



UNIVERSIDADE CATÓLICA PORTUGUESA

A Theoretical and Empirical Analysis of Sustainable Finance: The Existence of a Greenium in the Corporate Green Bond Market

Euclides Martins Lopes

Católica Porto Business School

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Euclides Martins Lopes

Under the supervision of
Paulo Alves

Católica Porto Business School
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Resumo

O tema da eventual diferença de preço entre obrigações verdes e obrigações convencionais é um tópico que atrai especial interesse no âmbito de *green finance*. Esta dissertação pretende contribuir para a literatura existente e responder à necessidade constante de dados e pesquisa atualizados acerca deste novo instrumento financeiro, e como o mesmo influencia as preferências dos investidores. Através de uma comparação entre obrigações verdes e obrigações convencionais idênticas, foi detetado um *premium* verde de -7.2 pontos base sem significância estatística, o que nos permite concluir sobre a inexistência de uma diferença de preço entre obrigações verdes e obrigações convencionais cujo maior fator de assimetria é a característica *green*. Estes resultados revelam-se idênticos após a divisão da amostra inicial em subamostras com base nas moedas mais dominantes e setores de atividade mais prevalentes, na medida em que, todas as subamostras revelam um pequeno *premium* verde que não apresenta significância estatística. Por fim, a amostra foi restringida a pares de obrigações emitidas após o início da pandemia Covid-19, na qual foi detetado um desconto verde, novamente, sem significância estatística. Estes resultados indicam que os investidores não estarão dispostos a abdicar de retorno financeiro em troca de benefícios intangíveis de índole ambiental.

Keywords: Obrigações verdes; *Premium*; Sustentabilidade; *Green Finance*; ESG; RSE

Abstract

The subject of an eventual difference in pricing between green bonds and conventional bonds is a widely researched topic within the realm of green finance. This thesis serves to contribute to the existing literature and the need for updated data and research regarding this new financial instrument and how they impact investors' preferences. By comparing corporate green bonds to quasi-identical conventional bonds, we find a statistically insignificant green bond premium of -7.2 bps and thus conclude that there seems to be no pricing difference between bonds that mainly differ with respect to their green label. These results remain identical when isolating subsamples from the most dominant currencies and the most prevalent industry groups as they all display a small, statistically insignificant green bond premium. Lastly, we analyzed bond pairings issued after the start of the Covid-19 pandemic and find a green bond discount which was, yet again, statistically insignificant. These findings imply that investors are not willing to exchange financial returns for non-pecuniary environmental benefits.

Keywords: Green Bonds; Premium; Sustainability; Green Finance; ESG; CSR

Number of words: 8645

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1. Introduction

Climate change is a humanitarian, ecological and world-threatening crisis of unprecedented magnitude in human history. An impending disaster that is already disrupting the lives of billions of people, namely in poorer countries, contributing to deepen already existing inequalities and threatening the livelihood of the people that have done the least to cause it. The consensus regarding the urgency and severity of the problem seems evident, however, the actions and measures needed to try and stop the process are still far from ideal. These actions and measures require large-scale investments in order to reduce future global emissions and reduce the risks associated with the climate crisis. The role of finance, more specifically, green finance, is a major one as it can shift investment to green sectors, help insure against climate-related disasters and, most importantly, gear the world economy towards sustainability.

The largest component of green finance is the green bond market which has been growing exponentially since 2014 after the introduction of the Green Bond Principles, with global green bond issuance surpassing \$500 billion in 2021 (CBI, 2022). Green bonds differ from conventional bonds as their proceeds serve to finance or re-finance new or existing Green Projects (ICMA, 2014). The matter of green bond pricing is one of the most researched topics regarding green bonds (Hachenberg and Schiereck, 2018; Karpf and Mandel, 2018; Febi et al., 2018;

Kapraun et al., 2019; Zerbib, 2019; Partridge and Medda, 2020; Larcker and Watts, 2020; Flammer, 2021; Zheng and Zhong, 2021).

The eventual existence of a greenium described as the difference in yield between a green bond and an equivalent conventional bond (Zerbib, 2019) could challenge standard theory regarding portfolio optimization and suggest that investors are willing to pay for the non-pecuniary benefits of investing in green projects, accepting lower returns.

Accordingly, the basis of this work is the study of empirical data on the corporate bond market to investigate the existence of the aforementioned premium and if it can be attributed to a bond's green label which can provide further insight into investors' willingness to "pay to save the planet". On the other hand, considering the perspective of the issuer, the existence of this premium could signify that green bonds would represent a cheaper source of financing which could incentivize firms to use these instruments despite the initial costs required to obtain a bond's green label.

With this objective in mind, a dataset of investment grade green bonds issued between January of 2014 and January of 2022 and quasi-identical conventional bonds was constructed and analyzed with regards to their pricing. The subsequent results do not support the existence of a green bond premium within our specified sample and subsamples.

As such, this thesis is organized as follows. Section 2 presents the background and literature review regarding the topics of sustainability, climate change, green finance, green bonds and, lastly, the green bond premium or greenium. Section 3 describes the methodology behind the extraction of data, the matching process utilized and presents the statistics for the sample of bonds used. Section 4 presents the tests used to investigate the existence of the greenium within the main sample of bonds and relevant subsamples and also discusses the results and main limitations of this thesis. Ultimately, section 5 provides the main

conclusions, contributions to the existing literature and improvement possibilities for future research.

Chapter 2

2. Literature Review

2.1. Sustainability

Sustainability has become much more than just a fad or a phase, as it may have been perceived at first, and its impact on the everyday reality of firms across the world is at an all-time high. We are living through the defining period of humanity's future on the only planet we have ever known and the need for sustainable development is yesterday's necessity.

Sustainable development is perceived as "meeting the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Sustainability, 1987). Indeed, it was over three decades ago that the world started paying serious attention to this growing need thanks to the chairman of the aforementioned commission and his self-titled report, the Brundtland Report. Ever since then, sustainable investing has grown exponentially to \$35.3 trillion in five major markets and represents more than a third of all assets in the world's biggest markets (Global Sustainable Investment Review, 2020).

In the field of Finance, sustainability is shaping businesses and strategies alike, aiming to fill the gap between finance and corporate strategy (Soppe, 2009) and

contributing to the fact that individual success is becoming more and more tied to societal improvement as part of a cultural change.

No longer can we say that profit for the shareholders is the sole purpose of a corporation (Friedman, 1970), but instead, modern businesses are striving to create value for all stakeholders. Like so, Corporate Social Responsibility (CSR) and Sustainable/Socially Responsible Investments (SRI) are intrinsic aspects of the reality of modern corporations.

On the one hand, corporate social responsibility is seen as the contribution of the business and civil society to the sustainable development of the economy (Kakabadse et al., 2006), but due to the intrinsic complex nature of theoretically analyzing a concept such as CSR, consensus on what the concept actually encompasses and how it should be regulated is still proving hard to reach which has incentivized the emergence of recent literature that studies the need to regulate CSR (Abah, 2016; Amao, 2013; Buhmann, 2006; Buhmann, 2011; Dentchev et al., 2017; Idemudia et al., 2018; Malesky et al., 2017; Malesky et al., 2019; Nieto, 2005; Okoye, 2016; Osuji, 2011; Osuji, 2015; Situ et al., 2018; Thirarungrueang, 2013).

On the other hand, the European Sustainable and Responsible Investment Forum (Eurosif) describes socially responsible investing as a generic term covering ethical investments, responsible investments, sustainable investments, and any other investment process that combines investors' financial objectives with their concerns about environmental, social and governance (ESG) issues. According to Barber et al. (2019), 2,372 organizations (\$86 trillion) had signed the United Nations Principles of Responsible Investment and the majority of consulting groups and investment banks displayed indications of demand for investing with a social conscience.

It is essential to analyze and understand the spectrum of motivations behind the concept of sustainability for firms. There is already an extensive line of

research and bodies of work regarding the beneficial nature of CSR for firms. Parastoo et al. (2015) concluded that CSR has a positive effect on competitive advantage, reputation and customer satisfaction which in turn leads to better performance. Flammer (2015) also demonstrated that close call CSR proposals lead to positive announcement returns and superior performance. According to Schalchian et al. (2015), a firm's irresponsible behaviour is perceived as additional financial risk and potential losses arising from said behaviour warrant more concern from investors than potential financial gains that originate from CSR. Socially responsible firms are also associated with lower cost of debt when compared to firms with social responsibility concerns (Goss et al., 2011; Raimo et al., 2021). Additionally, Cheng et al. (2011) found that firms with better CSR performance face lower capital constraints and these constraints are reduced even further when there is better stakeholder engagement and transparency around CSR performance.

As is the case with the large majority of topics, the literature is not unanimous and conclusions are contextualized and varied. While there is plenty of research that argues for the superior performance of sustainability, there is also the common view that firms may face a trade-off between social responsibility and financial performance (Aupperle, Carroll & Hatfield, 1985; Ullmann, 1985; Vance, 1975). Despite a wide array of literature covering the subject (Hamilton et al., 1993; Hutton et al., 1998; Mill, 2006; Renneboog et al., 2008) the nature of the relationship between sustainability and financial performance is still uncertain.

Xiao et al. (2013) argue that sustainability and returns are not related. Adegbite et al. (2019) find lower levels of financial performance for companies with medium level of CSR activities but correlate lower and higher levels of CSR with better performance which seems to support the perspective that defends the need for long-term planning and early resource expenditure in order for CSR to

contribute to and sustain better levels of financial performance and the existence of a U-shaped relationship (Lankoski, 2000; Wagner, 2001; Filis et al., 2016).

Concurrently, the relationship between ESG scores/disclosure and financial performance continues to be a major point of dissensus, with authors arguing over the overall importance of ESG reporting and the individual impact of its factors. Almeyda and Darmansya (2019) concluded that the Social and Governance factors of ESG are not related with financial performance despite confirming a positive relationship between the Environmental factor and the company's ROC and its stock price and a positive relationship between the disclosure of ESG and ROA as well as ROC. On the other hand, some part of the literature concludes that the Governance factor seems to have the biggest positive impact on financial performance (Velte, 2017; Arslan et al., 2021) or that Environmental performance correlates negatively with financial performance (Horváthová, 2010; Verbeeten et al., 2016; Myroshnychenko et al., 2017) or even that ESG scores as a whole have a weak correlation with financial performance (Balatbat et al., 2012, 2013).

Moreover, Adams et al. (2012) point out that sustainability efforts by the corporation seem to have no effect on its short-term performance when measured by its stock price and shareholder returns and emphasize the notion that sustainability might be the attraction for building customer loyalty and brand reputation on a long-term basis. There exists a parallel body of literature that studies the reputation/marketing role of sustainability in an important effort to infer about potential company misinformation, the impact of false sustainability efforts and the role of ESG metrics in deterring such corporate behaviour. The overwhelming majority of this literature focuses on "greenwashing", a phenomenon through which firms misrepresent their products and/or services in an attempt to benefit from the green image that is conveyed to the public which does not correspond to the companies' realities.

2.2. Climate Change and Global Warming

In order to delve into the world of green finance and its instruments, we must first provide the necessary context and essential information that serve as the foundation for any discussion on the subject – climate change and the environmental aspect of ESG.

The literature that studies the connection between economic/industrial growth and climate change is incredibly vast and dates back several decades. As Stern (2008) pointed out, the challenge of climate change is the most difficult and pressing matter in the history of humanity. A long-term topic full of uncertainty and discussion which requires urgent adaptation and change and that is vital to much of the world's industries and economic reality.

As per the World Meteorological Organization (WMO), our planet has been propelled into uncharted territory due to record breaking concentrations of greenhouse gases in the atmosphere and all time high global sea levels as of 2021. For the first time in modern history, it rained at the peak of the Greenland ice sheet and the world spent the year facing and suffering from widespread climatic phenomena. From the heavy floods that affected China and several European countries to devastating fires caused by unprecedented heatwaves, these extreme events seem to be the norm now and we have to bear the severe socio-economic, ecological and human losses that are a consequence of decades of uncontrolled industrial production that pushed nature to the brink of collapse.

Contrary to what may have been the general consensus just a few decades ago, it is now generalized common sense that climate change is a true and pressing matter and nations all around the world need to come together to tackle this challenge. From the Kyoto Protocol (1997) to the Paris Agreement (2015),

progress has been made to ensure a low carbon future. More recently, the Glasgow Climate Pact was adopted during the 26th Conference of The Parties (COP26) which intends to turn the 2020s into a decade of climate action and support (UNFCCC) and allowed for the final items of the Paris Agreement on carbon markets and transparency to be finally approved. This Conference held from late October to mid-November of 2021 focused on adaptation, mitigation and finance as the objects of analysis and discussion, culminating in key outcomes such as doubling the financing toward developing countries with a \$100 billion annual pledge from the developed countries and the promise to strengthen emission reduction to ensure the rise in the average temperature is limited to 1.5 degrees as established in 2015. Despite these positive advancements, the scientific community and several of the attending representatives left the Conference with concerns that even if countries were to meet their 2030 targets, the global temperature would still rise by 2.4 degrees as pointed out by the Climate Action Tracker. Concurrently, objections from China and India resulted in changing the promise to “phase out” coal to “phase down” with India’s climate and environment minister Bhupender Yadav (Reuters, 2021) claiming that poorer countries cannot stop subsidizing fossil fuels and that lower income households rely on fossil fuels to lower their energy costs. As stated by Niklas Hoehne (Forbes, 2021), the “COP26 seems to have closed the gap but not solved the problem”.

The socio-economic and ecological impacts of climate change are severe, widespread and more frequent than ever, with global hunger levels and ecosystem degradation reaching unprecedented values. Economists and scientists have had, historically, very different predictions and forecasts regarding climate change and the magnitude of the consequences it entails. Ranging from the direct impact on everyday human life to mass extinctions, the

actual impact of an unprecedented large externality such as climate change is neigh impossible to predict.

Dietz and Stern (2008) argue that economic research that oppose strong and urgent actions to tackle climate change failed to consider risks and ethics as vital parts of the issue and are, therefore, flawed. There is, however, an ever increasing pressure to align perspectives since environmental concerns have moved from the realm of just health and safety to that of corporate financial strategy as the ultimate driver of change (Labatt and White, 2007). Saunders (2019) found that the allocation of funds is not aligned with the sentiment of the Paris Agreement and that countries that are most affected by climate change and in most dire need of help from adaptation finance end up receiving smaller allocations than their less vulnerable counterparts. The governance of adaptation finance structures needs to work as envisioned in order to prevent alienating developing countries and to ensure a coordinated global response (Scoville-Simonds, 2016). The lack of effort to harmonize fund allocation has propelled international agencies to maximize their own institutional benefits rather than contributing to global progress, creating competition that will inevitably create winners and losers and result in suboptimal benefits on a global scale (Porter et al., 2008). The 2018 Nobel Prize for Economics William D. Nordhaus (2019) argues that only by creating, employing and enforcing policies focused on multinational cooperation can we ensure a combined effort to tackle this global externality. This perspective is corroborated by Barrett (1994, 2003) whose work sought out to demonstrate that previous global externalities were successfully dealt with through the creation of effective institutions that fostered cooperation between nations.

2.3. Green Finance

As a relatively new term, Green Finance has conveyed a variety of meanings and definitions over the past decade. Höhne et al. (2012) viewed green finance as a comprehensive term that includes climate finance but is not limited to it, consisting of financial investments that flow into different initiatives, products, projects and policies that contribute towards a sustainable economy. Bloomberg New Energy Finance, on the other hand, considers green finance to be a more inclusive iteration of green investment that also takes into account land acquisition and project preparation costs (Zadek and Flynn, 2013).

PricewaterhouseCoopers (PWC, 2013) defines green finance through the lens of the banking sector as being a collection of “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 projects and stimulate low-carbon technologies, projects, industries and businesses”. Böhnke et al. (2015) also consider banking as the key element when defining green finance as all forms of investing or lending whose decisions consider environmental screening and risk assessment to meet sustainability standards.

As a more extensive definition, Lindenberg (2014) proposes that green finance comprises not only the overall financing of public and private green investments (along with their preparatory and capital costs) that work either on environmental goods and services or in the prevention, minimization and compensation of damage to the environment and climate but also the financing of public policies that encourage the implementation of projects and incentives that serve the adaptation and mitigation of environmental damage. The author also proposes that green finance includes the components of the financial system that deal with green investments such as green bonds, green loans and green

structured funds along “with their specific legal, economic and institutional framework conditions”.

More recently, the European Parliament (2021) provided a definition that constitutes green finance as the collection of funds used to address climate and environmental issues (green financing) and managing financial risk related to these aforementioned issues (greening finance). This distinction considers green financing to represent the “financing of the green economy” while greening finance stands for “greening the financial system”. Furthermore, the EP provides a clear differentiation of climate finance which serves to address the funding needed for mitigation and adaptation of climate change, green finance as encompassing climate finance while also covering several different environmental goals and finally sustainable finance as an evolution of the previous that includes the other ESG factors, namely, Social and Governance.

The pivotal role that green finance has set to play on the road toward sustainability is not without its flaws and challenges ranging from information asymmetry to the lack of clear cut definitions, the suboptimal political commitment and the legal/regulatory concerns that have presented an obstacle ever since the its inception. In emerging markets, the problems do not arise from raising capital but instead, the challenge is the selection of suitable projects and structuring the associated finance (Guild, 2019). These are crucial concerns surrounding the future of green finance and the market and the overall consensus around the scientific community is that of a mismatch between ambition and implementation that has the potential the undermine the efforts and progress of the recent past.

2.4. Green bonds

In order to support the transition to a low or zero carbon economy, specialized instruments like green bonds, green loans or green funds will be essential in providing the necessary funding for the required measures, projects and investments and contributing towards a more sustainable economy (Tu et al., 2020; Tolliver et al., 2020). The large majority of these instruments are green bonds, which represent a little under half of the total sustainable finance market. Even during one of the most unprecedented and uncertain years in history, the total green bond issuance in 2020 rose to a record-breaking \$270 billion which propelled the total cumulative value of the green debt capital market to surpass the \$1 trillion mark (Climate Bonds Initiative, 2021).

The most common green bonds can be separated into four different categories. Use-of-Proceeds Bonds and Use-of-Proceeds Revenue Bonds are two types of green bonds whose proceeds are “earmarked for green projects in the issuer’s portfolio” with the latter having its “recourse limited to an issuer’s pledged revenue stream, not its entire balance sheet” unlike the former. Project Bonds are tailored for specific projects or groups of projects and the recourse is “limited to those project(s) assets and balance sheet”. Lastly, Securitized Bonds are collateralized by revenue-generating green projects which in turn are used to repay the bond and “recourse is limited to the collateralized asset” (Jones, 2020). Additionally, De Spiegeleer and Schoutens (2019) introduce a variant of vanilla green bonds - Reverse Green Bonds which offer a higher yield in exchange for the extra risk of missing coupon payments which are contingent on pre-agreed climate triggers.

The Green Bond Principles define green bonds as being “any type of bond instrument where the proceeds or an equivalent amount will be exclusively applied to finance or re-finance, in part or in full, new and/or existing Green

Projects and which are aligned with the four components of the GBP” (ICMA, 2021). These principles are still, to this day, one of the most relevant conquests of green bonds. Following the issuance of the first green bond – first referred to as Climate Awareness Bond (CAB) - in 2007 by the European Investment Bank (EIB) which managed to raise \$0.9 billion, the green bond market had a rough start. Be it the lack of a clear definition, the ambiguity in the green bond projects’ taxonomy, the slow acceptance from investors worldwide or lesser transparent issuers, the green bond market was not without its flaws. The work of a coalition of banks, investors, and issuers (IMCA), the Green Bond Principles, whose inception dates back to 2014, established a multitude of guidelines and recommendations that were globally accepted and paved the way for the issuance of credible green bonds. The creation of this standard, followed by the Paris Agreement in 2015, allowed for the steady growth of the green bond market which nearly doubled in size every year (Bachelet et al., 2019).

Following the Green Bond Principles, other green bond standard initiatives such as the CBI’s Climate Bond Standard or the EU Green Bond Standard developed by the EU Commission have contributed to the pursuit of transparency and integrity in the green bond market. A market which has been mostly dominated by the European Union, followed by the United States of America and China. Accordingly, the EU’s role in the development of the market has been crucial with the European Green Deal, presented in 2019, at the forefront of the strategic roadmap.

2.5. Greenium

Alongside the exponential growth of the green instruments market, the literature covering green instruments, specifically green bonds, has also thrived

in recent years with an exponential growth of empirical research on the subject (Cortellini and Panetta, 2021). The most popular theme of research within the realm of green bonds relates to the pricing structure of these instruments when compared to non-green/conventional bonds and the eventual existence of a green bond premium or greenium (Hachenberg and Schiereck, 2018; Karpf and Mandel, 2018; Febi et al., 2018; Kapraun et al., 2019; Zerbib, 2019; Partridge and Medda, 2020; Larcker and Watts, 2020; Flammer, 2021; Zheng and Zhong, 2021). The existence of a greenium would imply a contrast to “modern portfolio theory which assumes rational investors, efficient markets and expected returns as a function of risk” (Dorfleitner et al., 2021) and suggest that investors may be willing to accept a lower yield in exchange for non-fungible benefits. There is no consensus in sight regarding the existence and explanations of said premium within the literature, with the most common explanation being associated with investors’ pro-environmental and social preferences being responsible for the acceptance of lower risk-adjusted returns (Zerbib, 2019).

Gianfrate and Peri (2019) found green bonds to be more “financially convenient” than conventional bonds with this difference assuming a more significant role in the primary market but also existing in the secondary market. They conclude, then, that these instruments have a key role to play in transforming the economy without financially jeopardizing investors. Hyun et al. (2020) argued that externally reviewed green bonds demonstrated a significant discount when compared to synthetic conventional bonds but found no significant yield difference when comparing generalized green bonds, which supports the notion that the greenness standard of these instruments is a large contributor to their success and the development of the market. Additionally, Hachenberg and Schiereck (2018) found green bonds to be trading tighter than conventional bonds of the same issuer, with emphasis on financial and corporate bonds, and attribute the difference in pricing to industry and ESG rating while

concluding that issue size, maturity and currency had no significant influence on the matter. According to Kanamura (2020), green bond investment has outperformed investing in conventional bonds in recent years but this superiority has diminished over time.

Contrastingly, Larcker and Watts (2020) state that in real market settings investors do not seem willing to exchange financial returns for environmental benefits as their research finds no pricing difference between nearly identical green and non-green securities, implying the absence of any greenium. With resort to the same aforementioned methodology of comparing bonds that only differ with regards to their 'greenness', Flammer (2021) supports these findings of no pricing difference and claims that those results are consistent with qualitative evidence from interviews and surveys where investors indicate that they would not invest in green bonds if the returns were not competitive. With the primary objective of studying the inherent rationale associated with green bond issuance, the author finds evidence of increased environmental rating and equity ownership by long-term investors and green investors alike post-issuance which indicates that signaling the company's commitment towards environmental causes constitutes the main motivation behind green bond issuance and offsets the additional administrative and compliance costs associated with these instruments.

The first empirical study on the announcement returns and real effects on green bond issuance is attributed to Tang and Zhang (2018). The authors compiled data of green bond issuance by firms in 28 countries over a 10 year period (2007-2017) through the CBI and Bloomberg datasets. They found that stock prices of issuers react positively to green bond issuance announcement, with statistical significance and economic meaning. These findings are also consistent with previous literature in that they indicate a stronger reaction by first time issuers. In order to comprehend the sources of positive stock market

reaction and consequent short-term improvement in firm value behind green bond issuance, the researchers examined green bond yields, changes in institutional ownership and stock market liquidity. On the subject of a potential green premium, the research concludes that there exists no pricing difference for the same issuer in the same year. Additionally, there seems to be an increase in institutional ownership of green bond issuers. Finally, the study points out the increase in stock turnover, google search volume and liquidity of ask-bid spreads, indicating that the market pays attention to a firm's development regarding green bonds. The authors suggest that labeled green bond issuance increases media exposure and firm visibility which attracts a large investor base and higher demand resulting in benefits to existing shareholders.

Chapter 3

3. Methodology and Data

3.1. Data Extraction

With the objective of comparing green and equivalent conventional corporate bonds as it pertains to their pricing and consequently analyze if green bonds are indeed a cheaper source of capital or if investors are willing to pay an extra price for their non-pecuniary benefits, data regarding both types of bonds needs to be retrieved and matched in order to minimize the effects of other characteristics and try to encapsulate the impact of the bond's spread.

As such, we constructed a dataset of green and conventional investment grade corporate bonds issued between January of 2014 and January of 2022. Restricting the dataset to issuances in EUR and USD would help minimize the effects of currency risk and allow for the emphasis of the sample to be on the most liquid markets (Doronzo et al., 2021), but given the other constraints that were used and the need for a considerable sample size, issuances from all currencies were considered. On a different note, focusing on investment grade bonds only and disregarding high-yield bonds contributes to the minimization of the eventual effect of price volatility. The choice of restricting the sample to this time period

is, on the one hand, due to the implementation of the aforementioned green bond principles in 2014 which allowed for greater transparency and the exponential increase in green bond issuance and consequent sample size and, on the other hand, 2021 being, evidently, the last possible year from which data can be extracted but, also, being a record-breaking year for the green bond market which positively contributes to a broader and more comprehensive sample size needed for the everlasting research on a market that is still in its early stages (Flammer, 2021).

Given the emphasis on transparency regarding the green label of corporate bonds, the dataset was extracted from the DCM Analytics' comprehensive database of identified green bond instruments and crosschecked with the CBI's database which allows us to minimize eventual effects of greenwashing and helps solidify results and the validity of the green bond sample.

The initial sample of investment grade corporate bonds issued between 2014 and 2021 was comprised of 2,536 green bonds and 91,378 conventional bonds. The sample was then filtered based on different criteria. All callable bonds were removed from the sample as the difference in coupon rates for callable bonds and the subsequent effect on the value of the internal interest rate option, is an impediment to a proper comparison between securities (Larcker and Watts, 2020). Furthermore, the sample was also filtered to remove any bonds with missing values regarding issue date, issue amount, issue price, rating, currency or maturity. The final sample is comprised of 553 green bonds and 15,079 conventional bonds which are all senior, bullet, fixed-coupon bonds, in alignment with Zerbib (2019).

3.2. Matching Method

As the main objective of this work is to study the difference in pricing between bonds labeled green and otherwise, we must ensure that the other intrinsic characteristics of these instruments are matched to the fullest extent possible. Accordingly, and in line with the matching method used in previous work such as Zerbib (2019), Larcker and Watts (2020), among others, we used an exact matching method also known as a model-free approach or a direct approach (Zerbib, 2019) in order to create pairings of securities that possess similar attributes but differ with regards to the one property we are studying, the yield spread. Given this method, we take each corporate green bond from our sample and juxtapose it with the most similar conventional bond. The identified bond pairings share the same currency, issuer, bond structure, seniority, coupon type and rating.

Unlike Larcker and Watts' (2020) work on municipal bonds, seeking to match corporate bonds with coinciding issuance dates is neigh impossible. Following Zerbib (2019), and in order to minimize the effects of liquidity risk, the following constraints were applied to the matching process. A given eligible bond could not have been issued more than six years earlier or later than its counterpart and its issue amount could not have been less than one-quarter or more than four times that of its counterpart. As liquidity is essential for bond pricing, and considering that smaller issuances may suffer from a given liquidity premium demanded by the market, we decided to exclude issuances with a total face value below €100 million. These constraints were put in place to better control for the differences in liquidity given the limitation of not being able to retrieve the closing bid-ask spreads for our sample of bonds which would have allowed for the creation of a liquidity proxy as per Zerbib (2019).

With regards to minimizing the effects of maturity, and when faced with the impossibility of creating a dataset full of perfect pairings, we allowed matched pairings to have maturities that differ in no more than two years, which allowed for a broader sample while simultaneously controlling for the aforementioned maturity risk.

As such we took every bond from the green bond sample and matched it with the most similar conventional bond according to our criteria. Every bond was only allowed to have one match in order to create unique pairings within our criteria. Bonds that could not be matched were dropped from the sample.

Bond Characteristic	Matching Criteria
Issuer	Same
Issue Date	± 6 years
Rating	Same (Investment Grade)
Currency	Same
Coupon Type	Same (Fixed Coupon)
Structure	Same
Maturity	± 2 years
Seniority	Same (Senior)
Issue Amount	$\pm 25\% - 400\%$ & $> \text{€}100\text{M}$

Table 1: Criteria used in the matching process given a bond's characteristic and the applied constraint

3.3. Data Analysis and Descriptive Statistics

The final matched sample is comprised of 219 pairings of green and non-green bonds of which 133 were perfect matches, i.e., pairings of bonds sharing the same issuer, currency, rating and also exact maturity. The sample of bonds originates from 158 individual issuers which operate in 16 different industries.

As mentioned previously, 2021 was a record-breaking year in terms of green bond issuance and our sample of paired bonds is a clear indicative of that as it is the most represented year throughout the whole sample with 55 green bonds being issued in that same year. In fact, as expected, our sample denotes a generalized year-on-year increase, with the exception of 2019-2020, and the least number of issuances coinciding with the earliest years considered (2014, 2015).

Also unsurprising is the predominance of the financial sector, which represents more than half of the issued bonds in our sample as banks are key contributors to green bond issuance worldwide and the growth of the green finance market.

Additionally, we can verify that EUR and USD dominate our sample with 141 green bonds being denoted in the two most common currencies worldwide.

Year	N	%
2021	55	25.11%
2020	38	17.35%
2019	46	21.01%
2018	30	13.70%
2017	22	10.05%
2016	17	7.76%
2015	8	3.65%
2014	3	1.37%
Total	219	100.00%
Sector	N	%
Auto/Truck	4	1.83%
Computer & Eletronics	1	0.46%
Construction/Building	2	0.91%
Consumer Products	1	0.46%
Finance	134	61.19%
Food & Beverage	1	0.46%
Holding Companies	1	0.46%
Insurance	5	2.28%
Machinery	3	1.37%
Metal & Steel	1	0.46%
Oil and Gas	3	1.37%
Real Estate/Property	9	4.11%
Retail	1	0.46%
Telecommunications	1	0.46%
Transportations	11	5.02%
Utility & Energy	41	18.72%
Total	219	100%
Currency	N	%
Australian Dollar	2	0,91%
British Pound Sterling	2	0,91%
Canadian Dollar	3	1,37%
Chinese Renminbi Yuan	34	15,53%
Euro	82	37,44%
Indian Rupee	1	0,46%
Japanese Yen	21	9,59%
New Taiwan Dollar	3	1,37%
Philippine Peso	1	0,46%
South Korean Won	2	0,91%
Swiss Franc	5	2,28%
Thai Baht	4	1,83%
US Dollar	59	26,94%
Total	219	100,00%

Table 2: Distribution of the sample of green bonds by year, industry and currency

Comparing both samples of paired bonds, we can quickly observe the similarity between the median values for the total issuance value, maturity, price at issuance and coupon rate as well as the differences of the average values for those same parameters, which can be an indication of extreme outliers heavily influencing the average values.

Nevertheless, the average green bond in our sample has a considerably lower issuance amount (EUR) than the average conventional bond, with an average difference of 34%. The average green bond is also characterized by having a lower coupon rate (-7.8bps), being issued at a lower price (-2bps) and maturing later (0.93 years) than the average conventional bond in our samples.

Panel A: Green Sample	N	Mean	Median	St. Dev.	Min.	Max.
Total Value (mEUR)	219	701	500	669	102	4100
Maturity (years)	219	5.764	5.000	3.122	1.500	31.000
Price (% of par)	219	99.819	99.952	0.316	97.406	101.546
Coupon (%)	219	1.744	1.250	1.494	0	7.375
Yield (bps)	219	177.635	131.100	149.037	-1.748	748.000
Panel B: Conventional Sample	N	Mean	Median	St. Dev.	Min.	Max.
Total Value (mEUR)	219	1040	631	1300	106	7910
Maturity (years)	219	5.663	5.000	3.106	1.000	31.000
Price (% of par)	219	99.842	99.940	0.371	98.506	101.971
Coupon (%)	219	1.818	1.375	1.513	0	7.250
Yield (bps)	219	184.015	137.700	151.211	-17.903	728.000

Table 3: Descriptive statistics of the matched sample of bonds

At an initial glance we can analyze the difference between the yields of both bond samples and confirm that there seems to exist a small greenium of -7.2 bps which could indicate that investors are, in fact, willing to accept lower returns in

exchange for non-pecuniary benefits. It would also mean that green bond issuance would be a cheaper source of financing when compared to conventional bonds.

At this point, it is required to test the statistical significance of the observed data in order to draw any meaningful conclusions.

Chapter 4

4. Testing and Results

4.1. Preliminary Testing of the Dataset

As a prelude, we begin our analysis by testing and studying the distribution of our dataset, more specifically, the univariate distribution of the calculated greenium defined as the difference between the yields of our matched pairs ($Y_i^{GB} - Y_i^{CB}$).

As per Larcker and Watts (2019), we computed kernel density estimates for our variable of interest. This non-parametric estimation of the probability density function of our variable allows for a better understanding of the variation of yield differences within our sample and their frequency. We can see that there is a large concentration directly at 0 which supports the notion of a general price differential of 0, with a number of extreme outliers within the sample, both positive and negative.

As a follow-up, a Shapiro-Wilk normality test was performed in order to support the choice of significance test to be used later in the analysis. The test

allowed for the rejection of the null hypotheses which signifies that the variable is not normally distributed and that non-parametric tests allow for more sound results.

4.2. Testing the Greenium

Table 4 contains the results of paired t-tests and Wilcoxon tests to verify the statistical significance of the observed greenium in our sample and sub-samples. Firstly, the following univariate analysis was ultimately a byproduct of the lack of data regarding bid and ask yields which represented an obligatory deviation from the methodology and multivariate analysis employed by Zerbib (2019). Secondly, the choice concerning the usage of paired tests is motivated by the matching method that constructed the overall sample, requiring bonds to be issued by the same issuer and share the same structure. Both the t-test and Wilcoxon test reject the null hypotheses at a 5% level of significance. As such, we do not have enough statistical evidence to reject the null hypothesis and thus conclude that the average difference in yields of -7.2 bps is not statistically different from zero and we can reject the existence of a greenium in our overall sample.

Subsequently, in an attempt to identify potential variation within our sample, the same set of tests were performed on a series of subsamples that were created based on the bonds' characteristics described in the previous section: currency and general industry group. To ensure a considerable size of each subsample, we only broke the sample down in two subsamples within each of the aforementioned characteristics.

Bonds denominated in EUR have a green bond premium of -8.124 bps whereas bonds denominated in USD also showed a green bond premium of -17.492 bps.

Bonds originating from the Financial industry also have a green premium of -2.675 bps as well as those from the Utility & Energy (-9.614 bps). In line with the results from the overall sample, each of the subsamples reveals a green bond premium but all of them are statistically insignificant above a 10% significance level.

As mentioned in previous sections, the literature is incredibly divisive with regards to the existence and magnitude of a premium in the green bond market. Even within the same methodology used in this thesis, results and conclusions are vastly different. Given the usage of the exact matching, our results are in line with those of Larcker and Watts (2019) who found an insignificant yield differential and concluded that the greenium in their analysis was essentially zero. On the other hand, Zerbib (2019) found a significant, albeit small, greenium of -2 bps, whose significance carried over to the EUR and USD bonds subsample. However, it should be noted that despite the similarity in matching methodology, it is impossible to generalize any conclusion given the difference in the base sample as this work only deals with corporate bonds and not municipal U.S states like Larcker and Watts (2019) or any type of green bond like Zerbib (2019).

	Full Sample	EUR	USD	Finance	U&E
N	219	82	59	134	41
Mean difference (bps)	-7.167	-8.124	-17.492	-2.675	-9.614
p value Wilcoxon	0.075	0.167	0.308	0.321	0.517
p value t test	0.141	0.291	0.140	0.615	0.510

Table 4: Paired tests for the significance of the yield differential

Note: The statistical significance of the yield differential for the complete sample and defined subsamples was evaluated through nonparametric (Wilcoxon signed-rank test) and parametric tests (two sided t test) with a null hypothesis that the greenium was equal to zero.

4.3. Impact of the Covid-19 pandemic

The Covid-19 pandemic is an unignorable reality of the recent past which had monumental impact in global markets and the economy as a whole, acting as a paradigm shifter all around the globe. Three years since the start of this worldwide phenomenon, the economic and social challenges that resulted from this crisis are paramount on the road towards normalcy. Regarding the post-pandemic recovery, a report convened by commissioner Paolo Gentiloni (the commissioner for Economy of the European Union) and the work of a group of high-level academics declared that this could be an opportunity to pursue sustainable growth and promote global stability. Following the recovery plan presented in the midst of the pandemic catastrophe (European Commission, 2020) which foresaw the distribution of thirty percent of its funds towards climate-related affairs, it appears that the pandemic made the need for sustainability more imperative than ever.

As we have mentioned throughout this dissertation, green finance is a key component of the sustainable path that is being envisioned. Instruments such as green bonds can assume an improved role in the post-pandemic world by contributing to a more resilient economy and helping to implement systems that respond more quickly and effectively to shocks such as Covid-19 (CBI, 2020).

Accordingly, and considering that green bond issuance has kept breaking records in the past year of 2021, we decided to isolate from our matched sample the pairings issued after the start of the pandemic crisis in early 2019. We analyzed the new sample to confirm if any significant changes can be detected in terms of a green bond premium.

As opposed to the previous sample and subsamples, the results showed a green bond discount of 4.9 bps. Currently, there appears to be no theory and/or research on the extant literature regarding a green bond discount. Furthermore, both the Wilcoxon and paired t tests demonstrated, yet again, that there is not enough statistical evidence to reject the null hypothesis of the greenium being equal to zero and, thus, we conclude that there appears to be no pricing difference between paired bonds issued after the start of the Covid-19 pandemic.

4.4. Limitations

As mentioned in previous sections, the main limitation of this work is tied to the inability to gain access to certain data and databases that would have allowed for a more robust and in-depth analysis. More specifically, the information regarding bid and ask yields of the bonds in our main sample which would have allowed for the creation of a liquidity control variable. The small liquidity differential identified by Zerbib (2019) had significant explanatory power and the step used for its control would be a considerable plus towards a more robust and sound analysis. The deviation from this step also made it impossible to perform an extra analysis regarding the determinants of the green bond premium in our sample. Nonetheless, Wulandari et al. (2018) argue that the bid-ask spread has no influence on the yield spreads of green bonds as opposed to conventional bonds.

Another considerable limitation that is common to the literature covering the subject of green bond pricing is the amount of data available. Despite the recent exponential growth of the green bond market, it still only accounts for approximately 1% of the total global bond market. In conjunction with the already limited sample size, several stringent constraints had to be applied to our

initial sample of bonds in order to best isolate the green bond premium and ensure that pricing differences were mainly captured by the difference in the green label and not by other structural differences between bonds. This meant that there had to be a tradeoff between ensuring a considerable sample size and enforcing the said constraints as to obtain only the most appropriate matchings possible.

Lastly, and also in line with the previously mentioned limitation, a considerable amount of certified green bonds were missing crucial information. This made it impossible to perform an extra analysis with regards to a bond's spread to benchmark in addition to its yield. However, this work's focus on the yield at issue is in accordance with the recent literature on the subject as per Larcker and Watts (2020) and Flammer (2021).

4.5. Results

The findings in this study indicate that there is no extra incentive regarding green bonds vis a vis conventional bonds and that investors are not willing to forgo returns for non-pecuniary benefits. Despite the continued global increase in green bond issuance, investors are likely to retain their preference for the best investment possible regardless of its nature. This perspective is supported by industry practice which show that investors require a given project to offer competitive returns in order to invest (Flammer, 2021) (Larcker and Watts, 2020).

These results are also consistent when focusing on specific subsamples regarding currency and industry group. Bonds denoted in hard currencies such as the EUR and USD are correlated with more liquid markets and are expected to be able to attract a larger investor base. Even so, our results find no statistical evidence of a greenium when isolating the subsamples of bonds denominated in

said currencies. When isolating matched pairs that were issued after the Covid-19 crisis, a small, statistically insignificant green bond discount was observed. It should be noted, however, that the economic effects of the pandemic had disparate impact throughout different sectors and countries and they still persist as an outside risk to growth (McKinsey, 2021). As such, it may still be too early to completely gauge an eventual shift in paradigm favouring sustainability which could be reflected through green bonds and their pricing.

A considerable amount of the extant literature on green bond pricing concluded upon the existence of a significant greenium (Preclaw and Bakshi (2015), Ehlers and Packer (2017), Schmitt (2017), Baker et al. (2018), Hachenberg and Schiereck (2018), Gianfrate and Peri (2019), Nanayakkara and Colombage (2019), Zerbib (2019)). Larcker and Watts (2020) argue that some of these analyses are based on a small set of securities and that misspecifications considering the methodological design are to fault for some of the mixed evidence of previous studies. The exact matching methodology applied in this thesis as well as several recent studies such as the aforementioned Zerbib (2019), Larcker and Watts (2020), Flammer (2021), as well as the ever growing pool of green securities and the subsequent potential to apply the necessary constraints while maintaining considerable sample sizes, are poised to contribute to sounder results that can help comprehend the subject of green bond pricing, which may support or contradict the findings of this study.

Another relevant point to consider is the green bond market supply-demand and its impact on bond pricing dynamics. The additional costs associated with green bond issuance and certification have proven to be significant barriers in the early stages of market development. The uncertainty and inexperience regarding green bonds as a financial instrument and the need for companies to shift their strategy to accommodate the required preference towards green projects have also posed threats to the growth of the green bond market (I4CE, 2017). In spite

of this, as we have already mentioned, supply has been growing at a staggering pace in recent years, both in the number of issuances and volume. This continuous growth in supply may have alleviated the buying pressure which would have been an important factor behind the green bond premiums identified in previous studies. On the other hand, authors such as Chiang (2017) and Partridge and Medda (2019) as well as some industry professionals suggest that a greenium may become more common in years to come. In a market still in its early stages, intrinsic changes to its microstructure and dynamics can be responsible for the continuous shift in findings, accentuating the need for updated research.

As pointed out by Larcker and Watts (2020), perhaps the most likely explanation behind the inexistence of a greenium is simply that green projects offer competitive returns and, therefore, attract investors regardless of their green label or investors' preference.

5. Conclusion

This thesis serves to provide an overview of the framework of sustainable finance with a specific focus on green bonds and how these instruments are priced vis a vis conventional bonds. In a world in urgent and desperate need for change, sustainable finance is a key component in shifting the focus towards the implementation and development of projects, technologies and businesses that take into account environmental, social and governance related considerations in order to, ultimately, pave the way for a zero-carbon, resource-efficient and fair economy.

Green bonds are the most represented instrument in the global sustainable debt market with investors projecting that green bond issuance is set to surpass 1 trillion USD in 2022 alone. The considerable growth of the green bond market in recent years makes it all the more important to research and study these instruments and their impact.

One of the most researched subjects regarding green bonds is related to their pricing and how it compares to conventional i.e. non-green bonds. Exploring the topic of a potential green bond premium (greenium) intends to comprehend if investors are willing to exchange economic returns for non-pecuniary benefits.

Using an exact matching methodology, we constructed a paired dataset of green and conventional corporate bonds issued between 2014 and 2022 which share the same issuer, currency and credit rating. They are all bullet, fixed-

coupon, senior, non-callable investment grade bonds. We then analyze the yield difference between these pairings of quasi-identical bonds. We find a non-significant green bond premium of -6.7 bps. After isolating our sample according to the most represented currencies and company industry groups, the findings of non-significant green bond premiums are consistent across all subsamples.

These findings are consistent with Larcker and Watts (2020) and Flammer (2021) who also conclude that there seems to be no pricing difference between green and conventional bonds of near identical characteristics in the U.S. municipal bond market and corporate bond market, respectively. The lack of proof of a green bond premium implies that investors are not willing to forgo returns in exchange for environmental benefits and contradicts the idea that green bonds represent a cheaper source of financing.

The generalization of these results is neigh impossible as the intricacies of the corporate bond market are fundamentally different from those of other markets. Additionally, the limited amount of data regarding green bonds and, more specifically, corporate green bonds, impedes the creation of perfect matches between bonds within a considerable sample size and results could vary wildly according to the constraints that are used.

As such, there is a call for future research that can benefit from the increase in quality and quantity of green bond data in order to produce more sound results that can provide a better insight concerning the long-term implications of green bonds and investors' preferences. Notwithstanding the exact match methodology used in this thesis, future empirical settings could also prove to be more suited to the study of this subject. Lastly, future research could also build upon this methodology and provide more in-depth analyses, with resource to tools and databases that were inaccessible within the framework of this body of work.

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Appendices

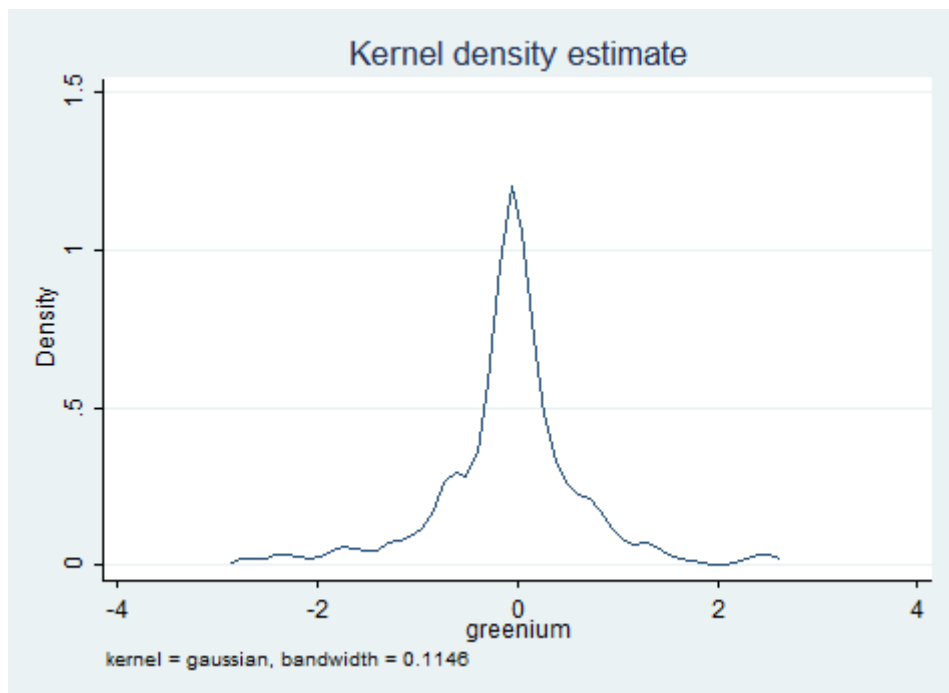


Figure A1: Kernel density estimates

Note: This figure details the kernel density estimate for the yield differentials of the matched sets described in Chapter 2. The graph was plotted using a Gaussian kernel and the Silverman rule for bandwidth selection.

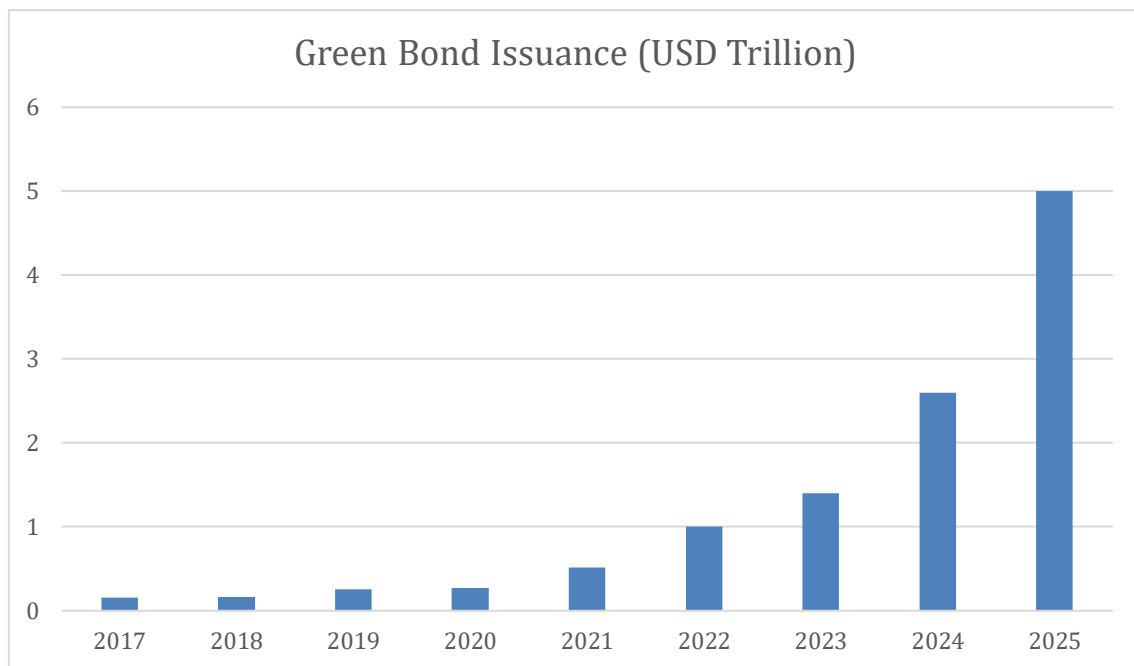


Figure A2: Green bond issuance forecast
(Source: Climate Bonds Initiative)

Company Name	Rating	Currency	Industry
ABN AMRO Bank NV	A+	Euro	Finance
ABN AMRO Bank NV	A+	Euro	Finance
ABN AMRO Bank NV	A-	Euro	Finance
Adif Alta Velocidad	BBB	Euro	Transportation
Agricultural Bank of China Ltd (New York)	A+	US Dollar	Finance
ALD SA	BBB+	Euro	Finance
Amipeace Ltd	A+	US Dollar	Finance
Arion Banki hf	BBB	Euro	Finance
Asahi Group Holdings Ltd	BBB+	Japanese Yen	Food & Beverage
Assicurazioni Generali SpA	BBB	Euro	Insurance
Axis Bank Ltd (Dubai)	BBB-	US Dollar	Finance
Banco Bilbao Vizcaya Argentaria SA - BBVA	BBB+	Euro	Finance
Banco Santander SA	A	Euro	Finance
Banco Santander SA	A-	Euro	Finance
Bank of America Corp	A-	US Dollar	Finance
Bank of China (Luxembourg) SA	A+	Euro	Finance
Bank of China (Macau)	A+	Chinese Renminbi Yuan	Finance
Bank of China (Paris)	A+	Chinese Renminbi Yuan	Finance
Bank of Chongqing Co Ltd	BBB-	Chinese Renminbi Yuan	Finance
Bank of Chongqing Co Ltd	BBB-	Chinese Renminbi Yuan	Finance
Bank of Communications Co Ltd	A	Chinese Renminbi Yuan	Finance
Bank of Communications Co Ltd	A	Chinese Renminbi Yuan	Finance
Bank of Communications Co Ltd	A	Chinese Renminbi Yuan	Finance
Bank of Nova Scotia	A+	US Dollar	Finance
Bank of the Philippine Islands	BBB	US Dollar	Finance
Bankinter SA	BBB	Euro	Finance
Banque Federative du Credit Mutuel SA - BFCM	AA-	Euro	Finance
Beijing Capital Polaris Investment Co Ltd	BBB	US Dollar	Utility & Energy
Beijing Capital Polaris Investment Co Ltd	BBB	US Dollar	Utility & Energy
Beijing Energy Group Co Ltd	A	Chinese Renminbi Yuan	Utility & Energy
Belfius Bank SA/NV	BBB+	Euro	Finance
Berlin Hyp AG	A+	Euro	Finance
BNP Paribas SA	A+	Euro	Finance
BNP Paribas SA	A	Euro	Finance
BPCE SA	A+	Euro	Finance
Canadian Imperial Bank of Commerce - CIBC	A	US Dollar	Finance
Castle Peak Power Finance Co Ltd	AA-	US Dollar	Utility & Energy
CDP Financial Inc	AAA	US Dollar	Insurance
China Construction Bank (Hong Kong)	A+	US Dollar	Finance

China Construction Bank (Hong Kong)	A+	US Dollar	Finance
China General Nuclear Power Corp	A	Chinese Renminbi Yuan	Utility & Energy
China Huadian Corp Ltd	A	Chinese Renminbi Yuan	Utility & Energy
China Huadian Corp Ltd	A	Chinese Renminbi Yuan	Utility & Energy
China Huadian Corp Ltd	A	Chinese Renminbi Yuan	Utility & Energy
China Huaneng Group Co Ltd	A	Chinese Renminbi Yuan	Utility & Energy
China Huarong Financial Leasing Co Ltd	A-	Chinese Renminbi Yuan	Finance
China Longyuan Power Group Corp Ltd	A-	Chinese Renminbi Yuan	Utility & Energy
China Longyuan Power Group Corp Ltd	A-	Chinese Renminbi Yuan	Utility & Energy
China Longyuan Power Group Corp Ltd	A-	Chinese Renminbi Yuan	Utility & Energy
China Merchants Bank (Hong Kong)	A-	US Dollar	Finance
China Petrochemical Corp	A+	Chinese Renminbi Yuan	Oil & Gas
China Southern Power Grid Co Ltd	A+	Chinese Renminbi Yuan	Utility & Energy
China Three Gorges Corp	A+	Chinese Renminbi Yuan	Utility & Energy
CLP Power Hong Kong Financing Ltd	A+	US Dollar	Utility & Energy
Commerzbank AG	BBB+	Euro	Finance
CPPIB Capital Inc	AAA	Euro	Insurance
Credit Agricole SA	A	Euro	Finance
Credit Agricole SA (London)	A+	Euro	Finance
Credit Suisse (London)	A+	Euro	Finance
Daimler AG	A-	Euro	Auto/Truck
Daimler AG	A-	Euro	Auto/Truck
Daiwa Securities Group Inc	BBB+	Japanese Yen	Finance
Danske Bank A/S	A-	Euro	Finance
De Volksbank NV	A-	Euro	Finance
Deutsche Bank AG (New York)	A-	US Dollar	Finance
Deutsche Pfandbriefbank AG	A-	Euro	Finance
Deutsche Pfandbriefbank AG	BBB+	Euro	Finance
EDP Finance BV	BBB-	Euro	Utility & Energy
Electric Power Development Co Ltd	A	Japanese Yen	Utility & Energy
Electricite de France SA - EDF	A-	Japanese Yen	Utility & Energy
Ferrovie dello Stato Italiane SpA	BBB	Euro	Transportation
First Abu Dhabi Bank	AA-	Swiss Franc	Finance
Franshion Brilliant Ltd	BBB-	US Dollar	Real Estate/Property
Global Power Synergy pcl	BBB-	Thai Baht	Utility & Energy
Global Power Synergy pcl	BBB-	Thai Baht	Utility & Energy
Global Power Synergy pcl	BBB-	Thai Baht	Utility & Energy
Guangzhou Metro Investment Finance (BVI) Ltd	A+	US Dollar	Transportation
Honda Finance Co Ltd	A-	Japanese Yen	Finance
HSBC Bank (Taiwan) Ltd	A+	New Taiwan Dollar	Finance
HSBC France SA	AA-	Euro	Finance
Hua Xia Bank Co Ltd	BBB-	Chinese Renminbi Yuan	Finance

HYPO NOE Landesbank fur Niederosterreich und Wien AG	A	Euro	Finance
Hyundai Capital Services Inc	A-	US Dollar	Finance
Hyundai Capital Services Inc	BBB+	Swiss Franc	Finance
Iberdrola International BV	BBB+	Euro	Utility & Energy
Iberdrola International BV	BBB+	Euro	Utility & Energy
Iberdrola International BV	BBB+	Euro	Utility & Energy
ICBCIL Finance Co Ltd	A	US Dollar	Finance
IDBI Bank Ltd (Dubai IFC)	BBB-	US Dollar	Finance
Ile-de-France Mobilites	AA	Euro	Transportation
Industrial & Commercial Bank of China (Hong Kong)	A+	US Dollar	Finance
Industrial & Commercial Bank of China (Hong Kong)	A+	US Dollar	Finance
Industrial & Commercial Bank of China (Hong Kong)	A+	US Dollar	Finance
Industrial & Commercial Bank of China (Luxembourg)	A+	US Dollar	Finance
Industrial & Commercial Bank of China (Singapore)	A+	Chinese Renminbi Yuan	Finance
Industrial & Commercial Bank of China (Singapore)	A+	US Dollar	Finance
Industrial & Commercial Bank of China Ltd (London)	A+	British Pound Sterling	Finance
Industrial Bank Co Ltd (Hong Kong)	BBB	US Dollar	Finance
Industrial Bank Co Ltd (Hong Kong)	BBB	US Dollar	Finance
ING Bank NV	A+	Euro	Finance
ING Bank NV	A+	US Dollar	Finance
ING Groep NV	A	Euro	Finance
ING Groep NV	A	Euro	Finance
Intesa Sanpaolo SpA	BBB	Euro	Finance
Intesa Sanpaolo SpA	BBB+	Euro	Finance
Intesa Sanpaolo SpA	BBB	Euro	Finance
KB Securities Co Ltd	A-	South Korean Won	Finance
KBC Group NV	A-	Euro	Finance
Komatsu Ltd	A	Japanese Yen	Machinery
Korea Hydro & Nuclear Power Co Ltd	AA	US Dollar	Utility & Energy
Korea Midland Power Co Ltd	AA-	US Dollar	Utility & Energy
Korea South-East Power Co Ltd - KOSEP	AA	US Dollar	Utility & Energy
Korea Southern Power Co Ltd	AA	US Dollar	Utility & Energy
Kyushu Electric Power Co Inc	A-	Japanese Yen	Utility & Energy
La Banque Postale SA	BBB+	Euro	Finance
Landesbank Baden-Wuerttemberg - LBBW	A	Euro	Finance
Landesbank Baden-Wuerttemberg - LBBW	A	Euro	Finance
Landesbank Baden-Wuerttemberg - LBBW	A	Euro	Finance

Landesbank Baden-Wuerttemberg - LBBW	A	Euro	Finance
Landsbankinn hf	BBB	Euro	Finance
Link Finance (Cayman) 2009 Ltd	A	US Dollar	Real Estate/Property
Majid Al Futtaim Properties LLC	BBB	US Dollar	Real Estate/Property
Mediobanca - Banca di Credito Finanziario SpA	BBB	Euro	Finance
Metropolitan Life Global Funding I	AA-	US Dollar	Insurance
Mitsubishi Estate Co Ltd	A+	Japanese Yen	Real Estate/Property
Mitsubishi UFJ Financial Group Inc	A+	US Dollar	Finance
Mitsubishi UFJ Financial Group Inc	A	Euro	Finance
Mitsubishi UFJ Financial Group Inc	A	US Dollar	Finance
Mitsui Fudosan Co Ltd	A	Japanese Yen	Real Estate/Property
Mizuho Financial Group Inc	A	Euro	Finance
Mizuho Financial Group Inc	A	Euro	Finance
Morgan Stanley	A-	US Dollar	Finance
Muenchener Hypothekbank eG	A	Euro	Finance
National Australia Bank (New York)	AA-	US Dollar	Finance
National Australia Bank Ltd	AA	Euro	Finance
National Australia Bank Ltd	AA-	Euro	Finance
National Bank of Abu Dhabi PJSC	AA-	US Dollar	Finance
NIBC Bank NV	BBB+	Euro	Finance
NIDEC Corp	A-	Japanese Yen	Machinery
NIDEC Corp	A-	Japanese Yen	Machinery
Nordea Bank AB	AA-	Euro	Finance
NTPC Ltd	BBB-	Indian Rupee	Utility & Energy
NTT Finance Corp	AA-	Japanese Yen	Finance
NTT Finance Corp	A	Japanese Yen	Finance
NTT Finance Corp	A	Japanese Yen	Finance
NTT Finance Corp	A	Japanese Yen	Finance
OP Corporate Bank Oyj	AA-	Euro	Finance
OP Mortgage Bank	AAA	Euro	Finance
ORIX Corp	A-	Japanese Yen	Finance
POSCO Co Ltd	BBB+	US Dollar	Metal & Steel
Prologis Yen Finance LLC	A	Japanese Yen	Real Estate/Property
PTT pcl	BBB+	Thai Baht	Oil & Gas
QBE Insurance Group Ltd	A-	US Dollar	Insurance
QNB Finance Ltd	A+	US Dollar	Finance
Raiffeisen Bank International AG	A-	Euro	Finance
Repsol International Finance BV	BBB	Euro	Oil & Gas
Ricoh Leasing Co Ltd	BBB+	Japanese Yen	Finance
Ricoh Leasing Co Ltd	BBB+	Japanese Yen	Finance
Rizal Commercial Banking Corp - RCBC	BBB-	Philippine Peso	Finance
Rongshi International Finance Ltd	A+	US Dollar	Holding Companies
Royal Bank of Canada	A+	Euro	Finance
Rural Electrification Corp Ltd	BBB-	US Dollar	Finance

Saudi Electricity Co	A	US Dollar	Utility & Energy
Saudi Electricity Co	A	US Dollar	Utility & Energy
SBAB Bank AB	A+	Euro	Finance
Shandong Hi-speed Group Co Ltd	A	Chinese Renminbi Yuan	Construction/Building
Shanghai Pudong Development Bank Co Ltd	BBB	Chinese Renminbi Yuan	Finance
Shenzhen Expressway Co Ltd	BBB	Chinese Renminbi Yuan	Transportation
Shenzhen Expressway Co Ltd	BBB	Chinese Renminbi Yuan	Transportation
Shinhan Bank	A+	South Korean Won	Finance
Skandinaviska Enskilda Banken AB	AA-	Euro	Finance
Societe Generale SA	A	Euro	Finance
South Coast British Columbia Transportation Authority	AA	Canadian Dollar	Transportation
South Coast British Columbia Transportation Authority	AA	Canadian Dollar	Transportation
SpareBank 1 SMN	A	Euro	Finance
State Bank of India (London)	BBB	US Dollar	Finance
State Grid Corp of China	AA-	Chinese Renminbi Yuan	Utility & Energy
State Grid Corp of China	AA-	Chinese Renminbi Yuan	Utility & Energy
State Grid Corp of China	A+	Chinese Renminbi Yuan	Utility & Energy
State Grid Corp of China	A+	Chinese Renminbi Yuan	Utility & Energy
State Grid Corp of China	A+	Chinese Renminbi Yuan	Utility & Energy
Sumitomo Mitsui Banking Corp	A+	US Dollar	Finance
Sumitomo Mitsui Financial Group Inc	A	Euro	Finance
Sumitomo Mitsui Financial Group Inc	A	Euro	Finance
Sumitomo Mitsui Financial Group Inc	A	US Dollar	Finance
Sumitomo Mitsui Trust Bank Ltd	A+	US Dollar	Finance
Svenska Handelsbanken AB	AA	Euro	Finance
Svenska Handelsbanken AB	A+	Euro	Finance
Swedbank AB	AA-	Euro	Finance
Swedbank AB	AA-	US Dollar	Finance
Swire Properties MTN Financing Ltd	A	US Dollar	Real Estate/Property
Taiwan Power Co	AA-	New Taiwan Dollar	Utility & Energy
TERNA - Rete Elettrica Nazionale SpA	BBB+	Euro	Utility & Energy
TERNA - Rete Elettrica Nazionale SpA	BBB+	Euro	Utility & Energy
TERNA - Rete Elettrica Nazionale SpA	BBB+	Euro	Utility & Energy
Terreno Realty LLC	BBB	US Dollar	Real Estate/Property
Toronto-Dominion Bank	AA	Canadian Dollar	Finance
Toronto-Dominion Bank	AA	US Dollar	Finance
Toyota Finance Corp	AA-	Japanese Yen	Finance
Toyota Finance Corp	A+	Japanese Yen	Finance
Turkiye Sinai Kalkinma Bankasi AS - TSKB	BBB-	US Dollar	Finance
Unilever plc	A+	British Pound Sterling	Consumer Products
Unione di Banche Italiane SpA	BBB-	Euro	Finance
Vanguard International Semiconductor Corp	BBB-	New Taiwan Dollar	Computers & Electronics

Vodafone Group plc	BBB+	Euro	Telecommunications
Volkswagen International Finance NV	A-	Euro	Auto/Truck
Volkswagen International Finance NV	A-	Euro	Auto/Truck
Westpac Banking Corp	AA	Australian Dollar	Finance
Westpac Banking Corp	AA-	Euro	Finance
Westpac Securities NZ Ltd (London)	AA-	Euro	Finance
Woolworths Group Ltd	BBB	Australian Dollar	Retail
Wuhan Metro Group Co Ltd	A	Chinese Renminbi Yuan	Transportation
Wuhan Metro Group Co Ltd	A	Chinese Renminbi Yuan	Transportation
Wuhan Metro Group Co Ltd	A	US Dollar	Transportation
Xingcheng (BVI) Ltd	BBB+	US Dollar	Construction/Building
Zhuhai Huafa Integrated Development Co Ltd	BBB	Chinese Renminbi Yuan	Real Estate/Property
Zuercher Kantonalbank - ZKB	AAA	Swiss Franc	Finance
Zuercher Kantonalbank - ZKB	AAA	Swiss Franc	Finance
Zuercher Kantonalbank - ZKB	AAA	Swiss Franc	Finance

Table A1 : List of all green bonds in the matched sample