UNIVERSIDADE CATÓLICA PORTUGUESA

Sustainable Bonds: An Empirical Analysis of Spread and Pricing

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by

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Resumo

Este estudo apresenta uma análise abrangente dos spreads de crédito e de precificação tanto de obrigações sustentáveis, bem como, de obrigações convencionais. É analisado um conjunto de dados que inclui 39,457 obrigações emitidas por 8,753 empresas a nível mundial, entre 2018 e 2024. Os resultados apresentados revelam respostas distintas entre obrigações sustentáveis e convencionais tendo em conta os fatores de precificação, considerando que os investidores consideram outros elementos para além das notações de crédito. Adicionalmente, o estudo identifica uma diferença significativa no spread entre obrigações sustentáveis e convencionais – um padrão também evidente quando analisando as obrigações verdes, sociais e de sustentabilidade. Esta evidencia também se encontra nas amostras onde se efetuou um emparelhamento de equivalência entre obrigações sustentáveis e convencionais, bem como, quando analisando regiões especificas como a Europa e o Estados Unidos da América. Uma exceção relevante surge na comparação entre empresas financeiras e não financeiras. No caso das instituições financeiras, as diferenças no spread não são estatisticamente significativas quando se avalia obrigações sustentáveis – verdes, sociais e de sustentabilidade. Isto sugere que as entidades financeiras tendem a implementar medidas de ESG mais estruturadas e práticas de gestão de risco mais consolidadas. Assim sendo, poderá haver uma integração de ESG mais consistente nas emissões das suas obrigações sustentáveis, o que atenua as diferenças estatísticas entre os dois tipos de obrigação, uma vez que as empresas não financeiras podem adotar medidas de ESG mais diversificadas, influenciadas pelos seus setores específicos ou fatores operacionais.

Palavras-Chave: Obrigações sustentáveis, obrigações verdes, obrigações sociais, obrigações de sustentabilidade. Classificação JEL: G12; G21; G22; G23; O50; O51; O52; Q56

Abstract

This study provides a comprehensive analysis of the credit spreads and pricing for both sustainable and conventional corporate bonds. It examines a dataset that includes 39,457 bonds from 8,753 firms globally, issued between 2018 and 2024. The findings reveal distinct responses between sustainable and conventional bonds regarding standard pricing factors, highlighting that investors consider factors beyond credit ratings. Additionally, the research reveals a significant spread difference between sustainable bonds and their conventional counterparts, a pattern also evident in green, social, and sustainability bonds, as well as on the matched samples. These findings are corroborated in specific regions, including Europe and the United States of America. A key exception arises when comparing financial and non-financial firms; for financial institutions, the differences are statistically insignificant when evaluating sustainable bonds - such as green, social, and sustainability bonds. This indicates that financial entities tend to implement more structured ESG frameworks and risk management practices. Consequently, they may have a more consistent ESG integration in their sustainable bond issuances, which diminishes the statistical differences among bond types when contrasted with non-financial firms that may adopt varied ESG strategies influenced by their specific sectors or operational factors.

Key words: Sustainable bonds, green bonds, social bonds, sustainability bonds, bond pricing. JEL classification: G12; G21; G22; G23; O50; O51; O52; Q56

Table of contents

Table of Tables

Introduction

In the past decade, concerns regarding climate change have markedly intensified the efforts toward sustainable development, aiming for net-zero carbon emissions. The Paris Climate Agreement (UNFCCC, 2015)[1], which 196 countries have ratified, establishes ambitious objectives to limit the rise in global average temperature to below 2°C above pre-industrial levels, alongside specific targets for achieving net-zero carbon emissions by 2050. A significant outcome of this global commitment has been the rapid transformation of investment strategies emphasising environmental, social, and governance (ESG) criteria. As per, The United Nations Conference on Trade and Development projects to fulfil the Sustainable Development Goals (SDGs), an annual investment ranging from $5 to $7 trillion will be required from 2015 to 2030 (Pinto & Ribeiro et al., 2024). Financial markets are progressively aligning with sustainability objectives through the introduction of innovative financial instruments such as green, social, sustainability, and sustainability-linked bonds (Baldi & Pandimiglio et al., 2022). These tools have effectively channelled investment into environmentally sustainable and socially responsible projects, such as renewable energy, energy efficiency, sustainable farming, and climate adaptation efforts. Green bonds are specifically designed to finance environmental projects that contribute to a low-carbon economy, such as wind and solar energy infrastructures and pollution reduction initiatives. Conversely, social bonds emphasise projects that yield direct social benefits, such as affordable housing, healthcare, and education, thereby addressing economic inequalities. Sustainability bonds are a mix of green and social bonds, funding initiatives that concurrently produce positive environmental and social effects. Additionally, sustainability-linked bonds (SLBs) are linked to the company´s sustainability performance rather than

[1] UNFCCC - https://unfccc.int/process-and-meetings/the-paris-agreement

sustainable-specific projects, incentivising companies to enhance their environmental, social and governance (ESG) by defining metrics to establish sustainability goals. As reported by the International Capital Market Association (ICMA, 2025), the issuance of sustainable bonds exceeded $1.0 trillion for the first time in 2021. In 2024, green bonds constituted approximately 58% ($491.92 billion) of the sustainable market, whereas social bonds represented 15.46% ($132.13 billion), and sustainability bonds accounted for 23.16% ($197.92 billion). This growth underscores the increasing global commitment to financing initiatives that promote environmental and social advancement. Nevertheless, further analysis of these asset classes' operational and financial dynamics is essential. For instance, do the pricing factors differ between sustainable and conventional bonds? Are the spreads associated with sustainable bonds lower than comparable conventional bonds? This research contributes to two distinct areas of the literature. Firstly, it builds upon the existing body of work regarding the determinants of bond spreads. While substantial theoretical literature exists on the pricing of traditional corporate bonds (Bao et al., 2011; Chen et al., 2007; Flannery et al., 2012; Longstaff et al., 2005), investigations into the determinants of sustainable corporate bond spreads remain relatively limited. Previous research about sustainable bond pricing has predominantly focused on the presence of a negative yield spread between green and conventional bonds, frequently neglecting the specific elements that influence sustainable bond spreads. This research further contributes to the expanding literature on exploring the "Greenium" phenomenon in bond markets, particularly concerning green bonds. Two essential strands of literature elucidate this phenomenon. First, investors may prefer to hold bonds that fund environmentally sustainable projects (e.g.,Flammer et al., 2021; Löffler et al., 2021; Zerbib et al., 2019). So, investors are willing to pay a higher price (accept a lower yield) for green bonds than their conventional counterparts (Dorfleitner et al., 2022; Wu et al., 2022). However, this market continues to experience inefficiencies

due to persistent information imbalances and the risk of misleading sustainability claims, "greenwashing", so it needs to be closely monitored (Dorfleitner et al., 2022; DeMarzo et al., 2005).

Furthermore, the existing literature provides ambiguous insights concerning the statistical comparison of credit spreads between sustainable and conventional bonds. Several studies, including those conducted by (Flammer et al., 2021; Tang & Zhang et al., 2020), have demonstrated no significant differences in spreads between standard and sustainable bonds. Conversely, other research suggests that such differences may be considerable, for example, Löffler et al., (2021) reported that the average disparity typically ranges from 15 to 20 basis points, whereas (Caramichael & Rapp et al., 2024) noted a difference of 8 basis points. Additionally, (MacAskill et al., 2021) documented that green bonds are issued at a spread that is 6.94 basis points lower, while (Zerbib et al., 2019) identified this difference to be as minimal as -2 basis points.

The most relevant research for my study includes the work conducted by Löffler et al., (2021) which presents similar estimates for yield spread differences, ranging from 15 to 20 basis points. This study employs comparable econometric techniques and supports the hypothesis that sustainable bonds are associated with a lower credit spread. Additionally, the research conducted by Fatica et al. (2021), which is also consistent regarding financial institutions, confirms that these types of firms do not derive significant pricing benefits from green bonds. Furthermore, this study estimated a yield gap of 22 basis points, favouring green corporate bonds, which corroborates my findings.

Consequently, I enhance the existing literature by incorporating not only green bonds but also social and sustainability bonds[2], utilising a more contemporary timeframe and applying specific filters. Prior studies often

[2] Since the spread on sustainability-linked bonds varies over the life of the bond based on the achievement of specific KPIs and this study will focus only on green, social, and sustainability bonds to ensure comparability with conventional bonds.

conflated green bonds issued by entities with markedly distinct characteristics—such as financial and non-financial firms—resulting in potentially significant spread fluctuations due to various factors (e.g., Marques & Pinto et al., 2020). In this investigation, I analyse these two different categories. Also, I analyse regions (USA and Europe). Additionally, my sample is considerably more significant compared to previous studies (Caramichael & Rapp et al., 2024; Löffler et al., 2021; Sergei & Alesya et al., 2022; Wang et al., 2020; Zerbib et al., 2019) encompassing 39,457 bonds with a total value of $20,517.17 billion. Among these, 3,475 bonds are classified as sustainable, while 35,982 are categorised as conventional. Within the sustainable bonds, there are 2,694 green bonds, 346 social bonds, and 435 sustainability bonds recorded during the 2018-2024 period.

At the beginning of my analysis, I examined if sustainable bonds exhibit pricing characteristics comparable to those of traditional bonds. I adhered to the research conducted by Pinto & Ribeiro et al., (2024), which demonstrates that factors such as country risk, callable features, credit ratings, and market volatility significantly influence the pricing of both categories of bonds, thereby corroborating my findings. Moreover, currency risk predominantly impacts conventional bonds, whereas maturity primarily affects sustainable bonds. Additionally, the number of tranches and the subordination of bonds influence both bond types, with a more pronounced effect on conventional bonds.

Subsequently, I analysed whether sustainable bonds are offered at a premium compared to conventional bonds. My findings indicate that the credit spread associated with sustainable bonds significantly differs from conventional bonds, exhibiting a reduced credit spread. This result remains consistent across subsamples of green, social, and sustainability bonds, except analyses focusing on financial institutions, where the difference was not statistically significant. However, only 8.8% of my sample pertains to sustainable bonds, which indicates that the choice between sustainable and conventional bonds may be endogenous. To address this issue, I followed the approach described by Flammer et al., (2021)

and Pinto & Ribeiro et al., (2024), where for each sustainable bond, I paired it with the most comparable conventional bond based on criteria such as year, industry, region, use of proceeds, rating, country risk, number of tranches, bond subordination, callable features, liquidity, and currency risk. My results remained constant when utilising this matched sample. Therefore, I support the literature indicating that sustainable bonds have a lower yield and are issued at a premium in comparison to conventional bonds (Caramichael & Rapp et al., 2024; Fama & French et al., 2007; Löffler et al., 2021; MacAskill et al., 2021; Pedersen et al., 2021; Zerbib et al., 2019).

This document is structured as follows: Section 2 reviews pertinent literature and delineates the research hypotheses. Section 3 elaborates on the data, econometric methodologies, and variables employed in the analysis. Section 4 examines the pricing dynamics and credit spread between sustainable and conventional bonds, whereas Section 5 presents the conclusions along with the study's limitations.

2. Literature review and hypothesis

2.1 Sustainable Bonds: Economic Perspective

Sustainable bonds are defined as debt instruments specifically designed to finance projects that yield environmental or social benefits. These financial instruments have experienced significant expansion in global markets as investors and issuers acknowledge the importance of promoting sustainability initiatives. Sustainable bonds are categorised into distinct classifications, including green, social, sustainability, and sustainability-linked bonds, each addressing unique environmental objectives. Green bonds, in particular, are debt instruments exclusively issued to fund projects that generate positive

environmental impacts, such as initiatives related to renewable energy, sustainable water management, improvements in energy efficiency, and pollution prevention strategies. The proceeds derived from these bonds must be allocated to qualifying green projects in accordance with the Green Bond Principles (GBP) established by the International Capital Market Association (ICMA) (Fatica et al., 2021). The market for green bonds has experienced rapid growth, with total global issuance reaching $556 billion in 2021 (Caramichael & Rapp et al., 2024) , and investors are willing to accept slightly reduced returns to align their investments with sustainability objectives (Wu et al., 2022). According to (Dong et al., 2023), including green bonds within a diversified portfolio can function as an effective hedging strategy against the downside risk and volatility associated with climate, geopolitical, and economic factors, particularly when compared to traditional bonds. Social bonds support initiatives that produce beneficial social outcomes, with initiatives typically prioritising the provision of affordable housing, accessibility to essential services such as healthcare and education, job creation, and socio-economic development, aligning with the Social Bond Principles (SBP) established by the ICMA. The prevalence of social bonds has notably increased, particularly during crises such as the COVID-19 pandemic, when resources were mobilised for public health and emergency response efforts (Baldi & Pandimiglio et al., 2022). Sustainability bonds incorporate elements from both green and social bonds, thereby financing a combination of environmental and social initiatives. The allocation of their proceeds is more flexible compared to green bonds, accommodating simultaneous support for projects like clean water initiatives and affordable housing (Caramichael & Rapp et al., 2024). Such bonds comply with the Sustainability Bond Guidelines (SBG) established by the ICMA and are frequently issued by major corporations and supranational entities.

Finally, Sustainability-Linked Bonds (SLBs) are distinct from green, social, and sustainability bonds as they are not tied to specific environmental or social

initiatives. Rather, they signify a corporation's commitment to sustainability. Typically, the targets associated with these bonds are reflected in companies' Key Performance Indicators (KPIs), which may include the reduction of carbon emissions, enhancements in energy efficiency, improvements in Environmental, Social, and Governance (ESG) performance, and bolstering of their credibility within an eco-friendly context. This enhancement can subsequently attract more investors who are also committed to sustainability principles (Caramichael & Rapp et al., 2024). However, as sustainable finance grows, the concerns regarding greenwashing—where issuers overstate or misrepresent their projects' environmental or social benefits —have become more pronounced. Greenwashing can undermine investor confidence and reduce the effectiveness of sustainable finance in addressing climate change and social challenges (Baldi & Pandimiglio et al., 2022). In response, robust frameworks and third-party certifications have been developed to ensure credibility and transparency in sustainable bond markets (MacAskill et al., 2021; Packer et al., 2017). Furthermore, according to Reboredo et al., (2018), compliance with green, social, and sustainability bond standards necessitates considerable efforts and resources, which can be financially costly for issuers, particularly for those issuing for the first time (Tang & Zhang et al., 2020).

In the present study, I have concentrated on green, social, and sustainability bonds and compared them with conventional corporate bonds. Supranational institutions, governments, and large corporate and financial entities primarily issue these standard sustainable bonds. The principal distinction between sustainable and conventional bonds lies in the commitment of sustainable bonds to allocate their proceeds toward environmentally or socially beneficial projects. Conversely, conventional bonds may be utilised for general corporate purposes without sustainability constraints (Löffler et al., 2021). Given the unique characteristics of sustainable bonds—specifically, their defined rules for the use of proceeds, environmental, social, and governance

(ESG) risks, reporting, and certification—it is anticipated that sustainable and conventional bonds will be priced differently due to common factors. Investors may rely on certain distinctive factors. Therefore, I propose the following hypothesis.

Hypothesis 1 (H1): Sustainable bonds are priced differently from conventional bonds, and investors consider factors beyond credit ratings when assessing their value.

2.2 Spread Behaviour in Sustainable and Corporate Bonds

Investors and corporations can be attracted to sustainable bonds not only because of their environmental and reputational benefits but also because of their financial benefits. A significant financial incentive is the lower yields these sustainable bonds may provide compared to traditional bonds. This phenomenon, known as "Greenium," indicates the premium that investors are willing to pay for bonds that support environmental initiatives (Hachenberg and Schiereck et al., 2018; Zerbib et al., 2019).

The research reveals varying results concerning the size of the Greenium. Hachenberg and Schiereck et al., (2018) found no significant pricing differences, while Zerbib et al., (2019) reported a moderate premium for green bonds. Notably, both Zerbib et al., (2019) and (Packer et al., 2017) demonstrate that this premium is maintained in the secondary market, indicating its potential for long-lasting sustainability. Löffler et al., (2021), further highlight a strong and persistent Greenium of 15-20 basis points, suggesting that investors often pay more for sustainable bonds. Additionally, Fatica et al., (2021) noted a Greenium for corporate green bonds of -22 basis points, with the premium found to be insignificant for financial institutions. Recent research, including the findings of (Caramichael & Rapp et al., 2024), supports the notion that the Greenium has risen since 2019, attributed to an increasing investor focus on sustainable finance.

Research consistently indicates that sustainable bonds demonstrate lower yield spreads compared to their conventional counterparts, consequently leading to a reduction in capital costs for issuers (Baldi & Pandimiglio et al., 2022; Caramichael & Rapp et al., 2024; Flammer et al., 2021; Löffler et al., 2021; MacAskill et al., 2021). This reduction in capital costs can be attributed to investors' willingness to accept lower returns due to the firm´s commitment to sustainable investments and the long-term benefits associated with supporting Environmental, Social, and Governance (ESG) initiatives (Wu et al., 2022; Zerbib et al., 2019). Additionally, the green bond premium, known as Greenium, reflects a lower cost of debt tied to sustainable bond issuance, extensively documented in various studies (Dorfleitner et al., 2022; Fatica et al., 2021; Flammer et al., 2021; Wu et al., 2022; Zerbib et al., 2019). Dorfleitner et al., (2022) illustrate that sustainable bonds accompanied by robust external certification and third-party verification exhibit an even greater Greenium, resulting in yield reductions of up to 5 basis points, as investors regard them as lower risk and more credible. Moreover, government policies and tax breaks significantly enhance the financial advantages of green bonds. For instance, (Baldacci & Possamaï et al., 2022) reveal that green bonds afforded tax incentives, resulting in considerable financing cost reductions compared to traditional bonds (Azhgaliyeva & Kapsalyamova et al., 2023). This underscores how regulatory backing increases the financial appeal of sustainable bonds, thereby aiding the growth of the Greenium. In addition, by leveraging sustainable bonds for financing, corporations can allocate funds towards initiatives that align with their long-term sustainability objectives (Flammer et al., 2021; Zheng et al., 2023).

Furthermore, the regular issuance of sustainable bonds necessitates an increase in transparency and accountability regarding fund utilisation. Issuers must comply with regulatory requirements by providing regular reports and disclosing fund distributions, enhancing their commitment to sustainability and mitigating the greenwashing effect. This enhanced transparency boosts investor

confidence and strengthens the corporation's credibility in financial markets. Fatica et al., (2021) and Dorfleitner et al., (2022) emphasise that external validation mechanisms further bolster investor confidence, resulting in lower perceived risk and, consequently, narrower bond spreads. Regarding environmental and reputational benefits, issuing sustainable bonds can yield significant reputational benefits. Companies that demonstrate a commitment to sustainability through the issuance of green or social bonds are often viewed more favourably by stakeholders, including investors, customers, regulators, and employees. This enhanced perception can increase brand value, heighten customer loyalty, and strengthen relationships with key stakeholders.

Moreover, sustainable bonds enable issuers to connect with a growing segment of ESG-focused investors who prioritise sustainability in their investment decisions. Given the increasing investor demand for ESG-aligned financial products, companies that proactively issue sustainable bonds can tap into a diverse and expanding investor base. Research indicates that investors favour firms that integrate sustainability into their financing strategies, perceiving these companies as more resilient and forward-thinking (Tang & Zhang et al., 2020; Wang et al., 2020). DeMarzo et al., (2005) articulate the significance of market imperfections, including incomplete markets and asymmetric information, in shaping the structure of financial securities. This matter is particularly pertinent when investors don´t have a clear or accurate view of the information provided by the issuers, which impacts their ability to assess and accurately price risk. Within this context, promoting greater transparency through Environmental, Social, and Governance (ESG) certification, external evaluations, and continuous monitoring and reporting can mitigate information asymmetry. Consequently, this reduction in asymmetry leads to a better perception of the risks and contributes to a better understanding of corporate spreads. This observation aligns with research concerning general

corporate bonds, indicating that increased transparency and disclosure are linked to diminished financing costs (Yu et al., 2005).

Building upon this theoretical framework, I hypothesise that green, social, and sustainability bonds— due to their reporting standards and external verification processes—will exhibit lower spreads than similar conventional corporate bonds, thereby reflecting the market's recognition of their reduced risk and enhanced credibility.

Hypothesis 2 (H2): The spreads of sustainable and conventional bonds differ significantly, with sustainable bonds offering lower yields than conventional ones.

3. Data, methodology and variable definition

3.1 Sample selection criteria

The sample utilised in this research was extracted from DCM Analytics, encompassing the period from 2018 to 2024. I successfully exported a comprehensive database of sustainable and conventional bonds issued within the debt capital markets during this timeframe. Specific restrictions were applied to refine this database for my research objectives, notably focusing on deal types such as Corporate-Bond-Investment-Grade and Corporate-Bond-High-Yield. By concentrating on these two categories, I was able to analyse more specific risk profiles and financial performance within the corporate bond market. Additionally, the database was filtered by specific OECD[3] countries, including key participants and leading partners, ensuring that the study encompasses nations with stringent regulatory environments and stable financial systems. Furthermore, the dataset has been limited regarding the use of proceeds and

[3] OCDE - Organisation for Economic Co-operation and Development; https://www.oecd.org/

types of security. To classify the use of proceeds, I adhered to the framework established by (Kleimeier, 2000)[4]. Regarding security types, catastrophe bonds, collateral trust bonds, step-up deferred coupon notes, and perpetual bonds have been excluded due to their specialised structures, ensuring that the research remains focused on standard corporate bonds. Moreover, this study emphasises fixed-rate bonds and floating-rate bonds. After implementing this filter, the final sample comprises 39,457 bonds, totalling $20,517.17 billion. Within this sample, 3,475 bonds, valued at $1,546.56 billion, represent sustainable bonds, while 35,982 bonds, valued at $18,970.61 billion, are classified as conventional bonds. Among the sustainable bonds, there are 2,694 green bonds valued at $1,205.79 billion, 346 social bonds valued at $151.82 billion, and 435 sustainability bonds valued at $188.95 billion. Panel A of Table 1 delineates the industry breakdown of the entire sample, while Panel B outlines the tranche distribution based on the issuers' geographic locations. Panel C presents data on the top 10 issuers categorised by bond type, and Panel D illustrates the trends in sustainable and conventional bonds over the years.

The analysis presented in Panel A reveals that green bonds are primarily issued by financial institutions (36.24%) as well as non-financial companies in the utility and energy sectors (28.08%) and the real estate sector (11.29%). In contrast, social bonds are predominantly concentrated in the finance (67.07%) and transportation (20.64%) industries. Sustainability bonds have their foremost issuers in the finance sector (36.13%), utilities (18.78%), and real estate (10.14%). Conversely, conventional bonds exhibit a more diverse distribution across various industries, with substantial portions being issued by financial

[4] Classification of the use of proceeds: (i) corporate control category, including funding utilised for acquisitions, leveraged buyouts, management buyouts, private placements, or spin-offs; (ii) capital (continued) structure category, involving borrowing for refinancing, debt repayment, recapitalisation, dividend recapitalisation, and restructuring; (iii) fixed asset-based proceeds, utilised for the procurement of aircraft, shipping, and general capital expenditures; (iv) general corporate purpose category, which encompasses funding stating a general corporate purpose, credit for working capital, public finance, investments, as well as funding with an unspecified loan purpose code; and (v) project finance.

institutions (34.51%), Utilities (8.13%), healthcare (7.11%), and electronics (6.45%), which represent the most prominent sectors in conventional bond issuance. This analysis offers substantial insights into the sectors with the highest activity levels in this domain.

Panel B emphasises the notable variation in geographic distribution between conventional and sustainable bond issuances. Traditional bonds are primarily issued in the United States, with Europe following closely behind. In contrast, green and social bonds are chiefly issued by European companies, with the European Union spearheading both categories. Regarding sustainability bonds, the Americas and Europe exhibit comparable proportions, with the United States holding a marginally more significant share than the European Union. This distribution underscores the global essence of sustainable finance and its ramifications for investors.

Panel C delineates the leading ten issuers along with their comparative significance across each market segment. These corporations command a modest share of conventional bonds, which stands at 7.21%, relative to the sustainable bond market, where notable financial institutions such as JPMorgan and Bank of America contribute 2.33%. Within the sustainable market, the primary issuers account for 11.11% of the green bond volume, with ENGIE SA providing 1.73%; they represent 48.02% of the social bond market, with West Nippon accounting for 9.54%; and they constitute 21.36% of the sustainability bond market, wherein Alphabet contributes 3.17%. Furthermore, it is pertinent to acknowledge that the top ten issuers in each respective market are not the same.

Panel D presents significant trends in the issuance of Green, Social, and Sustainable bonds over the years. The issuance of these bonds has witnessed a notable increase, with 2023 representing a peak in both the value and quantity of tranches issued within these categories. Although conventional bonds have retained dominance in total value since the beginning of the observed period, the percentage of Green, Social, and Sustainable bonds within the overall market has

progressively expanded. In 2023, Green bonds accounted for a substantial share of their total value, underscoring the heightened emphasis on environmental sustainability. This upward trend in sustainable finance indicates a shift towards more environmentally and socially responsible investment strategies, thereby providing meaningful insights into market trends and guiding investors regarding the current dynamics within the market.

*T*able 1 - Industrial and geographic distribution, top issuers, and issuance per year and bond type.

Panel A: Industry distribution

Industrial category of issuer	Conventional bonds			Green bonds			Social bonds			Sustainability bonds		
	Number of tranches	Total value [$ Million]	Percent of total value	Number of tranches	Total value [$ Million]	Percent of total value	Number of tranches	Total value [$ Million]	Percent of total value	Number of tranches	Total value [$ Million]	Percent of total value
Commercial and Industrial												
Aerospace	252	239 548	1,26	3	303	0,03	0	0	0,00	0	0	0,00
Agribusiness	63	9 633	0,05	5	811	0,07	0	0	0,00	0	0	0,00
Auto/Truck	895	487 528	2,57	72	50 261	4,17	0	0	0,00	18	6 831	3,62
Chemicals	756	339 246	1,79	43	20 251	1,68	2	134,00	0,09	4	224,00	0,12
Closed End Funds	17	1 685	0,01	0	0	0,00	0	0	0,00	0	0	0,00
Computers & Electronics	1 632	1 224 254	6,45	39	19 450	1,61	7	1 882	1,24	15	12 998	6,88
Construction/Building	1 478	504 262	2,66	67	17 343	1,44	0	0	0,00	4	1 145	0,61
Consumer Products	590	350 459	1,85	15	6 967	0,58	0	0	0,00	3	1 454	0,77
Defense	48	34 279	0,18	0	0	0,00	0	0	0,00	0	0	0,00
Dining & Lodging	275	136 770	0,72	3	812	0,07	0	0	0,00	5	3 143	1,66
Finance	11 144	6 546 921	34,51	797	436 991	36,24	179	101 815	67,07	146	68 273	36,13
Food & Beverage	1 056	609 812	3,21	22	7 895	0,65	6	1 334	0,88	6	2 345	1,24
Forestry & Paper	180	68 149	0,36	41	18 931	1,57	0	0	0,00	2	995	0,53
Government	40	9 587	0,05	4	499	0,04	0	0	0,00	4	3 229	1,71
Healthcare	1 703	1 349 049	7,11	13	4 590	0,38	11	2 125	1,40	9	6 821	3,61
Holding Companies	292	105 537	0,56	4	1 548	0,13	0	0	0,00	1	42	0,02
Insurance	1 349	691 259	3,64	46	26 905	2,23	6	2 595	1,71	17	9 544	5,05
Leisure & Recreation	407	237 752	1,25	1	77	0,01	0	0	0,00	0	0	0,00
Machinery	466	212 857	1,12	16	6 074	0,50	0	0	0,00	0	0	0,00
Metal & Steel	416	153 206	0,81	23	8 331	0,69	0	0	0,00	3	1 554	0,82
Mining	303	157 768	0,83	7	1 222	0,10	0	0	0,00	0	0	0,00
Oil & Gas	1 301	856 731	4,52	11	4 984	0,41	0	0	0,00	0	0	0,00
Professional Services	843	274 956	1,45	21	10 983	0,91	4	1 058	0,70	10	2 397	1,27
Publishing	80	39 552	0,21	0	0	0,00	3	1 047	0,69	0	0	0,00
Real Estate/Property	2 274	774 549	4,08	511	136 107	11,29	14	7 642	5,03	62	19 152	10,14
Retail	707	421 968	2,22	24	7 615	0,63	0	0	0,00	3	1 441	0,76
Telecommunications	1 085	854 217	4,50	46	31 163	2,58	0	0	0,00	12	6 027	3,19
Textile	61	21 823	0,12	0	0	0,00	0	0	0,00	0	0	0,00
Transportation	1 938	715 782	3,77	160	47 068	3,90	111	31 342	20,64	28	5 855	3,10
Utility & Energy	4 331	1 541 469	8,13	700	338 611	28,08	3	841	0,55	83	35 481	18,78
Total	**35 982**	**18 970 608**	**100,00**	**2 694**	**1 205 792**	**100,00**	**346**	**151 815**	**100,00**	**435**	**188 951**	**100,00**

Geographic location of issuer	Conventional bonds			Green bonds			Social bonds			Sustainability bonds		
	Number of tranches	Total value [$ Million]	Percent of total value	Number of tranches	Total value [$ Million]	Percent of total value	Number of tranches	Total value [$ Million]	Percent of total value	Number of tranches	Total value [$ Million]	Percent of total value
Europe	**10 336**	**5 464 537**	**28,81**	**1 659**	**788 230**	**65,37**	**118**	**74 650**	**49,17**	**164**	**70 946**	**37,55**
European Union	6 213	3 716 755	19,59	1 124	623 050	51,67	85	57 142	37,64	75	33 706	17,84
United Kingdom	1 853	1 235 034	6,51	91	54 244	4,50	33	17 508	11,53	71	29 531	15,63
Others Europe	2 270	512 748	2,70	444	110 936	9,20	0	0	0,00	18	7 709	4,08
America	**18 418**	**11 048 301**	**58,24**	**477**	**243 808**	**20,22**	**35**	**22 275**	**14,67**	**131**	**69 917**	**37,00**
United States	12 413	8 841 017	46,60	287	175 947	14,59	21	18 628	12,27	61	45 919	24,30
Canada	1 882	1 085 276	5,72	107	38 140	3,16	3	1 350	0,89	22	9 043	4,79
Latin America	4 123	1 122 008	5,91	83	29 721	2,46	11	2 297	1,51	48	14 955	7,91
Asia	**5 780**	**1 903 067**	**10,03**	**507**	**152 071**	**12,61**	**193**	**54 890**	**36,16**	**116**	**36 679**	**19,41**
China	2 831	892 602	4,71	197	76 280	6,33	2	800	0,53	16	8 426	4,46
Japan	2 333	971 892	5,12	251	62 067	5,15	138	36 604	24,11	62	13 434	7,11
Others Asia	616	38 573	0,20	59	13 724	1,14	53	17 486	11,52	38	14 819	7,84
Australasia	**1 402**	**545 186**	**2,87**	**51**	**21 683**	**1,80**	**0**	**0**	**0,00**	**24**	**11 409**	**6,04**
Africa	**46**	**9 517**	**0,05**	**0**	**0**	**0,00**	**0**	**0**	**0,00**	**0**	**0**	**0,00**
Total	**35 982**	**18 970 608**	**100,00**	**2 694**	**1 205 792**	**100,00**	**346**	**151 815**	**100,00**	**435**	**188 951**	**100,00**

(continued)

Panel C: Top issuers

Conventional bonds		Green bonds		Social bonds		Sustainability bonds	
Firm	**By value of deals**	**Firm**	**By value of deals**	**Firm**	**By value of deals**	**Firm**	**By value of deals**
Bank of America Corp	1,18%	ENGIE SA	1,73%	West Nippon Expressway Co Ltd	9,54%	Alphabet Inc	3,17%
JPMorgan Chase & Co	1,15%	E.ON SE	1,36%	East Nippon Expressway Co Ltd	8,92%	Housing New Zealand Ltd	3,02%
HSBC Holdings plc	0,74%	Intesa Sanpaolo SpA	1,30%	Motability Operations Group plc	6,94%	Southern Water Services (Finance) Ltd	2,70%
Wells Fargo & Co	0,66%	TenneT Holding BV	1,22%	CaixaBank SA	5,36%	Southern California Edison Co	2,59%
Royal Bank of Canada	0,65%	ABN AMRO Bank NV	1,17%	Citigroup Inc	3,95%	Severn Trent Utilities Finance plc	1,76%
Toronto-Dominion Bank	0,65%	DNB Bank ASA	1,00%	BPCE SA	3,43%	Koninklijke Philips NV	1,72%
Citigroup Inc	0,56%	Energias de Portugal SA-EDP	0,89%	Credit Agricole SA	2,75%	Comision Federal de Electricidad - CFE	1,68%
Banco Santander SA	0,54%	ING Groep NV	0,88%	Korea Housing Finance Corp	2,53%	Cofinimmo SA/NV	1,68%
Toyota Motor Credit Corp	0,54%	Iberdrola Finanzas SAU	0,78%	NH Nonghyup Bank	2,30%	Georgia Power Co	1,59%
Goldman Sachs Group Inc	0,54%	EDF Electricite de France SA	0,78%	Vonovia SE	2,30%	Clarion Funding plc	1,45%
	7,21%		**11,11%**		**48,02%**		**21,36%**

Panel D: Issuance per year and type of bond

	Conventional bonds			Green bonds			Social bonds			Sustainability bonds		
	Number of tranches	**Total value [$ Million]**	**Percent of total value**	**Number of tranches**	**Total value [$ Million]**	**Percent of total value**	**Number of tranches**	**Total value [$ Million]**	**Percent of total value**	**Number of tranches**	**Total value [$ Million]**	**Percent of total value**
2018	5 164	2 254 839	11,89	108	48 830	4,05	11	4 315	2,84	9	3 637	1,92
2019	5 031	2 429 714	12,81	210	88 762	7,36	10	4 796	3,16	36	13 719	7,26
2020	5 129	3 092 674	16,30	212	100 130	8,30	31	19 681	12,96	41	23 583	12,48
2021	4 326	2 560 811	13,50	401	210 813	17,48	42	24 009	15,81	93	50 908	26,94
2022	3 465	1 892 720	9,98	392	173 486	14,39	64	23 628	15,56	76	32 324	17,11
2023	7 628	4 133 906	21,79	840	369 220	30,62	114	43 424	28,60	116	43 432	22,99
2024	5 239	2 605 944	13,74	531	214 551	17,79	74	31 962	21,05	64	21 348	11,30
Total	**35 982**	**18 970 608**	**100,00**	**2 694**	**1 205 792**	**100,00**	**346**	**151 815**	**100,00**	**435**	**188 951**	**100,00**

Table 1: Panel A outlines the distribution of deals across the industry, while Panel B details the allocation of tranches to issuers in specific countries. Panel C highlights the major players and their significance within traditional and sustainable bond markets, and Panel D displays the types of bond issuances categorized by category and year. The data pertains to tranches with credit spreads and available amounts, covering the global period. from 2018 to 2024.

3.2 Methodology and key variables

This study investigates the prevalent pricing determinants for sustainable bonds, specifically green, social, and sustainability bonds. It compares their credit spreads to conventional corporate bonds with similar ratings. To facilitate this comparison, I have employed the Ordinary Least Squares (OLS) regression model delineated in Equation (1) to analyse this interaction while concurrently adjusting for potential heteroskedasticity and accounting for time-varying risk premiums and cross-country variances. The OLS model is widely recognised in financial research for its efficacy in managing multiple independent variables and yielding reliable estimates. Standard errors are calculated and clustered by year and country to mitigate potential biases. In conducting this analysis, I have

adhered to existing pricing models elucidated in recent studies that have provided valuable insights into these determinants, including works by (Chen et al., 2007; Fatica et al., 2021; Pinto & Ribeiro et al., 2024; Wu et al., 2022; Zerbib et al., 2019; Zhou & Kythreotis et al., 2024), thereby ensuring that the methodology employed in this study is both robust and reliable.

(1)

$$Credit\ Spread_{i,t} = + \sum_{n=1}^{20} \beta_n\ Rating\ dummy_{n,i,t} + \beta_{21}\ Not\ Rated_{i,t} + \gamma\ Contractual\ characteristics_{i,t} + \phi\ Marcroeconomic\ factors_t + \epsilon_{i,t}$$

By adhering to the above equation, Table 2 delineates comprehensive explanations and references for each variable utilised in the study.

Table 2 - Definition of variables and sources

Variable name	Variable definition	Source
Dependent variable:		
Credit spread	Spread between coupon rate of security and US Treasury or Benchmark (bps)	DCM Analytics
Independent variables:		
Core variables		
Sustainable	Dummy equal to 1 if a bond is classified as sustainable bond (green, social, and sustainability bonds), and 0 otherwise.	DCM Analytics
Green	Dummy equal to 1 if a bond is classified as green bond (instruments made available for the purposes of financing a 'green project'), and 0 otherwise.	DCM Analytics
Social	Dummy equal to 1 if a bond is classified as social bond (instruments made available for the purposes of financing projects designed to deliver social benefits or achieve positive social outcomes), and 0 otherwise.	DCM Analytics
Sustainability	Dummy equal to 1 if a bond is classified as sustainable bond (instruments made available for the purposes of (re)financing a combination of both green and social projects), and 0 otherwise.	DCM Analytics
Rating	Bond credit rating 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 DD=21. Code 0 = note rated.	DCM Analytics
Not rated	Dummy equal to 1 if the bond does not have a credit rating from S&P or Moody's, and 0 otherwise.	DCM Analytics

(continued)

Contractual characteristics		
Subordinated	Dummy equal to 1 if the bond is subordinated, and 0 otherwise.	DCM Analytics
Maturity	Maturity of bonds, in years.	DCM Analytics
Liquidity	Bond transaction size.	DCM Analytics
Number of tranches	The number of tranches per transaction.	DCM Analytics
Tranche Underwriters	The number of underwriters on a tranche	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
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.	Yahoo Finance
Country risk	Moddy´s country credit rating at close. The rating is converted as follows: Aaa=1, Aa1=2, and so on until Ca=20	Moddy´s Global Ratings
Yied curve slope	The difference between interest rates on short-term and long-term government bonds	Datastream

3.2.1 Credit Spread Analysis

The credit spread denotes the differences in yield between bonds of comparable maturity yet varying credit quality. This is predominantly the differential observed between a corporate bond and a risk-free government bond or benchmark. I have utilised the data exported from DCM Analytics Tranche-spread to benchmark (basis points) and for tranches with lacking values substituted with Tranche-spread to swap (basis points).

3.2.2 Core Variables

In pursuit of testing hypothesis *H2*, it is imperative to categorise bonds according to their ESG characteristics. I have developed a dummy variable

termed "sustainable", which assigns a value of one to sustainable bonds—those directed at financing projects yielding positive environmental or social outcomes—and a value of zero otherwise. I anticipate that sustainable bonds will demonstrate narrower credit spreads compared to their conventional counterparts. Furthermore, I have established three additional dummy variables representing each category of sustainable bond: green, social, and sustainability bonds.

According to the following authors, credit rating serves as a crucial determinant of credit spread (Elton et al., 2001; Longstaff et al., 2005); furthermore, specific authors have observed that credit ratings exert influence over premiums associated with green bonds, referred to as "Greenium" (Fatica et al., 2021; Zerbib et al., 2019). In this investigation, the credit ratings provided by Moody's and S&P have been reformulated into a numerical scale: AAA = Aaa = 1, AA+ = Aa1 = 2, and continuing down to DD= 21 (Fatica et al., 2021; Kapraun et al.,2021; Pinto & Ribeiro et al., 2024). For tranches lacking a rating, I have implemented a dummy variable labelled "not rated," which equals one when the bond does not possess rating information and zero otherwise. Considering the correlation between rating scales and a company's creditworthiness, I hypothesise that credit spreads will rise for tranches without ratings.

3.2.3 Contractual Characteristics

Numerous studies have underscored that, in addition to credit ratings, several fundamental contractual elements significantly influence the determinants of bond spreads (Fatica et al., 2021; Hinsche et al., 2022.; Hyun et al., 2020; Kapraun et al., 2021.; Löffler et al., 2021; Pinto & Ribeiro et al., 2024; Zerbib et al., 2019). These critical factors encompass subordination, maturity, liquidity (measured as proxy transaction size), the number of tranches, tranche underwriters, currency risk, and callability. Subordinated bonds inherently carry greater risk than senior bonds, as they are only repaid after senior debt in the event of default.

Consequently, investors necessitate a higher premium to offset this increased risk, which is anticipated to positively affect the credit spread (resulting in a higher spread). To facilitate this evaluation, I incorporate a subordinated dummy variable. Regarding maturity, longer-term bonds generally exhibit higher credit spreads due to their elevated credit risk than short-term securities. Investors will seek a more significant premium for long-term bonds in this context, positively influencing the spread. However, as Hyun et al., (2020) and Kapraun et al., (2021) noted, substantial green bond transactions tend to diminish green bond premiums, negatively impacting credit spreads. Some investors may depend on market information for decision-making; thus, I contend it is essential to consider tranche underwriters, as a more significant number of underwriters typically indicates robust market confidence, which reduces perceived risk and leads to lower spreads. Concerning currency risk, I believe that bonds issued in foreign countries will entail higher spreads due to their exposure to exchange rate risk. Kapraun et al., (2021) propose that investors possess greater confidence in green bonds issued in major currencies, while Fatica et al., (2021) suggest that bonds issued in local currencies are likely to maintain stricter credit spreads due to minimised exchange risk. Also, per the findings of Fatica et al., (2021), callable bonds present reinvestment risk for investors since these bonds grant the issuer the option to redeem the bond before its maturity. This phenomenon may occur when interest rates decline, resulting in heightened demand from investors to mitigate this risk. Consequently, I anticipate a favourable impact on the credit spread. I have incorporated a callable dummy variable into my analysis to assess this effect.

3.2.4 Macroeconomic Controls

In addition to the previous elements, I have conducted an analysis of how macroeconomic factors influence credit spread. To assess market volatility, I employed the Chicago Board Options Exchange Volatility Index (VIX), positing

that market volatility has a positive correlation with credit spread, as corroborated by the findings of Löffler et al., (2021). To address the uncertainty in the market over recent years due to the pandemic, elevated inflation, and geopolitical conflicts, I utilised the yield curve slope (the five-year treasury bond, three months), anticipating that this would adversely affect credit spread, as instability prompts a heightened demand from investors for risk compensation. Regarding country risk, I also anticipate a positive effect on credit spread; for this assessment, I gathered data from Moody's sovereign credit ratings, following the methodologies employed by Marques & Pinto et al., (2020), whereby the ratings were converted into numerical scores, with Aaa assigned a value of 1, Aa1 as 2, and so forth, culminating in Ca as 20.

3.3 Financial characteristics of sustainable versus conventional bonds

Concerning the pricing of sustainable bonds in comparison to conventional bonds, Table 3 demonstrates that the average spread is higher for conventional bonds, registering at 194.3 basis points (bps) than for any of the sustainable bond categories: 158.9 bps for green bonds, 94.1 bps for social bonds, and 163.9 bps for sustainability bonds. The average maturity for conventional bonds is recorded at 8.4 years, which is lower than that of sustainability bonds at 9.4 years. However, it is comparable to the maturities of green bonds at 8 years and social bonds at 7.1 years. The credit ratings remain consistent for both conventional and green bonds, with a notable decrease observed when analysing social and sustainability bonds. Furthermore, the average transaction size for conventional bond tranches exceeds that of the remaining categories. Analogous patterns are noted in the number of tranches per deal. All four types of funds exhibit significant similarity in the number of underwriters per deal; however, in the case of social and

sustainability bonds, there is a slight increase in country risk. The dummy variables in Table 3 indicate that the percentage of subordinated deals presented in conventional and green bonds remains relatively stable at 3.1% and 3.3%, respectively, in contrast to 1.4% for social bonds and 5.1% for sustainability bonds. These results suggest that the prevailing pricing characteristics diverge between sustainable and conventional bond tranches, leading to the expectation that the credit spread for sustainable bonds will be lower than traditional corporate bonds.

Table 3 - Univariate statistics – pricing features associated with bonds compared

Variable of interest	Conventional bonds	Sustainable bonds			Variable of interest	Conventional bonds	Sustainable bonds		
		Green bonds	Social bonds	Sustainability bonds			Green bonds	Social bonds	Sustainability bonds
Univariate analysis - continuous variables									
Credit spread (bps)					**Country risk [1-20 weak]**				
Number	35 982	2 694	346	435	Number	35 982	2 694	346	435
Mean	194,3	158,9	94,1	163,9	Mean	3,1	3,0	4,4	4,1
Median	140	128	68	113	Median	1	1	5	4
Rating [1-21 weak]					**Maturity (years)**				
Number	35 982	2 694	346	435	Number	35 982	2 694	346	435
Mean	6,2	6,2	4,2	5,5	Mean	8,4	8,0	7,1	9,4
Median	3	3	3	3	Median	6	6	5	6
Number of tranches					**N° of Underwriters**				
Number	35 982	2 694	346	435	Number	35 982	2 694	346	435
Mean	2,0	1,4	1,9	1,5	Mean	0,3	0,3	0,2	0,3
Median	1	1	2	1	Median	0	0	0	0
Tranche size (€ Million)									
Number	35 982	2 694	346	435					
Mean	527,2	447,6	438,8	434,4					
Median	431	447	370	398					
Univariate analysis - dummy variables									
Subordinated					**Callable**				
Nr. of tranches	35 982	2 694	346	435	Nr. of tranches	35 982	2 694	435	435
Nr. of tranches with d=1	1 098	90	5	22	Nr. of tranches with d=1	19 649	1 454	111	230
% of total	3,1%	3,3%	1,4%	5,1%	% of total	54,6%	54,0%	25,5%	52,9%
Currency risk									
Nr. of tranches	35 982	2 694	346	435					
Nr. of tranches with d=1	26 284	1 910	270	306					
% of total	73,0%	70,9%	78,0%	70,3%					

This table summarizes the statistics for a sample of sustainable bonds – green, social, and sustainability bonds -as well as conventional bonds. The data covers bonds with available credit spread and tranche amounts globally from 2018 to 2024. Information about bond issuance characteristics was obtained from DCM analytics. Ratings are converted as follows: AAA=Aaa=1, AA+=Aa1=2, continuing sequentially until DD=21. For definitions of variables, refer to Table 2.

4. Pricing dynamics and credit spread of sustainable versus conventional bonds.

4.1 Do the factors affect the credit spread of sustainable and conventional bonds differently?

To evaluate Hypothesis H1, a Chow test was conducted to determine whether the credit spread of sustainable and conventional bonds is influenced by distinct pricing characteristics, as outlined in Equation (1). The results of the Chow test (F = 9.78, Prob > F = 0.000) indicate a significant structural break (p-value = 0.000), thus confirming that the effects of primary financial characteristics on bond spreads indeed differ between sustainable and conventional bonds. This structural divergence suggests that financial markets assess sustainable bonds differently from conventional bonds, likely due to investors' preferences for environmental, social, and governance (ESG) factors. These findings align with the study conducted by Cicchiello et al., (2022), which emphasises that sustainable bonds may command a premium, with pricing primarily influenced by issuer characteristics and prevailing market conditions. Moreover, both the cited research and my analysis indicate that differences in credit ratings can significantly affect the pricing of sustainable bonds, supporting the observable structural break identified in the Chow test. Furthermore, market liquidity and macroeconomic factors are pivotal in influencing bond spreads, as evidenced by the inclusion of the VIX (volatility index) and country risk discussed in section 3.2.4. The results demonstrate that sustainable bonds exhibit a distinct sensitivity to these macroeconomic factors when compared to conventional bonds. Volatility is linked to broader spreads for all bond types, though its impact appears less pronounced for sustainable bonds, as indicated by the coefficients (conventional bond coefficient = 2. 40, p- value = 0. 001; sustainable bond

coefficient = 1. 89, p- value = 0. 000). This indicates that sustainable bonds may be viewed as safer or more stable during times of market volatility, likely due to investor confidence in their enduring value or their connection to ESG principles. Furthermore, country risk significantly influences both bond categories, but its effect is stronger for conventional bonds (coefficient = 13. 62, p- value = 0. 000; sustainable bonds coefficient = 6. 34, p- value = 0. 020). This implies that conventional bonds are more susceptible to specific country risks. Conversely, sustainable bonds generally attract investors focused on long- term stability, making them less affected by temporary political or economic instability. Additionally, sustainable bonds are often issued by organizations with strong governance or are tied to low- risk projects, helping to alleviate the impact of broader country- level uncertainties. Furthermore, liquidity is crucial in bond pricing; findings show that liquidity greatly lowers credit spreads for conventional bonds (Liquidity coefficient =- 13. 53, p- value = 0. 000). However, its influence on sustainable bonds is less significant and statistically negligible (Liquidity coefficient =- 5. 91, p- value = 0. 269), suggesting that liquidity issues may be less important for investors valuing sustainable bonds. Investors in sustainable bonds tend to prioritize mission- driven objectives or long- term results, which minimises their focus on short- term tradability. Additionally, these bonds may benefit from strong demand and a committed base of ESG-focused investors, reducing the impact of liquidity constraints on their pricing. Finally, the Chow test results affirm that a bond' s credit rating positively affects spreads for both categories: sustainable bonds show a coefficient of 3. 96 (p- value = 0. 000), while conventional bonds have a coefficient of 5. 55 (p- value = 0. 000). The difference in coefficients suggests that conventional bonds respond more to shifts in credit ratings, potentially because investors rely more on ratings to assess risk in traditional markets. For sustainable bonds, while credit ratings remain significant, the smaller coefficient indicates that investors might also

consider non- financial elements- such as ESG performance and the project' s intent- when assessing pricing risk.

Table 4 - Factors affecting spread of sustainable versus conventional bonds

Dependent variable: Credit spread (bps)	Sustainable bonds	Conventional bonds
Independent variables:		
Log liquidity	-5,91	-13,53 ***
	(0.269)	(0.000)
Number of underwriters	-1,89	-4,11 ***
	(0.453)	(0.000)
Currency risk	-16,94 **	4,77
	(0.026)	(0.456)
Maturity	1,81 *	-3,67 ***
	(0.051)	(0.000)
Log maturity	-30,59 **	44,73 ***
	(0.028)	(0.000)
Rating	3,96 ***	5,55 ***
	(0.000)	(0.000)
Not Rated	88,59 ***	88,87 ***
	(0.000)	(0.000)
Subordinated	56,23 ***	26,36 ***
	(0.000)	(0.008)
Callable	107,36 ***	105,76 ***
	(0.000)	(0.000)
Number of tranches	-16,73 ***	-12,80 ***
	(0.000)	(0.000)
Market volatility	1,89 ***	2,40 ***
	(0.000)	(0.001)
Yied curve slope	-0,10 *	-0,08 *
	(0.094)	(0.086)
Country risk	6,34 **	13,62 ***
	(0.020)	(0.000)
Intercept	107,25 **	38,09
	(0.024)	(0.121)
Number of observations	39 457	39 457
of which sustainable	3 475	3 475
of which conventional	35 982	35 982

This table displays the results of the OLS regression conducted on the Chow test for sustainable and conventional bonds over the period from 2018 to 2024. Sustainable bonds include green, social, and sustainability bonds. Bond characteristics data were obtained from DCM analytics. For each independent variable, the first row indicates the estimated coefficient, while the second row shows the p-value. Standard errors are robust to heteroskedasticity and clustered at the country-year level. The symbols ***, **, and * denote that the reported coefficients differ significantly from zero at the 1%, 5%, and 10% levels, respectively. For variable definitions, refer to Table 2.

In summary, my research elucidates the distinct pricing dynamics pertinent to sustainable bonds. This suggests that the market evaluates these two categories of bonds from divergent perspectives, influenced by both financial and non-

financial factors. Whereas conventional bonds are more susceptible to traditional risk metrics such as credit ratings, liquidity, and country risk, Sustainable bonds are evaluated with increased emphasis on Environmental, Social, and Governance (ESG) elements and long-term impact value. The reduced sensitivity of sustainable bonds to market fluctuations and country-specific risks suggests a more stable investor base focused on mission-driven goals. Ultimately, the findings highlight that sustainable bonds represent a distinct segment in financial markets, influenced not only by economic fundamentals but also by the values held by investors and wider societal aspirations.

4.2 Do sustainable bonds have a lower credit spread than conventional bonds?

This section investigates the existence of significant differences between the spreads of sustainable and conventional bonds. Moreover, it examines whether green, social, or sustainability bonds are issued at a premium compared to conventional bonds. If investors exhibit a preference for holding sustainable bonds, it follows that these bonds would display a lower credit spread than their conventional corporate counterparts, thereby substantiating Hypothesis 2 (*H2*). My analysis commences with comparing the credit spread between sustainable and conventional bonds, utilising Equation (1), which incorporates a sustainable dummy variable. This variable is assigned a value of 1 if the bonds are classified as sustainable (i.e., green, social, or sustainability) and a value of 0 for conventional bonds. The findings presented in column 1 of Table 5 - pertain to model [1] based on the samples delineated in Section 3.3 – indicate a significant difference in sustainable bonds' credit spread compared to conventional bonds. Comparable results are observed in the model [2], which includes controls for the use of proceeds, along with industry, year, and regional fixed effects. Furthermore, to assess the robustness of my findings, I have re-estimated the

models for specific sub-samples, focusing on regions such as Europe and the United States, which collectively represent 63% of the total sample of conventional bonds, 72% of the total sample of green bonds, 40% of the total sample of social bonds, and 52% of the total sample of sustainability bonds. Additionally, I re-estimated the model for financial and non-financial firms, employing identical fixed effects controls, specifically, model [3] for Europe, model [4] for the United States, and models [5] and [6] for financial and non-financial companies, respectively. The results align with those of the previous models, affirming that sustainable bonds' credit spread significantly diverges from conventional bonds. A potential limitation of the earlier models pertains to endogeneity, as the choice between sustainable and conventional bonds may not exhibit a sufficiently exogenous variation. Furthermore, sustainable bonds constitute only 9% of the total sample. To address these concerns, I adopted the methodologies proposed by Flammer et al., (2021) and Roberts and Whited et al., (2013), re-estimating the model [6] for a matched sample model [7]. A propensity score matching (PSM) approach was employed, wherein each sustainable bond was paired with its most comparable conventional bond through a 1-1 matching algorithm based on parameters including credit rating, transaction size, maturity, number of tranches, callable features, and currency risk. This method culminated in a final sample comprising 2,009 sustainable bonds matched with 2,009 nearly identical conventional bonds.

The results delineated in column 7 of Table 5, representing model [7], still reveal a significant disparity in the spread of sustainable bonds when compared to conventional bonds, where sustainable bonds show a decrease of the credit spread by 22.27 bps. These findings substantiate prior research (Baldi & Pandimiglio et al., 2022; Caramichael & Rapp et al., 2024; MacAskill et al., 2021; Pedersen et al., 2021; Wu et al., 2022; Zerbib et al., 2019). Consequently, I hereby endorse hypothesis *H2*.

Table 5 - The Pricing of sustainable versus conventional bonds

Dependent variable: Credit spread (bps)	[1] All bonds	[2] All bonds	[3] Europe	[4] U.S.	[5] Financial firms	[6] NonFinancial firms	[7] All bonds | Matched
Independent variables:							
Sustainable bond	-44,41 ***	-21,97 ***	-7,86 **	-15,16 ***	-11,57 *	-25,80 ***	-22,27 ***
	(0.000)	(0.000)	(0.041)	(0.007)	(0.066)	(0.000)	(0.000)
Log liquidity	-13,47 ***	-14,29 ***	-3,84 ***	-14,83 ***	-7,76 ***	-20,33 ***	-14,78 ***
	(0.000)	(0.000)	(0.004)	(0.000)	(0.000)	(0.000)	(0.000)
Number of underwriters	-4,06 ***	-2,35 ***	-1,93	-2,88 ***	0,01	-3,48 ***	-2,89 **
	(0.000)	(0.000)	(0.109)	(0.000)	(0.996)	(0.000)	(0.039)
Currency risk	2,50	-10,99 ***	-14,10 ***	7,77 ***	-0,12	-13,58 ***	-19,62 ***
	(0.681)	(0.000)	(0.000)	(0.005)	(0.977)	(0.000)	(0.000)
Maturity	-3,26 ***	-2,80 ***	-0,15 ***	-3,42 ***	-1,80 ***	-2,99 ***	-1,61 ***
	(0.000)	(0.000)	(0.711)	(0.000)	(0.004)	(0.000)	(0.004)
Log maturity	39,46 ***	33,77 ***	-21,65 ***	44,07 ***	36,48 ***	33,38 ***	11,83 *
	(0.008)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.069)
Rating	5,41 ***	4,27 ***	3,50 ***	4,73 ***	4,94 ***	4,04 ***	3,24 ***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Not Rated	89,90 ***	81,34 ***	99,81 ***	64,39 ***	74,95 ***	88,61 ***	85,03 ***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Subordinated	30,12 ***	48,66 ***	55,38 ***	87,91 ***	40,96 ***	74,65 ***	45,31 ***
	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Callable	105,87 ***	73,00 ***	114,69 ***	28,20 ***	59,82 ***	72,05 ***	83,89 ***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Number of tranches	-13,08 ***	-15,18 ***	-15,10 ***	-20,44 ***	-7,56 ***	-17,86 ***	-18,75 ***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Market volatility	2,38 ***	1,68 ***	1,56 ***	2,62 ***	2,36 ***	1,42 ***	1,83 ***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Yied curve slope	-0,08	-0,09 ***	-0,19 ***	-0,10 ***	-0,12 ***	-0,09 ***	-0,08 *
	(0.080)	(0.000)	(0.000)	(0.001)	(0.002)	(0.002)	(0.070)
Country risk	13,03 ***	13,36 ***	8,80 ***	1,68	13,88 ***	11,80 ***	9,71 ***
	(0.000)	(0.000)	(0.000)	(0.123)	(0.000)	(0.000)	(0.000)
Intercept	48,75 **	194,76 ***	241,58 ***	213,17 ***	80,81 ***	270,06 ***	253,54 ***
	(0.047)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Use of proceeds fixed effects	No	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	No	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	No	Yes	Yes	Yes	Yes	Yes	Yes
Region fixed effects	No	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	39 457	39 457	12 277	15 870	12 266	27 191	4 018
of which sustainable	3 475	3 475	1 941	540	1 122	2 353	2 009
of which conventional	35 982	35 982	10 336	15 330	11 144	24 838	2 009
Adjusted R^2	0,14	0,19	0,29	0,36	0,13	0,21	0,33

This table illustrates the findings of OLS regression concerning credit spread across a global selection of sustainable and conventional bonds issued between 2018 and 2024. Sustainable bonds include green, social, and sustainability bonds. Data on the characteristics of these bonds were obtained from DCM analytics. Models [1] and [2] encompass the entire bond sample, whereas Models [3] and [4] concentrate on country-specific subsamples, namely Europe and the U.S. Models [5] and [6] analyse firm characteristics, differentiating between financial and non-financial subsamples. Model [7] presents findings for a matched subsample of sustainable and conventional bonds, generated through a propensity score matching technique that utilizes a 1-to-1 matching algorithm to pair each sustainable bond with its closest conventional counterpart sharing the same characteristics. For each independent variable, the first row displays the estimated coefficient, and the second row shows the p-value. Standard errors are robust to heteroskedasticity and clustered at the country-year level. Statistical significance is indicated by ***,**, and * for coefficients that differ from zero at the 1%, 5%, and 10% levels, respectively. For variable definitions, refer to Table 2.

As illustrated in Table 1, the sample of sustainable bonds encompasses 2,694 green bonds, 346 social bonds, and 435 sustainability bonds. The results of the re-evaluation of the models presented in Table 5 are exhibited in Table 6, where the sustainable dummy variable has been substituted with three distinct dummy variables corresponding to each category of sustainable bonds (green, social, and sustainability). Model [9] analysis indicates that sustainability bonds no longer demonstrate significantly lower spreads than conventional bonds. Nevertheless, on average, green bonds maintain a lower spread of 23.18 basis points, while social bonds exhibit a reduction of 10.47 basis points compared to conventional bonds.

Table 6 - The Pricing of sustainable versus conventional bonds: category breakdown

Dependent variable: Credit spread (bps)	[8] All bonds	[9] All bonds	[10] Europe	[11] U.S.	[12] Financial firms	[13] NonFinancial firms	[14] All bonds | Matched
Independent variables:							
Green bond	-42,10 ***	-23,18 ***	-9,28 **	-11,16 **	-8,56	-29,68 ***	-22,26 ***
	(0.000)	(0.000)	(0.024)	(0.075)	(0.244)	(0.000)	(0.000)
Social bond	-35,20 ***	-10,47 *	-4,19	-38,18 ***	-11,55	-4,78	-8,83 *
	(0.000)	(0.052)	(0.532)	(0.002)	(0.115)	(0.543)	(0.079)
Sustainability bond	-12,71 ***	-5,19	2,39	-5,18	-4,54	-3,27	-8,49 ***
	(0.003)	(0.102)	(0.532)	(0.243)	(0.400)	(0.401)	(0.003)
Log liquidity	-13,45 ***	-14,28 ***	-3,78 ***	-14,82 ***	-7,78 ***	-20,35 ***	-14,79 ***
	(0.000)	(0.000)	(0.005)	(0.000)	(0.000)	(0.000)	(0.000)
Number of underwriters	-4,06 ***	-2,35 ***	-1,91	-2,91 ***	0,01	-3,46 ***	-2,88 **
	(0.000)	(0.000)	(0.113)	(0.000)	(0.997)	(0.000)	(0.039)
Currency risk	2,73	-11,02 ***	-14,11 ***	7,95 ***	-0,05	-13,87 ***	-19,85 ***
	(0.652)	(0.000)	(0.000)	(0.004)	(0.989)	(0.000)	(0.000)
Maturity	-3,25 ***	-2,80 ***	-0,16	-3,41 ***	-1,79 ***	-2,99 ***	-1,61 ***
	(0.000)	(0.000)	(0.689)	(0.000)	(0.004)	(0.000)	(0.004)
Log maturity	39,36 ***	33,75 ***	-21,73 ***	43,95 ***	36,46 ***	33,36 ***	11,92 *
	(0.009)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.068)
Rating	5,39 ***	4,28 ***	3,52 ***	4,72 ***	4,93 ***	4,07 ***	3,25 ***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Not Rated	89,36 ***	81,44 ***	100,10 ***	64,53 ***	74,82 ***	89,37 ***	85,22 ***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Subordinated	30,11 ***	48,65 ***	55,65 ***	88,40 ***	40,76 ***	74,49 ***	45,48 ***
	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

(continued)

Callable	105,63 ***	72,98 ***	114,57 ***	28,43 ***	59,93 ***	72,13 ***	83,86 ***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Number of tranches	-13,04 ***	-15,18 ***	-15,06 ***	-20,44 ***	-7,54 ***	-17,86 ***	-18,88 ***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Market volatility	2,38 ***	1,68 ***	1,56 ***	2,62 ***	2,36 ***	1,42 ***	1,83 ***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Yied curve slope	-0,08 *	-0,09 ***	-0,19 ***	-0,10 ***	-0,12 ***	-0,09 ***	-0,08 *
	(0.078)	(0.000)	(0.000)	(0.001)	(0.002)	(0.002)	(0.070)
Country risk	13,07 ***	13,36 ***	8,75 ***	1,64	13,91 ***	11,77 ***	9,71 ***
	(0.000)	(0.000)	(0.000)	(0.130)	(0.000)	(0.000)	(0.000)
Intercept	48,84 **	194,81 ***	241,47 ***	212,95 ***	80,72 ***	270,34 ***	253,83 ***
	(0.047)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Use of proceeds fixed effe	No	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	No	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	No	Yes	Yes	Yes	Yes	Yes	Yes
Region fixed effects	No	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	39 457	39 457	12 277	15 870	12 266	27 191	4 018
of which green	2 694	2 694	1659	431	797	1897	1541
of which social	346	346	118	25	179	167	202
of which sustainability	435	435	164	84	146	289	266
of which conventional	35 982	35 982	10 336	15 330	11 144	24 838	2 009
Adjusted R^2	0,14	0,19	0,29	0,36	0,13	0,21	0,33

This table displays the OLS regression results evaluating credit spreads across a diverse range of sustainable and conventional bonds issued between 2018 and 2024. Sustainable bonds encompass green, social, and sustainability bonds. The characteristics data for these bonds were obtained from DCM analytics. Models [8] and [9] analyze the entire bond sample, while Models [10] and [11] focus on specific country subsamples, especially in Europe and the U.S. Models [12] and [13] investigate firm characteristics, making a distinction between financial and non-financial subsamples. Model [14] presents findings for a matched subsample of sustainable and conventional bonds, created through a propensity score matching method that uses a 1-to-1 algorithm to pair each sustainable bond with its nearest conventional counterpart that shares similar traits. The green bond variable is a dummy coded as 1 if the bond follows the Green Bond Principles (GBP) and 0 otherwise. The social bond variable is a dummy that equals 1 if the bond adheres to the Social Bond Principles (SBP) and 0 otherwise. The sustainability bond variable is also a dummy that is 1 if the bond complies with the Sustainability Bond Guidelines (SBG) and 0 otherwise. For every independent variable, the first row lists the estimated coefficient, and the second row provides the p-value. Standard errors have been adjusted for heteroskedasticity and clustered at the country-year level. Statistical significance is indicated by ***, **, and * for coefficients significantly different from zero at the 1%, 5%, and 10% levels, respectively. Check Table 2 for variable definitions.

It is notable that during the analysis of financial firms employing the model [12], it has been observed that the coefficients associated with the three sustainable categories exhibit a loss of statistical significance. This phenomenon suggests that financial institutions incorporate Environmental, Social, and Governance (ESG) considerations in a manner distinct from non-financial firms. A primary reason for this divergence is that financial firms inherently embed ESG factors into their fundamental business operations, such as green lending, sustainability-linked loans, and ESG investment portfolios. In contrast to non-

financial corporations, which may utilise sustainable bonds to signal a transition towards greener practices, financial firms actively engage with ESG through lending and investment strategies rather than through the issuance of bonds. Moreover, regulatory frameworks such as Basel III and ESG disclosure mandates require financial firms to integrate sustainability risks into their credit assessments, diminishing the necessity for sustainable bond issuance to attract investors. In the matched sample analysis utilising the model [14], conversely, all coefficients for sustainable bonds achieve statistical significance, indicating that the spreads for green, social, and sustainability bonds notably differ from those of their corresponding conventional bond spreads. Consequently, I have conducted a Wilcoxon rank-sum test, which confirms that the spread of sustainable bonds (green, social, sustainability) is statistically distinct from conventional bonds, with all p-values documented at 0.000.

In summary, the findings elucidate substantial discrepancies in the spread between green, social, and sustainability bonds compared to conventional bonds. These results can be explained by the enhanced availability of market information and the increasing sophistication of investors. Also, enhancements in an issuer's sustainability practices may significantly alter the pricing of sustainable bonds compared to their traditional counterparts, consistent with theoretical predictions. Primarily, investors may demonstrate a propensity to relinquish higher financial returns in pursuit of positive environmental and social impacts, potentially culminating in the elevated pricing of green and social bonds relative to standard corporate bonds (Fama & French et al., 2007; Flammer et al., 2021; Löffler et al., 2021). Furthermore, green, social, and sustainability bonds may safeguard against risks, functioning as a hedge against environmental and social uncertainties(Dong et al., 2023; Pástor et al., 2021; Pedersen et al., 2021). Additionally, the involvement of independent third-party assessments and ongoing monitoring contributes to the reduction of information asymmetry,

thereby enhancing the credibility of these bonds (DeMarzo et al., 2005; Yu et al., 2005; Dorfleitner et al., 2022).

Conclusion

This research provides a comprehensive analysis of sustainable bond pricing, a sector that has experienced substantial growth over the past decade. The study conducts a comparative analysis of the credit spreads and pricing of sustainable bonds—specifically green, social, and sustainability bonds—in relation to their conventional counterparts. It employs a cross-section of corporate bonds issued by financial and non-financial entities globally between 2018 and 2024. Additionally, the research identifies the determinants influencing credit spreads while maintaining consistency among sustainable and conventional bonds. It also evaluates whether sustainable bonds exhibit significantly different credit spreads when compared to traditional bonds.

Key findings indicate that sustainable and conventional bonds respond differently to similar pricing factors. The spread for sustainable bonds is predominantly influenced by (i) credit ratings, liquidity, bond subordination, the number of tranches, and maturity, as well as (ii) market volatility and country risk. Conversely, conventional bond spreads are primarily affected by currency risk, which has a minimal influence on sustainable bonds. These results suggest that credit ratings may not fully capture the relevant pricing information as markets consider additional factors. This understanding is pivotal for both issuers and investors, facilitating a deeper comprehension of the pricing dynamics between sustainable and conventional bonds, such awareness can improve investment strategies, risk assessments, and issuance decisions. Consequently, achieving precise pricing for green, social, and sustainability bonds is crucial for efficient market operation. Given the complexities of

sustainable bond transactions and the often-ambiguous nature surrounding the projects they finance, numerous investors encounter difficulties accurately assessing their value. As a result, they may rely excessively on ESG ratings or benefit from the contributions of others without conducting their analyses. Therefore, we advocate for enhanced transparency and the standardisation of disclosure practices—mainly through the alignment of ESG rating methodologies, data, assumptions, and costs—to strengthen the efficacy of the sustainable bond market.

Importantly, I found statistically significant differences in the spread of sustainable and conventional bonds, except when analysing financial firms for the three types of sustainable bonds, where the difference was not statistically significant. The results hold across subsamples of green, social, and sustainability bonds. One possible explanation is that financial firms already incorporate ESG considerations into their business models, reducing the spread differential between sustainable and conventional bonds.

The primary limitation of this study pertains to the quality of the existing data. The scarcity of historical data and the inconsistency in methodologies—evidenced by the lack of standardised metrics and comparable disclosures (Eren et al., 2022) - induce a degree of uncertainty and exacerbate information asymmetry, thereby complicating the accurate pricing of bonds. Considering sustainable bonds represent relatively new financial instruments, there is a data deficit regarding critical pricing determinants, such as the credit spread associated with tranche ratings. Future research endeavours may benefit from access to more extensive datasets, particularly in the context of social and sustainability bonds.

The integration of ESG considerations into corporate strategies gained momentum following the 2015 Paris Agreement. While Green Bond Principles, Social Bond Principles, and Sustainability Bond guidelines provide best practice frameworks, risks such as “greenwashing”, “social washing”, and “sustainability

washing" persist. Recent regulatory initiatives, including the EU Taxonomy regulation, the Securities and Exchange Commission (SEC), the Sustainable Finance Disclosure Regulation (SFDR), and the Corporate Sustainability Reporting Directive (CSRD), aim to enhance transparency, standardise sustainability reporting, and mitigate misleading claims. As regulatory scrutiny increases, companies must ensure robust due diligence, impact measurement, and alignment with globally recognised sustainability benchmarks to maintain investor confidence and credibility. These developments also represent promising areas for future research.

Declaration

I hereby declare on my honour that I have prepared my written work/thesis, "Sustainable Bonds: An Empirical Analysis of Spread and Pricing", with complete honesty and free from any fraudulent practices, namely copying or plagiarism.

I also declare that I am aware that committing fraud during written assessments constitutes a serious violation of the rules of ethics and academic conduct in force at the Universidade Católica Portuguesa, resulting in disciplinary action, as outlined in the Code of Ethics and Conduct of this University – paragraph b, nr. 3 of article 8 and nr. 3 of article 12.

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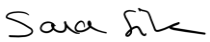
Signature: 

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of my thesis, "Sustainable Bonds: An Empirical Analysis of Spread and Pricing", Grammarly, Mendeley and ChatGPT were used for the following tasks: correction of syntax and write improvements, automatic bibliography and author´s citation and error correction of Stata codes, with the prompts used listed at the end of the document in the Prompts List section. After using these tools, I reviewed and edited the content as necessary, and I take full responsibility for the content presented in this work.

I also declare that I am aware of and respect the Artificial Intelligence Rules of Conduct of Católica Porto Business School.

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Signature: 

Prompt List

1. Could you provide some information about the sustainable bonds market? What are the main differences between instruments?
2. Could you provide some information about the 2015 Paris Agreement and the regulation in place for sustainable bonds?
3. Sustainable bonds should benefit from tax benefits due to their sustainable linked projects. Provide me studies where this was studied.
4. In my thesis, I want to compare the main factors influencing the pricing of sustainable and conventional bonds, with spread as my dependent variable. What test can I conduct in Stata?
5. Aiming to compare the spread between sustainable and conventional bonds. Is the OLS regression the best approach?
6. In my thesis, I want to analyse "Greenium" in the market, assuming that the spread of sustainable bonds is lower than that of conventional bonds. After the OLS models, what additional test can I conduct in Stata to robust my findings?
7. How can I add the variables that I want to use as Fixed Effects on my stata code? How to differentiate 1 from 0 on stata code having dummy variables?
8. Can you advise why I have this stata error code?
9. What are the limitations of Chow test?

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