total	9.1%		13.3%	
Callable					**Subordinated**				
Nr. of tranches	607		13,985		Nr. of tranches	607		13,985	
Nr. of tranches with d=1	369	***	10,543	***	Nr. of tranches with d=1	8	**	660	**
% of total	60.8%		75.4%		% of total	1.3%		4.7%	

Notes: This table reports summary statistics for a sample of green bonds and corporate bonds issued between 2013 and 2020. The data gathered to perform this analysis was extracted from DCM Analytics and Datastream. We test for similar distributions in contractual characteristics using the Wilcoxon rank-sum test for continuous variables and the Fisher's exact test for discrete ones. (***) indicates significant difference at the 1% level. (**) indicates significant difference between the 1% level and the 5% level. (*) indicates significant difference at the 10%. Bond rating is based on the S&P and Moody's rating at the time of bond issuance. The rating is converted as follows: AAA=Aaa=1, AA+=Aa1=2, and so on until D=22. For a definition of the variables, see Appendix B.

5. Regression Results

5.1 Are green bond spreads lower than the spreads of similarly rated corporate bonds?

Table 3 makes use of the regression model detailed in section 3 - equation (1) -, using the sample defined in sections 3 and 4: a full sample of 14,592 bond, from which 13,985 are corporate bonds and 607 are green bonds; and a high-information sample of 4,787 bonds with information on firms' accounting and market characteristics, of which 4,610 are corporate bonds and 177 are green bonds.

To answer this question, we estimated the model including a dummy variable for green bonds, which takes the value of 1 if the bond is deemed as green, and 0 otherwise. We estimated the model for the full sample - Model [1] -, as well as for the high-information sample - Model [2]. We can conclude that spreads do not differ significantly between green bond and corporate bonds, even when taking into account the firm specific characteristics. One reason that sustains this result is that the current degree of disclosure regarding climate matters is not sufficient (Ilhan et al., 2019), and investors have to resort to private reporting channels of firms to get hold of this type of information (Solomon et al., 2011). If there is a lack of information, it is expected that the traditional pricing factors (i.e., credit ratings) are the main determinants of both green bond and corporate bond spreads. Statman (2006) also points out that socially responsible bonds do not offer higher or lower returns than conventional investments. Our results also corroborate Larcker and Watts (2020), who find that green bonds do not have a pricing difference when compared to conventional corporate bonds. Flammer (2019) also finds that there is no significant difference between the yields of a green bond and a credit bond. Therefore, we do not corroborate H1 (green bonds

have lower spreads than similarly rated corporate bonds) for both full and high-information samples.

5.2 Are green bonds and standard corporate bonds similarly priced?

In this section we re-estimate previous models for each bond type separately, for the full sample - Model [3] and Model [4], and for the high-information sample - Model [5] and Model [6].

As expected, when a bond is rated, the impact on the spread is negative, both for the green bond sample (-139.87 bps) or the corporate bond sample (-158.73 bps). Nevertheless, when we include the company variables, surprisingly the impact of the rated variable increases the spread for green bonds in 296.2 bps, whilst for corporate bonds with company variables, as expected, it decreases the spread (in -148.78 bps). This might be explained by the small sample for green bonds in Model [4]. For the green bond sample presented on Model [3], the worst the rating, the higher the impact is on the spread. For instance, while the rating AA+ increases the spread by 11.29 bps vis-à-vis the AAA rating, while the rating B- increases the spread in 412.99 bps, again versus the AAA rating. The same does not happen for the green bond sample with the company variables, where all the ratings significantly decrease the spread of the bond. For corporate bonds, both Models [5] and [6] behave fairly similarly, with the impact on spread increasing as the rating gets worse.

As expected, the rating discordance has a positive impact on the spread for the corporate bond samples with and without company variables, at the 1% level, whilst it does not have any significant impact on the case of green bonds.

Maturity behaves the exact same way, with a positive impact on the spread for corporate bonds (as expected), but with no effect on green bonds.

Considering the deal value, the samples with company variables are not significantly affected by this variable, whilst both type of bonds without the firms' specific variables observe a significant decrease (at the 5% level for green bonds, and at the 1% level for corporate bonds) of their spread, as expected.

When bonds are callable, it is expected that their spread increases. That is exactly what we observe for all the samples, with and without company variables, for the 1% level of significance. The impact of this variable on green bonds is almost three times bigger than on their counterparts: green bonds that are callable increase their spread in 108.72 bps in Model [3], and 169.97 bps in Model [4] (corporate bonds increase their spread in 46.50 bps and 42.19 bps for the full and the high-information samples, respectively).

The dummy variable for switcher year, which takes the value of 1 if the issuer issued both types of bonds in the same year, does not have any impact in any of the models. Subordinated bonds, as expected, increase the spread. For the sample without company variables, green bonds and corporate bonds have very similar values (71.57 and 73.85 bps, respectively). When we include the firms' specific variables, there is no statistically significant impact of the subordinated variable on corporate bonds, but there is on green bonds, which increases 116.14 bps.

The currency risk also behaves as expected, although more strongly for green bonds than for their counterparts. Corporate bonds with currency risk increase their spread in 22.59 and 22.03 bps, for the sample without and with company variables, respectively. The impact on green bonds is higher, with an increase of 58.08 bps on the bond spread in Model [3], and 75.31 bps in Model [4].

The number of tranches in the bond deal does not seem to have any significant impact, except for Model [4]. The number of banks has an impact only on Model [4] as well, with a negative relationship with the spread (as initially expected).

Contrary to the anticipated behaviour, the bank reputation variable has a significant positive impact for Model [3], increasing the spread in 1.09 bps, and in Model [5] and [6], with a slightly lower increase than green bonds, but still positive (0.74 and 0.78 bps, respectively).

Country risk follows the expected behaviour for three of the four models. For the green bond sample, as well as for the corporate bond sample, with and without company variables, there is a significant positive relation of country risk with the spread. For the green bonds with company variables, the spread impact is -7.25 bps, which is significant at the -10% level.

The variable creditors rights is only statistically significant at the 10% level for the green bond sample with company variables and for the corporate bond sample without firms' variables. For Model [4], the variable has the expected impact; i.e., we find a negative relationship with the spread. For the corporate bond sample, there is a positive impact of 3.95 bps. The dummy variable "collateralized" also has an unexpected impact on the green bond sample with company variables, having a negative impact on the spread. For remaining models, the impact is as expected, significantly positive. Volatility also behaves as expected for all the models, with a very similar significant impact for all the models.

The EUSA5y-Libor3M variable on the other hand behaves as expected for the green bond sample without company variables, and for the corporate bonds sample with company variables. On these models, the impact on the spread is -30.71 bps and -0.27 bps, respectively. For the other two models, it behaves as anticipated, with a positive impact of 46.13 bps in Model [4] and 2.42 bps in Model [5]. It becomes apparent that the impact on spread is way more expressive for green bonds than for corporate bonds.

Finally, moving to the firm specific characteristics - Model [4] and Model [6] - the total assets behave as expected, although with more impact on green bonds.

Market to book has a significant impact on the spread for Model [4] and [6]. We expected a negative relation between this variable and the spread, but we find the inverse to happen (t it slightly increases the spread on bonds), with a bigger impact on green bonds (1.49 bps). Return on assets behaves as expected, with a bigger impact on green bonds (-4.87 bps) than on corporate bonds (-1.55 bps).

Total debt to total assets behaves similarly. As expected, the impact of leverage on the spread is positive on both type of bonds, more expressively on green bonds.

Overall, we find evidence that green bonds and standard corporate bonds are influenced differently by common pricing factors, and therefore accept H2.

Table 3 - Regression analysis of the determinants of the spread.

Dependent variable: Credit spread (bps)	[1] Full Sample	[2] Full Sample with company variables	[3] GB Sample	[4] GB Sample with company variables	[5] CB Sample	[6] CB Sample with company variables
Independent variables:						
Intercept	149.44 ***	116.46 ***	374.38 ***	210.68	148.44 ***	120.77 ***
	(8.03)	(4.35)	(4.26)	(1.49)	(8.04)	(4.41)
Green Bond	-7.98	-11.73				
	(-1.18)	(-0.98)				
Rated	-157.96 ***	-149.47 ***	-139.87 ***	296.20 ***	-158.73 ***	-148.78 ***
	(-10.29)	(-14)	(-3.06)	(4.59)	(-9.76)	(-14.15)
AA+	8.59	0.40	11.29	-553.03 ***	3.58	-10.05
	(0.89)	-0.02	-0.22	(-5.74)	-0.35	(-0.48)
AA	9.92	4.53	53.45	-395.61 ***	7.79	8.52
	(0.9)	(0.29)	(1.17)	(-4.86)	(0.63)	(0.6)
AA-	1.23	-7.22	12.32	-309.50 ***	1.20	-6.97
	(0.1)	(-1.18)	(0.29)	(-3.82)	(0.1)	(-1.11)
A+	12.94	3.67	20.74	-351.25 ***	12.92	2.76
	(1.14)	(0.41)	(0.49)	(-6.03)	(1.08)	(0.28)
A	27.58 **	11.91	42.73	-431.96 ***	27.51 **	11.94
	(2.15)	(1.43)	(1)	(-7.71)	(2.01)	(1.32)
A-	43.24 ***	23.54 **	45.16	-451.08 ***	43.11 ***	24.48 ***
	(3.36)	(3.16)	(1.01)	(-7.78)	(3.17)	(3.33)
BBB+	70.51 ***	38.89 ***	76.63 *	-429.13 ***	70.69 ***	40.20 ***
	(5.38)	(4.97)	(1.73)	(-6.66)	(5.12)	(5.18)
BBB	94.33 ***	72.56 ***	95.58 **	-416.52 ***	94.34 ***	74.16 ***
	(6.68)	(8.67)	(2.16)	(-5.86)	(6.37)	(9.71)
BBB-	137.63 ***	104.41 ***	94.76 *	-407.88 ***	139.50 ***	108.46 ***
	(8.15)	(10.02)	(1.9)	(-4.62)	(7.83)	(11.02)

(Continued on the next page)

Table 3 (continued)

Dependent variable:	[1]		[2]		[3]		[4]		[5]		[6]	
Credit spread (bps)	Full Sample		Full Sample with company variables		GB Sample		GB Sample with company variables		CB Sample		CB Sample with company variables	
Independent variables:												
BB+	233.63	***	198.60	***	158.61	***	-221.45	**	234.97	***	201.74	***
	(7.37)		(10.56)		(2.81)		(-2.48)		(7.21)		(11.31)	
BB	256.51	***	222.11	***	249.02	***	-193.47	**	257.46	***	224.58	***
	(9.74)		(16.75)		(4.14)		(-2.07)		(9.54)		(18.3)	
BB-	299.81	***	262.58	***	355.40	***	-386.67	***	299.47	***	265.56	***
	(13.44)		(15.82)		(6.68)		(-3.47)		(13.11)		(17.11)	
B+	362.91	***	330.33	***	340.38	***			363.18	***	333.90	***
	(19.04)		(15.33)		(5.39)				(18.53)		(16.23)	
B	432.20	***	380.47	***	543.68	***			432.89	***	382.89	***
	(16.38)		(12.81)		(8.3)				(16.04)		(13.43)	
B-	467.89	***	403.17	***	412.99	***			469.57	***	407.29	***
	(19.73)		(14.92)		(5.81)				(19.69)		(15.78)	
CCC+	601.31	***	419.87	***					602.54	***	426.31	***
	(31.03)		(16.66)						(30.97)		(16.36)	
CCC	611.73	***	546.13	***					613.33	***	553.94	***
	(18.45)		(3.3)						(18.56)		(3.31)	
CCC-	889.55	***							890.95	***		
	(8.24)								(8.28)			
CC												
D												
Rating discordance	15.94	***	13.64	***	16.31		-5.66		16.19	***	12.94	***
	(7.85)		(5.19)		(1.6)		(-0.2)		(7.8)		(4.61)	
Maturity	0.90	***	1.30	***	0.23		0.34		0.96	***	1.42	***
	(4.83)		(4.79)		(0.73)		(0.79)		(5.19)		(5.03)	
Deal Value	-10.45	***	0.22		-20.32	**	-19.63		-10.07	***	1.07	
	(-5.36)		(0.06)		(-2.1)		(-1.31)		(-5.19)		(0.3)	
Callable	49.69	***	46.69	***	108.72	***	169.97	***	46.50	***	42.19	***
	(6.58)		(4.69)		(4.03)		(5.02)		(6.6)		(4.57)	
Switcher Year	-13.64		-6.77		-12.32		-20.86		-5.89		17.10	
	(-1.53)		(0.63)		(-1.14)		(-0.84)		(-0.59)		(1.26)	
Subordinated	75.70	***	45.88	*	71.57	**	116.14	**	73.85	***	37.90	
	(3.85)		(1.85)		(1.93)		(2.33)		(3.53)		(1.48)	
Currency risk	24.39	***	24.44	***	58.08	***	75.31	***	22.59	***	22.03	***
	(6.69)		(5.51)		(5.53)		(3.15)		(6.32)		(5.06)	
Number of tranches	1.15	*	0.90		6.04		19.01	*	1.00		0.30	
	(1.66)		(0.45)		(1.36)		(1.98)		(1.42)		(0.14)	
Number of banks	0.17		-0.001		-1.51		-4.074	**	0.173		0.080	
	(0.5)		(0)		(-1.41)		(-2.08)		(0.5)		(0.21)	
Bank reputation	0.74	***	-0.76	**	1.09	**	1.46		0.74	***	0.78	***
	(5.38)		(3.11)		(2.05)		(1.63)		(5.31)		(3.1)	
Country risk	5.49	***	2.70	**	6.15	***	-7.25	*	5.59	***	2.79	**
	(4.96)		(2.21)		(2.74)		(-1.93)		(4.78)		(2.18)	
Creditor rights	3.54	*	2.97		-2.71		-21.25	*	3.95	*	3.55	
	(1.82)		(1.16)		(-0.64)		(-1.9)		(1.94)		(1.38)	

(Continued on the next page)

Table 3 (continued)

Dependent variable: Credit spread (bps)	[1] Full Sample	[2] Full Sample with company variables	[3] GB Sample	[4] GB Sample with company variables	[5] CB Sample	[6] CB Sample with company variables
Independent variables:						
Collateralized	61.90 ***	100.26 ***	45.81 **	-182.10 **	61.71 ***	101.79 ***
	(7.71)	(2.99)	(2.02)	(-2.28)	(7.47)	(2.98)
Table 3 (continued)						
Volatility	3.76 ***	3.58 ***	3.00 ***	2.95 ***	3.78 ***	3.59 ***
	(8.88)	(9.35)	(3.18)	(2.94)	(9.23)	(9.56)
EUSA5y-Libor3M		1.19	-30.71	46.13	2.42	-0.27
		(0.14)	(-0.99)	(1.18)	(0.42)	(-0.03)
Total Assets		-7.08 ***		-19.11 **		-6.64 ***
		(-4)		(-2.17)		(-3.9)
Market to Book		0.02 *		1.49 *		0.02 *
		(1.8)		(1.81)		(1.79)
Return on Assets		-1.62 ***		-4.87 **		-1.55 ***
		(-3.55)		(-2.05)		(-3.43)
Total Debt to Total Assets		28.08 **		289.95 ***		24.44 **
		(2.32)		(3.34)		(2.13)
Fixed Assets to Total Assets		34.39		-74.42		42.20
		(0.51)		(-0.58)		(0.54)
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	14592	4787	607	177	13985	4610
Adjusted R^2	0.69	0.68	0.51	0.68	0.69	0.68
Rated and rating dummies as independent variables only						
Adjusted R^2	0.6	0.6	0.31	0.31	0.61	0.61
Differences in adjusted R^2	0.09	0.08	0.2	0.37	0.08	0.07

Note: Regression analysis of the determinants of the spread for the full sample with and without company variables, and for the green bonds and corporate bonds separately, with and without company variables. model [1] is the full sample of 14,592 observations, model [2] is the full sample with company variables with 4,787 observations, model [3] is the green bond sample with 607 observations, model [4] is the green bond sample with company variables, with 177 observations, model [5] is the corporate bond sample with 13,985 observations, and model [6] is the corporate bond sample with company variables, with 4,610 observations. For a definition of the variables, see appendix B. ***, ** and * indicate that the reported coefficients are significantly different from zero at the 1%, 5% and 10% levels, respectively. The t-statistics reported in parentheses are based on heteroskedasticity-consistent standard errors. Due to time varying risk premia and cross-country differences, we estimate standard errors clustered by year and country.

6. Endogenous Switching Regression Model

Considering that the choice between green bonds and corporate bonds may be endogenous to spreads, we use an endogenous switching regression model (Lokshin and Sajaia, 2004) to test the robustness of the previous results. Our aim is to assess the pricing considering the potential self-selection by firms concerning issuing these two types of bonds.

In order to do so, we utilize a full information maximum likelihood (FIML) method on the spreads of the model specifications, with a probit selection equation, where the choice between green bonds and corporate bonds is a function of contractual characteristics, macroeconomic factors, and firm's characteristics. The empirical model consists in the following equations: where $I_i^* > 0$ means that the firm *i* issues green bonds, and otherwise it issues corporate bonds.

$$\begin{aligned} Spread\ CB_{i,t} = {} & \alpha_0 + \beta_1 Rated_{i,t} + \beta_2 Rated * Rating_{i,t} + \beta_3\ rating\ discordance_{i,t} \\ & + \gamma\ Contractual\ characteristics_{i,t} + \varphi\ Macroeconomic\ factors_t \\ & + \omega\ Firm\ Charecteristics_{i,t-1} + \varepsilon_{i,t} \end{aligned} \tag{2}$$

$$\begin{aligned} Spread\ GB_{i,t} = {} & \alpha_0 + \beta_1 Rated_{i,t} + \beta_2 Rated * Rating_{i,t} + \beta_3\ rating\ discordance_{i,t} \\ & + \gamma\ Contractual\ characteristics_{i,t} + \varphi\ Macroeconomic\ factors_t \\ & + \omega\ Firm\ Charecteristics_{i,t-1} + \varepsilon_{i,t} \end{aligned} \tag{3}$$

$$\begin{aligned} I*_{i,t} = {} & \delta_0(Spread\ GB_{i,t} - Spread\ CB_{i,t}) + \beta_1 Rated_{i,t} + \beta_2 Rated * Rating_{i,t} \\ & + \beta_3\ rating\ discordance_{i,t} + \gamma\ Contractual\ characteristics_{i,t} \\ & + \varphi\ Macroeconomic\ factors_t + \omega\ Firm\ Charecteristics_{i,t-1} + \varepsilon_{i,t} \end{aligned} \tag{4}$$

We also adjust these equations to heteroskedasticity and given that there may exist cross-country differences and varying risk premia, we estimate the standard errors clustered by country and by year.

Considering the Wald test statistics of independent equations, we reject the hypothesis of equations being independent for Model [7].

Results in Table 4 indicate that the total debt to total assets, which is a proxy for the company's leverage, has a significant positive impact of 249.44 bps on the spread, as expected. The other firm specific characteristics end up not having any significant impact on this analysis. On the other hand, corporate bonds' firms' specific characteristics have an important role explaining the spread. Again, the proxy for leverage works as expected, increasing the spread. Return on assets, a proxy for profit, has a negative significant impact on the spread of -4.20 bps. Surprisingly, fixed assets to total assets also have a positive impact on the spread (contrary to what was expected, but in line with the results obtained in Model [6]). The market to book value, contrary to what was initially expected, also has a positive impact on corporate bonds, which is in line to what we had observed in Model [6].

The country risk has a negative impact on the spread (-9.05 bps), in line with Model [4] and contrary to Model [3]. Bank reputation affects positively both type of bonds' spread, with a bigger impact (2.7 bps) on green bonds, which is in line with Models [4], [5], [6] and [7]. The same happens for the variable callable, which also has a positive impact on bonds' spread (the impact is also bigger on green bonds than corporate bonds).

Table 4 - Endogenous switching regression model.

Dependent variable:	[7]			
Spread (bps)	Green Bonds		Corporate Bonds	
Independent variables:				
Intercept	-32.43		24.70	
	(-0.50)		(1.27)	
Bank Reputation	2.70	**	0.98	*
	(2.46)		(1.89)	
Creditors Rights	1.04		1.19	
	(0.14)		(-0.26)	
Country Risk	-9.05	**	-1.28	
	(-2.15)		(-0.67)	
Callable	91.11	***	74.39	***
	(3.25)		(12.74)	
Currency Risk	29.00		8.06	
	(1.33)		(0.91)	
Collateralized	75.08		215.27	***
	(1.22)		(10.42)	
Volatility	1.30	*	2.65	***
	(1.82)		(5.28)	
EUSA5y-Libor3M	27.43		8.45	*
	(1.33)		(1.95)	
Fixed assets to Total Assets	-74.89		197.00	*
	(-0.78)		(1.81)	
Return on Assets	-6.56		-4.20	***
	(-1.62)		(-9.85)	
Total debt to Total Assets	249.44	***	126.57	***
	(2.81)		(6.70)	
Market to Book	0.45		0.03	***
	(0.43)		(2.63)	
Dependent variable:	GB vs CB			
Probability of observing:				
Independent variables:				
Intercept	-0.54			
	(-0.17)			
Bank Reputation	0.003			
	(0.09)			
Creditors Rights	0.05			
	(0.15)			
Country Risk	0.01			
	(0.19)			
Callable	-0.35			
	(-0.35)			
Currency Risk	0.05			
	(0.04)			
Collateralized	-1.35	***		
	(-4.87)			
Volatility	-0.01			
	(-0.12)			
EUSA5y-Libor3M	-0.24			
	(-0.49)			

(Continued on the next page)

Table 4 (continued)

Independent variables:		
Fixed assets to Total Assets	-0.49	
	(-0.11)	
Return on Assets	0.03	
	(0.30)	
Total debt to Total Assets	-0.91	*
	(-1.85)	
Market to Book	0.00	
	(-0.35)	
Number of observations	4,787	
Wald chi2	22.75	**
Log pseudolikelihood	-30,717.18	
Wald test of indep. equations	0.06	

Note: ***, ** and * indicate that the reported coefficients are significantly different from zero at the 1%, 5% and 10% levels, respectively. The t-statistics reported in parentheses are based on heteroskedasticity-consistent standard errors. Due to time varying risk premia and cross-country differences, we estimate standard errors clustered by year and country.

7. What are the determinants of firms' choice between green bonds and standard corporate bonds?

Models [8] to [11] of Table 5 report the results of the logistic regression presented below, to predict the firms' choices between green bonds and standard corporate bonds. Models [8] and [9] include all the bonds available, first with the variable for company rating, and then without the variable. Models [10] and [11] do the same but only include switchers.

$$Choice\ of\ debt_{i,t} = \alpha_0 + \beta\ Firm\ characteristics_{i,t-1} + \gamma\ Contractual\ characteristics_{i,t} + \varphi\ Macroeconomic\ factors_t + \varepsilon_{i,t} \quad (5)$$

To answer this question, we want to find whether firms with higher creditworthiness prefer green bonds over traditional corporate bonds. Analysing table 5, we find that green bonds issuers have lower return on assets (a proxy for profitability). Green bond issuers also have a lower total debt to total assets ratio than corporate bonds, and a higher credit rating. Therefore, we find that less profitable firms and those with lower leverage and higher credit rating choose green bonds over corporate bonds.

Table 5 - Logit models.

Dependent variable:	GB deal = 1 CB deal = 0	GB deal = 1 CB deal = 0	GB deal = 1 CB deal = 0	GB deal = 1 CB deal = 0
Choice of debt	Model [8] Full Sample with company rating	Model [9] Full Sample	Model [10] Switchers with company rating	Model [11] Switchers
Independent variables:				
Intercept	0.047	-0.329	4.065 *	3.224
	(0.04)	(-0.22)	(1.83)	(1.54)
Log total assets	0.093	0.222 **	0.186	0.344 **
	(0.87)	(2.26)	(1.00)	(2.23)
Market to book ratio	0.000	0.002	0.015	0.019
	(-0.27)	(0.52)	(0.64)	(0.82)
Return on assets	-0.108 ***	-0.075 ***	-0.181 **	-0.130 **
	(-4.36)	(-3.02)	(-2.46)	(-2.08)
Total debt to total assets	-4.356 ***	-4.388 ***	-6.270 ***	-6.523 ***
	(-2.79)	(-2.66)	(-3.79)	(-3.99)
Fixed assets to total assets	1.783	-0.603	0.173	-1.729
	(1.09)	(-0.3)	(0.09)	(-1.08)
Company rating	-0.172 ***		-0.133 ***	
	(-3.52)		(-2.64)	
Log deal size	-0.122	-0.329 **	-0.132	-0.278
	(-0.84)	(-2.17)	(-0.72)	(-1.62)
Maturity	-0.027 **	-0.025 **	-0.012	-0.011
	(-2.31)	(-2.36)	(-1.13)	(-1.05)
Currency risk	-0.210	-0.180	-0.652	-0.560
	(-0.53)	(-0.45)	(-1.30)	(-1.14)
Switcher	4.120 ***	3.965 ***		
	(8.99)	(8.19)		
Creditors Rights	0.252	0.251	0.190	0.211
	(1.61)	(1.61)	(1.06)	(1.16)
Volatility	0.010	0.014	0.020	0.023
	(0.74)	(0.98)	(1.39)	(1.59)
EUSA5y-Libor3M	-1.557 ***	-1.481 ***	-1.533 ***	-1.496 ***
	(-4.97)	(-4.60)	(-3.97)	(-3.90)
Industry fixed effects	yes	yes	yes	yes
Number of observations	4,382	4,382	660	660
Correct predictions	96.74%	96.58%	83.03%	82.27%
Pseudo-R^2	0.489	0.474	0.295	0.288

Note: ***, ** and * indicate that the reported coefficients are significantly different from zero at the 1%, 5% and 10% levels, respectively. The t-statistics reported in parentheses are based on heteroskedasticity-consistent standard errors. Due to time varying risk premia and cross-country differences, we estimate standard errors clustered by year and country.

Concerning the choice between green bonds and corporate bonds when we insert switchers in the regression, the impact seems to be very similar to models [8] and [9]. With switchers, maturity has no significance, whereas in the full sample, green bonds have a lower maturity than corporate bonds.

Including the company rating variable also brings up some differences on the explanation of the choice of debt. When we take out the company rating variable, we find that green bonds issuers have more total assets than corporate bonds issuers.

Conclusion

This dissertation does a comparison between green bond and conventional corporate bond spreads. We use a sample of 14,592 tranches, from which 13,985 are corporate bonds and 607 are green bonds.

Our findings indicate that the variable green bond has no significant influence on the spread; i.e., the spread does not differ significantly between green and corporate bonds. This can be justified by the fact that regulators and investors consider that the current degree of disclosure regarding climate matters is not enough (Ilhan et al., 2019; Solomon et al., 2011). If there is a lack of information, it is expected that the traditional factors (mainly credit ratings) are the main determinants of spread for both typologies of bond. Additionally, Statman (2006) points out that socially responsible bonds do not offer higher or lower returns than conventional investments. Our results also corroborate Larcker and Watts (2020) and Flammer (2019) findings.

However, we find that green bond and corporate bond spreads react differently to common pricing factors. For example, currency risk behaves as expected, although more strongly for green bonds than for corporate bonds. The rating discordance has a positive impact on the spread for the corporate bond, and maturity a negative impact (as expected) on corporate bonds spread. These same two variables have no impact on green bonds spread.

We also find that less profitable firms and those with lower leverage and higher credit rating choose green bonds over corporate bonds.

This thesis expands the knowledge in the pricing factors effect on the spread at issuance of green bonds, comparing them with conventional corporate bonds, opening the path to discussion on this topic.

A further research on green bonds spread at issuance would be important to better understand its behaviour in relation with the pricing factors, especially

given that with time, the sample size for green bonds will keep growing, which will lead to better results.

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Appendices

Appendix A: Green Bonds and Corporate Bonds summary statistics. This data was obtained from DCM Analytics. For a definition of each variable, see appendix B.

Panel A: Continuous variables

Variable of interest	Green Bonds						Corporate bonds					
	Number	Mean	Median	Std. Dev.	Min	Max	Number	Mean	Median	Std. Dev.	Min	Max
Contractual characteristics												
Tranche Spread to Benchmark (bp)	607	171.32	128.00	131.87	-23.00	875.00	13,985	219.43	158.00	177.70	-30.00	1419.00
Deal Value [M$]	607	958.00	518.45	1792.67	10.72	11943.20	13,985	1277.85	646.80	1877.90	0.02	25267.55
Number of Banks	607	6.75	5.00	5.69	1.00	34.00	13,985	8.41	7.00	6.32	1.00	50.00
Number of Tranches	607	1.65	1.00	1.26	1.00	9.00	13,985	2.05	1.00	1.62	1.00	17.00
Maturity	607	9.91	7.04	10.38	-117.96	60.56	13,985	10.95	8.05	9.53	-115.41	100.74
Company rating	607	4.83	6.00	4.18	0.00	17.00	13,985	7.09	8.00	4.71	0.00	22.00
Tranche rating	607	5.35	6.00	3.95	0.00	16.00	13,985	7.53	8.00	4.29	0.00	19.00
Bank's Reputation	607	16.09	18.00	9.58	1.00	26.00	13,985	10.21	4.00	9.53	1.00	26.00
Macroeconomic factors												
VIX	607	19.69	15.80	10.46	9.14	75.91	13,985	17.45	14.24	8.96	9.14	75.91
GDP (B$)	607	4830.00	574.00	7390.00	0.00	21600.00	13,985	9260.00	3600.00	8890.00	0.00	21600.00
EUSA5y-Libor3M	607	0.43	0.23	0.53	-0.59	1.78	13,985	0.82	0.87	0.60	-0.59	1.83
Creditors Right	607	1.76	2.00	1.07	0.00	4.00	13,985	1.42	1.00	0.98	0.00	4.00
Country risk	607	2.86	1.00	2.72	1.00	14.00	13,985	1.77	1.00	2.01	1.00	21.00
Firms Characteristics												
Total Assets (Million $)	177	1992.37	69.94	12541.87	0.43	94303.94	4,610	406.95	36.17	3742.41	0.10	94303.94
Total Debt (Million $)	177	584.58	24.52	3547.48	0.27	25831.29	4,610	176.07	12.75	1771.35	0.00	32305.47
Market to book	177	4.08%	1.80%	11.58%	-84.24%	34.78%	4,610	-1.05%	2.43%	97.43%	-1354.79%	639.77%
Return on assets	177	5.18%	4.48%	5.22%	-10.88%	20.66%	4,610	5.97%	5.40%	8.48%	-92.26%	97.89%
Total debt to Total assets	177	37.86%	35.84%	13.73%	4.72%	64.40%	4,610	39.58%	38.59%	16.96%	0.00%	256.83%
Short-term debt to total debt	177	14.02%	12.28%	10.50%	0.00%	75.17%	4,606	11.30%	8.09%	12.79%	0.00%	100.00%
Fixed assets to total assets	177	6.17%	4.38%	7.43%	0.83%	55.93%	4,610	4.46%	3.38%	4.12%	0.01%	55.93%

(continued on the next page)

Appendix A (continued)

Panel B: Dummy variables

Variable of interest	Asset securitization			Corporate bonds		
	Number	% of total	Std. Dev.	Number	% of total	Std. Dev.
Callable	607	60.8%	48.9%	13,985	75.4%	43.1%
Tranche Collateralized	607	9.1%	28.7%	13,985	13.3%	34.0%
Tranche Subordinated Debt	607	1.3%	11.4%	13,985	0.5%	6.9%
Rated Company	607	63.1%	48.3%	13,985	79.0%	40.8%
Rated Tranches	607	73.5%	44.2%	13,985	87.8%	32.7%
Switcher Year	607	30.1%	45.9%	13,985	1.3%	11.4%
Switcher	607	80.4%	39.7%	13,985	7.8%	26.9%
Tranche rating discordance	607	23.4%	42.4%	13,985	40.8%	49.1%
Currency risk	607	21.4%	41.1%	13,985	25.4%	43.5%

Appendix B: Variable Definitions.

Variable name	Variable definition	Source	Expected impact on credit spread	
			GB	CB
Dependent variable:				
Credit spread	Margin yielded by the security at issue above a corresponding currency treasury benchmark with a comparable maturity (OAS).	DCM Analytics		
Independent variables:				
Contractual characteristics				
Rated tranche	Dummy equal to 1 if the tranche has a credit rating from S&P, Moody's or Fitch, and 0 otherwise.	DCM Analytics	-	-
Rating tranche	Tranche rating based on the S&P's, Moody's and Fitch rating at the time of bond issuance. The rating is converted as follows: AAA=Aaa=1, AA+=Aa1=2, and so on until D=22.	DCM Analytics	+	+
Rating company	Company rating based on the S&P's, Moody's and Fitch rating at the time of bond issuance. The rating is converted as follows: AAA=Aaa=1, AA+=Aa1=2, and so on until D=22.	DCM Analytics	+	+
Tranche rating discordance	Dummy equal to 1 if S&P, Moody or Fitch assign a different credit rating for the same tranche, and 0 otherwise.	DCM Analytics	+	+
Maturity	Maturity of bonds, in years.	DCM Analytics	+	+

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Appendix B (continued)

Variable name	Variable definition	Source	Expected impact on credit spread	
			GB	CB
Independent variables:				
Contractual characteristics				
Tranche value	Tranche transaction size. Transaction size is converted into US Dollars.	DCM Analytics	-	-
Deal value	Deal transaction size. Transaction size is converted into US Dollars.	DCM Analytics	-	-
Subordinated	Dummy equal to 1 for tranches that are subordinated, and 0 otherwise.	DCM Analytics	+	+
Tranche value	Tranche transaction size. Transaction size is converted into US Dollars.	DCM Analytics	-	-
Number of tranches	The number of tranches per transaction.	DCM Analytics	-	-
Currency risk	Dummy equal to 1 for bonds that are denominated in a currency different from the currency in the deal's nationality, and 0 otherwise.	DCM Analytics	+	+
Switcher year	Dummy variable that takes the value of 1 if the switcher has issued both Green bonds and Corporate Bonds in the same year	DCM Analytics	?=	?=
Number of banks	The number of financial institutions participating in bond issuance, as bookrunners, underwriters or servicers.	DCM Analytics	-	-
Country risk	Each country has a number regarding the risk, from 1 (AAA) to 21 (C).	Moody's	+	+
Bank reputation	EMEA bookrunners rank according to Thomson Reuters League Tables. Ranks range from 1 (worst) to 25 (best).	Thomson Reuters DMI	-	-
Collateralized	Dummy equal to 1 if the tranches are backed by fixed assets, and 0 if, instead, they are backed by current assets.	DCM Analytics	+	+
Green Bond	Dummy variable that takes the value of 1 if the bond is considered Green, and 0 otherwise.	DCM Analytics	-	-
Callable	Dummy equal to 1 if the bond has a call option, and 0 otherwise.	DCM Analytics	+	+
Macroeconomic factors				
Volatility	The Chicago Board Options Exchange Volatility Index (VIX). VIX reflects a market estimate of future volatility.	Datastream	+	+
EUSA5y-Libor3M	The slope of the Euro swap curve. Obtained as the difference between the five-year Euro swap rate and the 3-month Libor rate.	Datastream	-	-

(Continued on the next page)

Appendix B (continued)

Variable name	Variable definition	Source	Expected impact on credit spread	
			GB	CB
Independent variables:				
Macroeconomic Factors				
Country risk	S&P's country credit rating at close. The rating is converted as follows: AAA=1, AA+=2, and so on until D=22.	S&P Global Ratings	+	+
GDP	The value of the Gross Domestic Product in US Dollars of a given country on a certain date.	Datastream	-	-
Creditor rights	Measured using La Porta, Lopez-de-Silanes, Shleifer and Vishny's (1998) indices. We use four creditor rights variables (no automatic stay on assets; secured creditors first paid; restrictions for going into reorganization; management does not stay in reorganization) and added up the scores to create an index as in Esty and Megginson (2003).	LLSV (1998)	-	-
Financial firms' characteristics				
Total assets	Firms' total assets measured in Euro million.	Datastream	-	-
Total debt to total assets	The ratio of total debt to total assets.	Datastream	+	+
Fixed assets to total assets	The ratio of fixed assets to total assets. Fixed assets include property, plant and equipment.	Datastream	-	-
Market to book	The sum of book value of liabilities and market value of equity divided by the book value of assets.	Datastream	-	-
Return on assets	The net income before preferred dividends minus preferred dividend requirement, divided by total assets.	Datastream	-	-

I = insignificant impact on the credit spread.
HS = humped-shaped.
? = sign cannot be determined clearly from either the theoretical or empirical literature.
- = negative impacts on the credit spread.
+ = positive impact on the credit spread.
NA = information about this variables is not available.