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Signalling sustainability? The role of green labels in green bond pricing and environmental outcomes

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Abstract

This thesis explores the role of green bond labelling, established green bond standards and certification in green bond pricing and issuers' environmental performance. We use a global sample of 6,643 green bonds issued by listed and private corporates between 2016 and 2025 and study how different levels of green labels affect yield spreads at issuance and issuers' environmental scores. For green labels, we use the CBI categorization of self-labelled, CBI-aligned and CBI-certified green bonds, as well as external reviews as an additional layer of green credibility.

We find that bonds with more credible green signalling through CBI-alignment and, in particular, external reviews are associated with lower yield spreads at issuance compared to self-labelled green bonds or bonds without such review. However, the pricing benefit of CBI-alignment appears significant only for first-time issuances, highlighting the information and signalling value of the green labels when green bonds are first issued. When studying the joint effect of CBI-alignment and external review, the pricing benefit appears partially substitutive, indicating potential overlapping signals. Furthermore, issuers tend to improve their environmental pillar and emissions scores after issuing a green bond, regardless of the green label. The issuers of CBI-aligned bonds seem to have higher scores than the issuers of self-labelled bonds post-issuance; however, they appear to have higher scores already before the issuance and their incremental post-issuance improvement is insignificant or even negative – implying that the higher post-issuance scores appear to reflect the pre-existing difference between the issuer types.

Our findings are particularly relevant in the current green bond market, characterized by increasing interest from investors as well as light and voluntary-based regulation. With the risk of greenwashing present, certification and green labels have emerged as an essential way for issuers to signal their environmental commitment to investors. Going forward, there rises a need for unified and comparable green bond standards to ensure efficient capital allocation in this maturing market.

Keywords green bond, bond pricing, ESG, green labels, sustainable investing

Tekijät Ida Pulkkinen & Lotta Viljakainen

Työn nimi Signalointia kestävyydestä? Vihreiden luokitusten merkitys vihreiden joukkovelkakirjojen hinnoitteluun ja liikkeellelaskijan ympäristöarvosanoihin

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Tiivistelmä

Tässä tutkielmassa tarkastellaan vihreiden joukkovelkakirjalainojen (jvk-laina) luokitusten, standardien ja sertifiointien roolia jvk-lainojen hinnoittelussa sekä liikkeellelaskijoiden ympäristöarvosanojen kehityksessä. Tutkimuksen globaali otos kattaa 6 643 vihreää jvk-lainaa, jotka ovat joko julkisten tai yksityisten yritysten liikkeelle laskemia vuosina 2016–2025. Tutkimme, kuinka vihreän luokituksen eri tasot vaikuttavat tuottoeroihin liikkeellelaskuhetkellä sekä liikkeellelaskijoiden ympäristöarvosanoihin. Vihreään luokitukseen käytämme CBI:n vihreiden jvk-lainojen luokitusta itseluokiteltuihin, CBI-linjattuihin ja CBI-sertifioituihin jvk-lainoihin. Lisäksi käytämme ulkopuolisten tahojen tekemiä arviointeja vaihtoehtoisena mittarina jvk-lainan vihreän merkinnän luotettavuudelle.

Tulostemme mukaan luotettavammin vihreillä jvk-lainoilla, kuten CBI-linjatuilla sekä erityisesti ulkopuolisen arvioinnin saaneilla jvk-lainoilla vaikuttaa olevan matalammat tuottoerot kuin itseluokitelluilla jvk-lainoilla tai lainoilla ilman ulkopuolista arviointia. CBI-linjattujen jvk-lainojen hinnoittelupreemio vaikuttaa kuitenkin olevan tilastollisesti merkitsevä vain ensimmäisten liikkeellelaskujen yhteydessä, mikä korostaa vihreän luokituksen informaatio- ja signaaliarvoa erityisesti silloin, kun liikkeellelaskija laskee liikkeelle vihreän jvk-lainan ensimmäistä kertaa. Kun tarkastelemme CBI-linjauksen ja ulkopuolisen arvioinnin yhteisvaikutuksia, hinnoitteluetu ei ole täysin kumulatiivinen, mikä viittaa signaalien mahdolliseen päällekkäisyyteen. Lisäksi liikkeellelaskijat vaikuttavat parantavan ympäristöarvosanojaan vihreän jvk-lainan liikkeellelaskun jälkeen riippumatta vihreän luokituksen tasosta. CBI-linjatut liikkeellelaskijat saavuttavat korkeammat pisteet liikkeellelaskun jälkeen verrattuna itseluokiteltuihin liikkeellelaskijoihin. Toisaalta näillä liikkeellelaskijoilla vaikuttaa olevan korkeammat pisteet jo ennen liikkeellelaskua, eikä sen jälkeinen parannus arvosanoissa ole tilastollisesti merkitsevä - korkeammat pisteet heijastavatkin pitkälti liikkeellelaskijoiden välisiä lähtötasoeroja.

Tuloksemme ovat erityisen ajankohtaisia vihreiden jvk-lainojen markkinoilla, joille on ominaista sijoittajien kasvava kiinnostus sekä kevyt, pitkälti vapaaehtoisuuteen perustuva sääntely. Viherpesun riskin vuoksi sertifikaatit ja vihreät luokitukset ovat muodostuneet yrityksille keskeisiksi tavoiksi viestiä sijoittajille ympäristövastuullisuudestaan. Vihreiden jvk-lainojen markkinoilla on kasvava tarve yhtenäisten ja vertailukelpoisten standardien ja sääntelyn kehittämiselle, jotta pääomia voidaan allokoida tehokkaasti ympäristöystävällisiin kohteisiin.

Avainsanat vihreät joukkovelkakirjat, joukkovelkakirjojen hinnoittelu, ESG, kestävä sijoittaminen

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1 Introduction

In recent years, financial markets have witnessed increasing investor demand and interest for sustainable investments and financial instruments that can help hedge climate risk and support the transition to a low-carbon economy (Morgan Stanley Institute for Sustainable Investing, 2025). One such instrument is the green bond which offers issuers a way of signalling their environmental commitment. The green bond market has grown rapidly, reaching approximately $300B in annual issuance volume.[1] Studies have documented that green bonds often carry lower yields at issuance and receive more positive market reactions compared to conventional bonds. Meanwhile, the market remains lightly regulated and largely based on voluntary standards, which introduces information asymmetry and risk of greenwashing. In response, third-party certification has emerged as a more credible signal of a bond's true greenness and genuine commitment to sustainability.

In this thesis we study the effects of green labels, established green bond standards and certification on green bond pricing and the development of issuers' environmental performance after green bond issuance. We construct a sample of 6643 corporate green bonds issued globally between 2016 and early 2025. Our sample includes three levels of green labels based on Climate Bonds Initiative's categorization: CBI-certified, CBI-aligned and self-labelled green bonds. LSEG (previously known as Refinitiv) is our main data source for collecting bond-, issuer- and market-level data.[2]

First, we study whether CBI-certified and CBI-aligned bonds have lower yield spread at issuance compared to self-labelled bonds. As certification and alignment can be considered more credible signals of environmental commitment, we hypothesize that they receive this pricing premium. Using fixed effects regression, we find that the aligned and certified bonds are indeed associated with lower yield spreads. However, while the effect is consistently negative with varying significance, the yield spread reduction appears to be driven mainly by first-time issuances where the information and signalling value of green label seems particularly relevant. Extending our baseline regressions with external review as an additional layer of credibility, we find that on its own, it is associated with a 24 basis points yield spread reduction. The joint effect of CBI-alignment and external review is -40 basis points; however, the signals appear not fully additive but partially substitutive. According to our findings, green bonds with more credible green signalling could receive premium relative to self-labelled bonds especially in the case of

[1] Annual issuance volume estimated from LSEG bond data. Section 2.1 Figure 1 presents development of green bond annual issuance volume between years 2013-2024

[2] Data and sample construction described in detail in section 3

first-time issuances, and external review seems to be a more consistent signal of greenness than certification or alignment.

Next, we examine whether green bond issuers improve their environmental performance post-issuance. We expect them to do so, as by definition the proceeds of green bonds must be used for a green purpose which could materialize into their performance as well. Further, we study whether CBI-aligned bond issuers improve more compared to self-labelled bond issuers, as could be expected since alignment with commonly recognized standards could again signal better commitment. Using environmental pillar and emissions scores as proxies for environmental performance, we find that regardless of the green label, the issuers consistently improve their performance post-issuance. Based on two different specifications for difference-in-differences, we find that while aligned bond issuers outperform self-labelled bond issuers both before and after the issuance; the higher post-issuance scores appear to reflect the pre-existing difference between the issuer types. With a granular decomposition of the treatment effect, CBI-aligned bond issuance, we conclude that the incremental effect of alignment on post-issuance environmental performance is insignificant or even negative. Therefore, the environmental performance post-issuance may not be linked with alignment status of the bond itself but rather reflect pre-existing firm characteristics.

This thesis makes several contributions to the literature. First, our study adds to the growing body of literature regarding green bonds and more specifically the effects of green bond labels which remains a relatively underexplored area of research. Second, our thesis extends existing research on the real impacts of green bonds, in this case focusing on the development of green bond issuers' environmental performance post-issuance. Compared to previous studies, our analysis takes a more granular approach as we examine both officially certified green bonds and those aligned with recognized standards. Furthermore, while much of the prior research has focused on specific markets, such as China, or on a particular issuer type like municipal bonds or publicly listed companies, our global sample includes green bonds from 65 countries and 16 currencies, both from listed and private companies. Finally, we include bond issuances until early 2025 and therefore offer a current and timely perspective given the recent rapid growth of the green bond market.

The rest of this thesis is structured as follows. Section 2 reviews relevant literature and motivates our research questions. Section 3 describes data and sample construction. Section 4 describes methodologies and presents the empirical results. Section 5 discusses the main findings and their implications, and finally, section 6 concludes the study.

2 Literature review

In this section we review relevant literature related to our research topic. This includes an introduction to green bonds, green bond market and "greenium", an overview of the regulatory framework of the green bond market, and discussion of information asymmetry. We also examine different rationale for green bond issuance, such as signalling and greenwashing, and the role of third-party certification in the market. Furthermore, we review literature on whether issuers of green bonds, certified or non-certified, improve their environmental performance post-issuance compared to issuers of conventional bonds. Finally, we present our research questions and hypotheses based on the existing literature.

2.1 Introduction to green bond market and "greenium"

According to the World Meteorological Organization (2025), the year 2024 was the world's warmest year on record and the first calendar year to surpass 1,5°C above pre-industrial era. This development contradicts the Paris Agreement signed by 196 parties in 2015, aiming to limit global warming well below 2°C (UNFCCC, 2025). This recent trend in climate change is mostly attributed to human action, particularly greenhouse gas (GHG) emissions from fossil fuels, with just 57 companies attributing 80% of global fossil CO_2 emissions since 2016 (Watts, 2024). The shifted weather conditions cause various consequences including extreme weather events, floods, rising sea levels, wildfires and biodiversity loss, factors directly threatening agriculture, infrastructure, health and living conditions (European Commission, 2025). Since 1980s, Europe has been the fastest-warming continent on Earth, increasing the climate risks faced in the area (C3S & WMO, 2025).

As climate change poses various risks for people, communities and economies around the world, sustainable investments have shifted from an ethical preference to a necessity for financial market participants. It is estimated that nearly $6 trillion is needed to implement developing countries' climate action plans by 2030 (UNFCCC, 2024) while in Europe, the EU has clearly indicated that private capital is needed to complement public funding in capital allocation towards sustainable investments across sectors (European Commission, 2020). One increasingly popular instrument for channelling funds toward environmentally beneficial projects is the green bond.

Green bonds are financial instruments, bonds, used to finance or re-finance green and environmentally beneficial projects. Therefore, green bonds are structured similarly to conventional bonds, but their proceeds must be allocated to green investments such as renewable energy, energy efficiency or clean transportation. (ICMA, 2021; Caramichael and Rapp, 2024) The Green Bond Principles (GBP), introduced by ICMA, also acknowledge different types of green bonds, such as standard use of proceeds bonds, green revenue bonds, green project bonds and secured green bonds (ICMA, 2021). The first ever green bond, then named Climate Awareness Bond, was issued by the European Investment Bank in 2007, followed by the World Bank in 2008 to support lending for climate-focused projects (European Investment Bank, 2025; World Bank Group, 2021). Since then, the green bond market has grown drastically with issuers including municipalities, governments, sovereigns and corporations, of which corporations contributed 57% of annual issuance in 2023 (Chouhan et al., 2024).

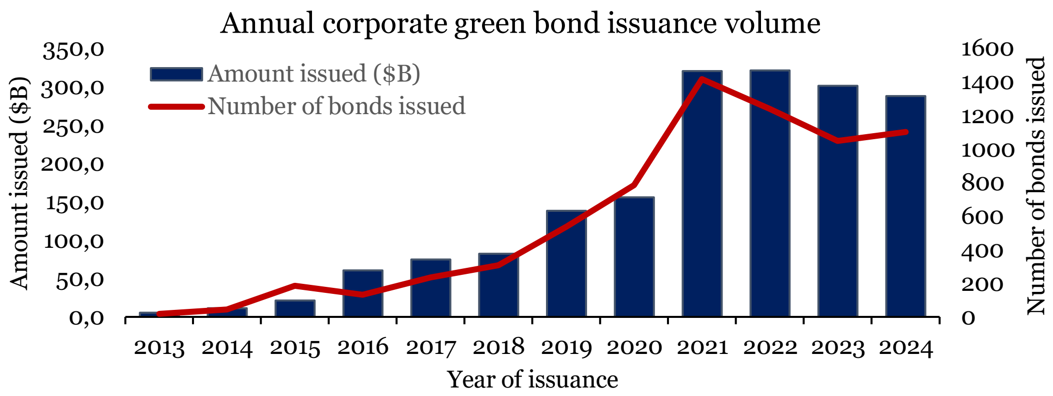

Figure 1: Annual corporate green bond issuance volume. Source: LSEG, data described in detail in section 3.

Figure 1 presents the annual corporate green bond issuance volume, utilizing the raw data sample of this thesis sourced from LSEG. The annual volume has grown steadily since 2013 and peaked in 2021 at $321B. Since then, while the number of new issues has declined slightly, issuance amounts have remained more stable, indicating larger average deal sizes. The rise of the green bond market has also led to the emergence of similar labelled bonds such as social bonds, sustainability bonds and sustainability linked bonds (SLBs). According to Climate Bonds Initiative (CBI) database, the total volume of these four instruments aligned with CBI standards reached $870B in 2023, 68% of which came from green bonds. Europe was the largest issuing region, representing 46% of the total volume. (Chouhan et al., 2024) Similarly, assets under management in sustainable and impact bonds exceeded $500 billion in 2022, with most funds in Europe (Dobrescu, 2023). The surge of the market is driven by multiple reasons, such as investors' changing sustainability preferences and green bonds catering to those preferences, and increased demand pressure from new policy frameworks establishing incentive to increase sustainable investment (World Bank Group, 2021; Caramichael and Rapp, 2024).

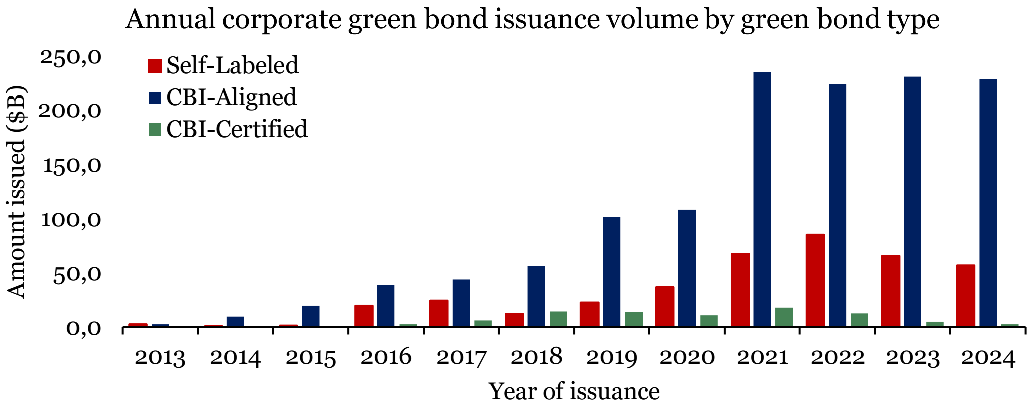

Figure 2: Annual corporate green bond issuance volume by green bond type. Source: LSEG, data described in detail in section 3.

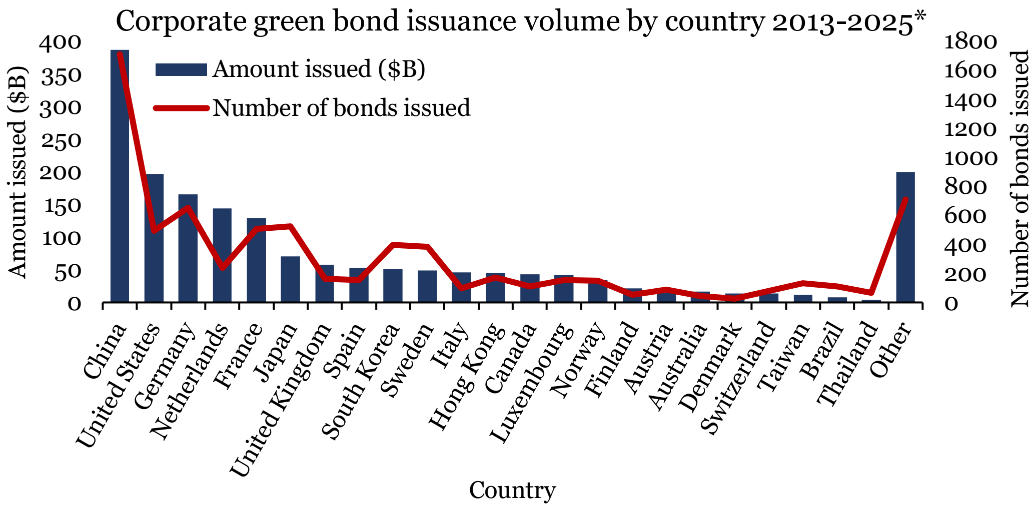

Figure 3: Corporate green bond issuance volume by country. Source: LSEG, data described in detail in section 3. * Sample includes bonds issued between 1st of January 2013 and 9th of March 2025.

In this thesis we utilize CBI Standard categorization of CBI-aligned, CBI-certified and self-labelled green bonds. Figure 2 shows the market composition by bond type, highlighting the dominance of CBI-aligned bonds which represent 79% of the corporate green bond market in 2024. Certified bonds remain a minority, potentially due to a costly and cumbersome certification process, while the trend of self-labelled bonds closely mirrors overall volume trend. Figure 3 illustrates the geographical distribution by presenting the cumulative green bond issuance by country during 2013-2025.[3] Major issuers include China, United States and European countries, with the 5 largest issuing countries accounting for 56% of the total cumulative volume. However, as

[3] Sample includes green bonds issued between 1st of January 2013 and 9th of March 2025. More detailed data description in section 3.

recorded by the CBI database, in terms of currency, EUR-denominated bonds make up 44% of CBI-aligned green bonds, followed by USD, CNY, GBP and INR (Chouhan et al., 2024).

Academic literature on green bonds has primarily focused on investigating either the pricing differences between green and conventional bonds and the underlying factors or the stock market reactions to green bond issuance. A central concept of green premium, “greenium”, refers to green bonds being issued or traded at lower yields than comparable conventional bonds. So far, the findings on the stock return impact of green bonds and the existence and magnitude of “greenium” remain mixed.

Several studies suggest that investors are indeed willing to pay a premium for green bonds (Caramichael and Rapp, 2024; Pastor et al., 2022; Baker et al., 2022; Zerbib, 2019). Caramichael and Rapp (2024) report that green corporate bonds have on average 3 to 8 basis points lower yield spread compared to conventional bonds based on a global panel, and the effect is strengthened by bond governance and external review. They attribute this pricing difference primarily to demand pressure at issuance. Studying German governmental twin bonds, Pastor et al. (2022) find that green bonds outperformed their paired, higher-yielding non-green twin bonds. Similarly, Baker et al. (2022) find that US municipal green bonds are issued at a small premium over similar conventional bonds. Zerbib (2019) finds a small average negative premium of -2 basis points for a broad sample of green bonds compared to that of conventional bonds; however, they conclude it as low impact. According to a review by Ehlers and Packer (2017), it seems that green bonds are often on average priced at a premium at issuance compared to conventional bonds but their post-issuance performance in the secondary market is similar.

In contrast, some studies question the existence of a greenium (Larcker and Watts, 2020; Hyun et al., 2020; Fatica et al, 2021). Larcker and Watts (2020) observe investors to be unwilling to trade wealth for sustainability and find no pricing difference between municipal green and non-green bonds. Similarly, Hyun et al. (2020) find no significant or robust green premium or discount on green bonds; however, bonds with independent review or CBI certificate are associated with -6 and -15 and basis points reductions in premium, respectively. Fatica et al. (2021) observe a premium for green bonds issued by supranational institutions and corporations, but not for those issued by financial institutions.

Beyond pricing, several studies explore stock market reactions to green bond issuance. Flammer (2021), using an event study approach, finds a positive investor response to corporate green bond issuance, particularly for first-time issuers and bonds certified by third parties. Similarly, Tang and Zhang (2020) observe a positive stock price reaction for green bond issuance although they do not find a consistently significant premium in bond pricing. Finally, studies have highlighted the influence of external factors, showing that climate change news and regulatory risk are connected to corporate bond returns and bond pricing (Huynh and Xia, 2021; Seltzer et al., 2022). Overall, the results across green bond studies vary considerably and the results are challenging to compare due to differing geographies, methodologies, time periods and issuer types investigated.

2.2 Policy and regulatory framework

A commonly shared objective of financial markets has traditionally been the efficient allocation of capital resources, a principle rooted in the Efficient Market Hypothesis developed in the 1970s (Fama, 1970). In the context of today's financial markets, achieving this goal requires consideration of the ESG efforts of market participants which in turn necessitates new financial regulation. Given that the green bond market is still relatively new, the level of regulation, or more notably the lack of it, has played a significant role. While the market lacks a universal global regulatory framework, the true "greenness" of green bonds currently relies either on third-party certification or the trust of investors (Caramichael and Rapp, 2024). The two most used global standards in the market have been ICMA's Green Bond Principles (GBP) and Climate Bonds Initiative (CBI) Standard and Certification Scheme. To complement the standardization practises in the EU area, European Green Bond Standard (EU GBS) came into force at the end of 2024 (European Commission, 2025b).

Green Bond Principles (GBP) published by the International Capital Markets Association (ICMA) are voluntary process guidelines for issuing green bonds intended to promote transparency and accountability in the global green debt markets. These principles include frameworks and best practises for disclosure with a focus on ensuring aligned use of proceeds. The principles encourage post-issuance reporting but as it is only a recommendation, the level of disclosure varies among issuers. (ICMA, 2021) Furthermore, given the voluntary nature of the principles, there is no formal proof of compliance or consistent monitoring of the issuer's actions.

The Climate Bonds Initiative (CBI) is an international non-profit organization seeking to channel capital into sustainable investments by developing a set of standards and definitions for green debt instruments. The CBI Certification Scheme yet remains the only global green bond certification system and is based on the Climate Bonds Taxonomy created by CBI. Their taxonomy is developed for assessing the eligible assets and projects consistent with the goals of the Paris Agreement and has been a contributor in developing the EU Taxonomy by the European Commission. A green bond can either be aligned with CBI standards or CBI-certified, which requires an independent assessment of the bond by an approved verifier. Climate Bonds Standard and Climate Bonds Taxonomy are used to assess entities, assets and bonds globally, while CBI also engages with governments, providing help with policy research and constructing widespread green debt market analysis. (Climate Bonds, 2025a; Climate Bonds, 2025b; Climate Bonds, 2025d)

In Europe, the European Union has declared an intention to be a global leader in sustainability and sustainable investments, followed by an introduction of ambitious action plans, legislative proposals and transformative policies such as the EU Green Deal launched in 2019. As part of this broader sustainability agenda, EU has for instance introduced the EU Taxonomy, a classification system for sustainable activities, and more recently, the EU Green Bond Standard (EU GBS). (European Commission, 2025b; European Commission, 2025c; European Commission, 2025d) The EU GBS is a voluntary but standardized regulatory framework based on the EU Taxonomy. It establishes requirements that must be met in order for a bond to be labelled a European green bond, including allocation requirements, pre- and post-issuance reporting and external review of disclosed information. Therefore, the EU GBS aims to set a "gold standard" for the green bond market enhancing transparency and supervision. (European Commission, 2025b; European Commission, 2023)

As the EU GBS officially came into effect only at the end of 2024, its long-term impact remains to be seen. The standard could potentially establish a new benchmark for credibility in the green bond market, but the adoption outside of the EU can be challenging due to its reliance on EU directives and EU Taxonomy. Outside of Europe, there is also ongoing effort in China to improve the consistency of green bond standards (Ehlers and Packer, 2017). Investors have expressed concerns about the credibility and actual greenness of Chinese green bonds, due to differences between China's own green bond guidelines and more universal standards (Yu et al, 2024). In addition to the European and Chinese green bond frameworks, several other countries have introduced national-level guidelines regarding green bonds. Overall, the light and fragmented regulation of the market is evident globally and for now it remains a critical characteristic of the green bond market.

2.3 Information asymmetry, signalling and greenwashing

Due to the limited regulation of the green bond market and its reliance on voluntary standardization schemes, it poses investors with a possible concern of the true environmental value of green bonds. In the world of imperfect markets, companies typically hold more information about their capabilities and actions, such as sustainability practises, than investors. Therefore, there exists information asymmetry between the issuers of green bonds and investors, introducing a transaction cost of evaluating desirable companies. (Akerlof, 1978; Flammer, 2021) This asymmetry further reduces market transparency, making it harder for investors to evaluate green bonds accurately and potentially lowering investor confidence in the market (Yu et al., 2024).

Investors' preference for green assets can be linked to financial motives such as better financial performance or lower risk, or non-pecuniary motives like pro-environmental attitudes (Zerbib, 2019). As the proceeds of green bonds are earmarked for environmentally beneficial projects, these bonds enable investors with sustainability preferences to channel their investments according to their green mandate (Tang and Zhang, 2020). However, from an issuer's perspective green bonds are subjective to restrictions on the use of proceeds, and may impose additional administrative and compliance costs, especially when opting for third-party certification (Flammer, 2021). Therefore, it is relevant to ask why an issuer would choose to issue a green bond over a conventional one, if the intended use of funds is similar. Compared to conventional bond issuance, Flammer (2021) presents three rationales for issuing green bonds: the signalling argument, greenwashing argument and cost of capital argument.

While investors often lack sufficient information about companies' sustainability practises due to information asymmetry, issuing green bonds could be a credible and valuable signal of commitment as supported by the findings of Flammer (2021). As information asymmetry can decrease investor confidence and deter investment, it is of issuers best interest to reduce this asymmetry by sending a credible signal. A signal can be considered credible, if it is costly to imitate by other, less committed, market participants (Riley, 1979). Companies can therefore signal their true commitment toward the environment by issuing green bonds instead of conventional bonds, a signal further strengthened by taking additional costly action, such as third-party certification (Flammer, 2021; Lyon and Montgomery, 2015)

As opposed to sending a credible signal, green bonds can also be a way of greenwashing. Greenwashing means the act of making misleading statements about the environmental or sustainability aspects of products or practises (Lindwall, 2023). In the case of green bonds, companies could issue them as a way of appearing more sustainable and environmentally responsible while not taking any real action, which is enabled by voluntary regulation and light governance (Flammer, 2021; Caramichael and Rapp, 2024). Greenwashing has increased greatly, while taking multiple forms such as selective disclosure, misleading imagery and false narratives (Lyon and Montgomery, 2015). Bachelet et al. (2019) argue that third-party certification is essential for reducing information asymmetry and avoiding greenwashing as they appear to be of higher risk for non-certified bonds. Studying greenwashing in the green bond market, Shi et al. (2023) found that the quantity of green patent applications increased after issuing green bonds, suggesting some genuine environmental effort.

Lastly, according to Flammer's (2021) cost of capital argument, a green bond issuer could benefit from cheaper financing if investors are willing to trade financial benefit for environmental benefit. As discussed in section 2.1, multiple studies find a premium of some sort for green bonds (Caramichael and Rapp, 2024; Pastor et al., 2022; Baker et al., 2022; Zerbib, 2019;) although some fail to document a consistent and significant pricing difference between green and conventional bonds (Larcker and Watts, 2020; Hyun et al., 2020; Fatica et al., 2021). In addition to the arguments presented above, other rationales such as increased media and investor attention following green bond issuance have been proposed to be the reason for positive announcement returns. Tang and Zhang (2020) explore financing costs, investor attention and firm fundamental as potential sources for green bond announcement returns and find that the positive market reactions are primarily driven by the investor attention channel. Further, they document other shareholder benefits, including increased institutional ownership, enlarged investor base and improved stock liquidity, from issuing green bonds.

Due to the information asymmetry, signalling and greenwashing observed in the green bond market, the role of certification has become vital for ensuring the credibility of green bonds and providing objective assessment to the market (Fatica et al., 2021; Baker et al., 2022). Indeed, Yu et al. (2024) propose three channels through which third-party certification could benefit green bond issuers: the information asymmetry channel, the greenwashing prevention channel and the environmental performance channel, offering empirical support for each of these channels. Certification agencies and external review providers have emerged as key market actors, informing investors on the true greenness of the bonds offered and reducing information asymmetry (Ehlers and Packer, 2017). Similarly, independent external review and certification may serve as information enhancers and reduce information costs for investors (Hyun et al., 2020). Since certification is costly and resource-intensive, it tends to be pursued only by truly committed issuers which makes it a credible signal. Consequently, some limited literature have looked at potential pricing premium and market reactions for certified green bonds over uncertified ones.

Hyun et al. (2021) provide evidence that labelled green bonds are likely to have lower yields. According to them, investors are willing to pay more for a labelled bond due to increased information disclosure by the issuer and therefore reduced information asymmetry. Further, Li et al. (2020) find that certification has a significant and favourable impact on interest costs faced by the issuer in the Chinese green bond market as only officially certified green bonds can reduce the observed yield spread. According to Fatica et al. (2021) external review enhances the pricing difference between green and conventional bonds at issuance.

Beyond pricing, Flammer (2021) finds that positive market reactions to green bond issuance are significantly stronger for certified bonds, and green bonds are a credible way for signalling company's environmental commitment. Similarly, Yu et al. (2024) find that in the Chinese market, issuance of certified green bonds imposes a favourable market reaction, as opposed to a non-significant or even negative effect for non-certified green bonds. Furthermore, Yeow and Ng (2021) argue that green bonds are an effective way of improving environmental performance, but only when the bond is certified by a third party, highlighting the weak governance of the green bond market. To conclude, the act of third-party certification provides additional information disclosure to the market, reducing the screening costs for investors evaluating the issuers environmental credibility, thus decreasing the risk of greenwashing (Yu et al, 2024.)

2.4 Post-issuance environmental performance

Market participants issue green bonds with the purpose of raising capital for financing or refinancing environmentally beneficial projects, such as those related to renewable energy or efficient waste management. However, as discussed in the previous section, the credibility of these claims depends on whether the bond proceeds genuinely support green activities or merely serve as a tool for greenwashing. In such cases, the green bond issuance would not lead to any measurable improvements in the environmental performance of the issuer. In this context, environmental performance reflects the relationship between the issuer and environment, often measured by indicators like greenhouse gas emissions, such as CO_2 emissions (Yeow and Ng, 2021). While it is a key question in the green bond market whether bond issuance translates into tangible improvements in such indicators, the literature studying these real effects is still limited.

Flammer (2021) finds that corporate green bond issuers indeed improve their environmental performance after issuance compared to conventional bond issuers, reflected in both environmental ratings and CO_2 emissions. Her findings support the view that companies can credibly signal their commitment towards sustainable goals with green bond issuance. She also argues that issuing a green bond alone is unlikely to generate noticeable environmental improvements but instead acts as a signal of broader longer-term commitment. Fatica et al. (2021) examine financial institutions and find that those issuing green bonds tend to reduce lending to less sustainable, carbon-intensive sectors post-issuance, suggesting a shift in capital allocation. Looking specifically at Chinese listed companies, Zhou and Cui (2019) find that green bond issuance can improve companies' corporate social responsibility, among other benefits.

Nevertheless, not all studies find consistent results. Ehlers et al. (2020) conclude that there is mixed evidence on the impact of green bond issuance on decreasing carbon emissions of the issuer, with green bond labels not associated with falling CO_2 emissions. Yeow and Ng (2021) argue that green bonds are an effective way of improving environmental performance, but only when the bond is certified by a third party, highlighting the weak governance of the green bond market. In line with this, Yu et al. (2024) find that certification by a third party reduces information asymmetries and improves issuers' environmental performance following bond issuance, relative to non-certified green bonds. Moreover, they show how certification also attracts long-term investors, increases analyst coverage and induces positive opinions, thus generating both economic and environmental benefits.

As already concluded in section 2.3, the literature on post-issuance environmental performance further underscores the importance of third-party certification in the green bond market. Certification by a third party may help investors to identify issuers genuinely aiming for improving their environmental performance, thus mitigating the risk of greenwashing (Yu et al., 2024). However, Christensen et al. (2022) have interestingly shown how greater ESG-disclosure is associated with higher disagreement of ESG-ratings among rating agencies. Therefore, while disclosure serves an important role reducing information asymmetry between firms and market participants, it does not necessarily lead to consistency in ESG scores. Thus, even increased transparency and third-party certification may not provide uniform signals on firm's environmental performance.

2.5 Research questions and hypotheses development

In this thesis, we extend the existing literature on green bonds, the effects of alignment with established green bond standards and third-party certification, and environmental performance following green bond issuance. We want to understand whether green bonds that are aligned with commonly recognized CBI standards or certified by a third party enjoy more favourable pricing compared to their self-labelled counterparts lacking these elements. Furthermore, we wish to find out how bond issuers' environmental performance develops following green bond issuance, and whether there are differences in this development depending on possible certification or alignment status of the bond. Next, we define our research questions and hypothesize the expected findings based on the existing literature.

Research question 1: Do CBI-certified and CBI-aligned green bonds have lower yield spreads at issuance compared to self-labelled bonds?

Green bonds are financial instruments designed for channelling funds toward environmental benefits as the proceeds must be used for green projects and therefore, they enable catering to investors sustainability preferences in the growing sustainable investments market (Tang and Zhang, 2020). However, in the capital markets, there exists information asymmetry between market participants as companies often obtain more information of their actions and attributes than is visible to investors (Riley, 1979). Regarding the bond market, literature has identified several motivations for issuing green bonds over conventional ones, such as green bonds acting as a credible signal of issuer's environmental commitment (Flammer, 2021). Indeed, multiple studies have found that green bonds obtain lower yields and attract more positive market reactions compared to conventional bonds (Zerbib, 2019; Caramichael and Rapp, 2024; Baker et al., 2022; Flammer, 2021; Tang and Chang, 2020).

However, particularly in the green bond market, the issuers have better understanding of the true greenness of their bonds and such asymmetry imposes additional transaction costs, reduces market transparency, decreases investor confidence and increases the risk of greenwashing (Yu et al., 2024; Caramichael and Rapp, 2024). While green bonds can serve as a credible signal for environmental commitment, this credibility can be further reinforced by pursuing costly action, such as third-party certification, which is difficult to imitate by non-committed companies. (Riley, 1979; Flammer, 2021) As discussed in greater detail in section 2.2, the green bond market is characterized by limited regulation and voluntary standards, leading to differences in the quality and quantity of issuers' information disclosure regarding their use of proceeds. Consequently, this introduces the possibility of greenwashing, wrongly benefiting from making false environmental statements, and certification can act as an essential way of reducing that risk (Bachelet et al., 2019). Studies have found that certification can strengthen positive market reaction obtained from issuing a green bond and have a favourable effect on issuers interest costs (Flammer, 2021; Yu et al., 2024; Li et al., 2020).

In this study, we examine the difference between three levels of green bond types: self-labelled, CBI-aligned and CBI-certified. Following the theory of information asymmetry and signalling, we hypothesize that investors would be willing to pay premium for a more credible green signal and thus, both

CBI-aligned and CBI-certified green bonds would enjoy lower yield spreads at issuance compared to self-labelled bonds, and the effect would be stronger for CBI-certified bonds.

Research question 2: How does the bond pricing effect of CBI-certification and CBI-alignment compare to the effect of external review at issuance?

In addition to the comparison of CBI-certified and CBI-aligned bonds versus self-labelled bonds we also introduce the effect of external review as an alternative measure of assessing the credibility of green bond issuers environmental claims. While CBI classification is a common way of practise in the market, an overall external review variable gives an additional layer to investigate. In our study, externally reviewed bonds have received an independent opinion pre-issuance from an experienced second party. Previous literature has identified similar benefits from external review as from certified labels. According to Caramichael and Rapp (2024) the effect of documenting lower yield spreads for green bonds versus conventional bonds was strengthened by external review. Similarly, Fatica et al. (2021) find a pricing difference between green and conventional bonds and conclude that external review enhances this difference.

Extending from the theoretical base presented for Research question 1, we consider CBI-certification and external review to be stronger signals of environmental commitment than mere CBI-alignment. This is because CBI-certified and externally reviewed bonds have been officially verified by another party making their information disclosures more transparent and trustworthy. Therefore, we hypothesize that the lowering effect of CBI-certification and external review on bond yield spreads compared to self-labelled bonds would be comparable to each other and stronger than the effect of CBI-alignment.

Research question 3: Does issuer's environmental performance improve after green bond issuance?

As a second part of our research, we focus on issuers' environmental performance. Over the past years considerably larger part of companies has begun reporting about the environmental impact of their actions and sustainability practices while regulation demands, especially in Europe, have also increased (IFAC, 2024; European Commission, 2025e). While the companies' actions become more transparent one could expect them to also aim to improve their sustainability performance to continue attracting investors. From a green bond issuance perspective, improvement of environmental performance after bond issuance seems sensible, as the proceeds of the bond must be used for green projects. On the other hand, in case the issuer is utilizing the green bond as a way of greenwashing to benefit of the green label without taking any material environmental action, there would not be expected any difference in terms of real environmental performance.

Flammer (2021) finds that issuers environmental performance improves significantly following green bond issuance compared to conventional bond issuances, but she does not necessarily attribute that causally to the issuance of the green bond. Instead, she argues that a green bond issuance is likely a too minor event to generate significant improvements alone but rather acts as an overall signal of the company's environmental stance which can realize into improvements in the environmental performance, some of which due to the newly financed green project. Nevertheless, regardless of the causal chain, we hypothesize that issuer's environmental performance improves following green bond issuance, reflecting issuer's overall environmental commitment.

Research question 4: Do issuers of CBI-aligned green bonds improve their environmental performance more than issuers of self-labelled green bonds after bond issuance?

While we hypothesize that all issuers' environmental performance improves following green bond issuance regardless of the label, we further expect that issuers of CBI-aligned bonds would improve more compared to issuers of self-labelled bonds. Compared to self-labelling, although not officially verified or certified, CBI-alignment still offers an additional layer of environmental credibility as the bond is aligned with commonly recognized global standards instead of just self-labelling it green without further validation. In a market where no consistent regulation exists, even an alignment with some established standards may improve the credibility of the green claims. To our understanding, there does not exist previous literature on the effects of alignment with standards on the development of environmental performance. However, literature pursued so far regarding the effects of certification seems to suggest that certification has a considerable impact on this matter, although the evidence remains very limited. Yeow and Ng (2021) look at corporate green bonds across multiple countries and find evidence for improved environmental performance after the green bond issuance only when the bond has been certified. Yu et al. (2024) support this view with the same finding in Chinese green bond market, concluding that third-party certification improves environmental performance following the bond issuance and prompts them to genuinely prioritize sustainable practices. Compared to certification, alignment with CBI standards does not take out the possibility of greenwashing which makes it interesting to examine whether the perceived greater credibility compared to self-labelled bonds translates into material environmental improvement.

3 Data and sample construction

In this section, we describe the data used in this study. We start by describing the data collection process and sample construction and then provide summary statistics of the sample, both at bond- and issuer-levels.

3.1 Data collection

This study is conducted with a broad set of corporate green bonds issued globally, categorized using a framework for bond certification by Climate Bonds Initiative (CBI). CBI maintains a global green bond database and applies a screening process which classifies bonds in three categories based on their green eligibility: CBI-certified green bonds (highest green bond standards, certified under Climate Bond Standard), CBI-aligned green bonds (second tier, deemed by CBI to meet the screening requirements) and CBI non-aligned green bonds (i.e. self-labelled green bonds that do not meet the screening requirements). The CBI-aligned bond type represents the majority of the green bonds in the market. (FTSE Russell, 2021)

LSEG is our primary data source for this study as it provides comprehensive data on corporate green bonds. The dataset used in this study includes corporate green bond data, global bond market data, and corporate green bond issuers' environmental performance and company fundamental data.

3.1.1 Bond-level data

For the research questions regarding yield spreads at issuance, we collect data on corporate green bonds issued globally during 2013-2025[4] from LSEG Workspace. The collected data includes bond, issuance and issuer characteristics, credit ratings, information on green bond type and other green bond-specific characteristics.

Our main variables of interest for each bond are *Issue Date, Amount Issued (USD), Issue Price, Coupon, Maturity, Principal Currency, ESG Bond Type, Second Party Opinion Provider, Domicile,* and *Sector*. Additionally, we collect information on bond options, Moody's and Fitch's issue long-term credit ratings and issuer's ultimate parent. *ESG Bond Type* categorizes bonds into self-labelled, CBI-aligned and CBI-certified green bonds, as described earlier. *Second Party Opinion Provider* names the institution with environmental or sustainability expertise that has provided an independent opinion pre-issuance for the ESG bond if it has obtained one. This is later used to construct our *External Review* variable. *Sector* is based on SIC-codes and using

[4] The exact time period of bond issuance 1st of January 2013 – 9th of March 2015

this variable, we further create 11 broader sector categories according to the most relevant industries in our green bond sample, also reflecting the most relevant sectors in the green bond market in general.[5]

Further, we collect market-level data for controlling general bond market conditions and calculating the yield spreads. We collect 10-year daily government bond yields for each currency for calculating the 30-day realized volatility, and daily option-adjusted spreads for Bank of America global investment grade corporate bond index and Bank of America global high-yield corporate bond index from Datastream to take into account the aggregate credit risk. This data is matched for each green bond's issuance date. For yield spreads, we collect daily government bond yields for available maturities for each currency which are further linearly interpolated and maturity-matched for each bond's issuance date and currency.

3.1.2 Issuer-level data

The second part of our analysis regarding post-issuance environmental performance is done at issuer-level since the available environmental performance scores are reported for the issuing companies rather than for the individual bonds. More specifically, the analysis is done with issuer-year observations since the environmental scores are reported on an annual basis.

LSEG offers a wide range of environmental variables at issuer-level. For the purpose of this study, we collect annual ESG scores, environmental, social and governance pillar scores, and emissions scores for the green bond issuers. LSEG's *ESG Score* is an overall company score based on self-reported information in the environmental, social and corporate governance pillars. *Environmental Pillar Score* is the weighted average relative rating of a company based on the reported environmental information and the resulting three environmental category scores. These categories include resource use, emissions and innovation. *Social Pillar Score* and *Governance Pillar Score* are defined in a similar manner based on respective categories. *Emissions Score* measures a company's commitment and effectiveness towards reducing environmental emissions in the production and operational processes.[6]

The post-issuance environmental analysis is complemented by issuer's financial data from LSEG, and similarly to environmental data, financial variables are also collected as annual observations. We collect *Total Assets, Total Debt* and *EBITDA* in order to construct variables for issuer's *Size*, *Leverage* and

[5] The constructed broader sector categories: Banks, Construction & Infrastructure, Energy & Utilities, Finance, Manufacturing & Industrials, Mining & Extractives, Non-bank Financials, Public Services & Government, Real Estate, Transportation & Logistics and Other
[6] Variable descriptions for the scores are obtained directly from LSEG

return on assets (*ROA*). An average of *Total Assets* from a given year and a year preceding that is used for *Size*. *Leverage* is calculated by taking a similar average of *Total Debt* and dividing that by *Size*. *ROA* is calculated by dividing *EBITDA* by *Size*.

3.2 Sample construction

The focus of this study is on corporate green bonds, and the sample includes all three types of green bonds available in LSEG Workspace: CBI-certified, CBI-aligned and self-labelled bonds. From the green bond universe in LSEG Workspace, we obtain all fixed-rate and zero-coupon bonds both from public and private corporate issuers. Following the common practice in the studies, we narrow the sample to fixed-rate and zero-coupon bonds due to methodological reasons – to ensure consistency and comparability of yield spread calculations across bonds and to improve internal validity of our findings.

The first corporate green bond was issued in 2013 which marks an important milestone as private sector issuers began to participate in the market previously dominated by supranational organisations (Climate Bonds, 2025c). The original sample includes all corporate green bonds issued from 2013 until 9th of March 2025, and it includes 7,204 bonds in total from 2,323 unique issuers. However, only bonds issued from 2016 onward are included in the final sample to ensure a sufficient representation of all green bond types, broader market participation, geographic expansion and increasing standardization following the Paris Agreement in 2015.

Liquidity is an important consideration when analysing bond pricing. To ensure a sufficient depth of the green bond market, we further restrict our sample to the most liquid currencies with a reasonable number of green bonds available over the sample period. This limits our sample to bonds denominated in Australian Dollar, Brazilian Real, British Pound, Canadian Dollar, Chinese Yuan, Euro, Hong Kong Dollar, Japanese Yen, Indian Rupee, Norwegian Krone, South Korean Won, Swedish Krona, Swiss Franc, Taiwanese Dollar, Thai Baht and US Dollar, a total of 16 currencies.

To ensure a meaningful economic size of the bonds in the sample, we also require the notional amount of the bond to exceed 100,000 US dollars. Finally, we drop bonds without sufficient data for calculating the yield spreads, and bonds with yield spreads over 10% or issue price below 90 since these bonds may be distressed, outliers or data errors (Caramichael & Rapp, 2024). These restrictions leave us with a sample of 6,643 green bonds from 2,190 unique issuers.

Our analysis requires comprehensive data on bond and issuer characteristics, however, there are some constraints in data availability especially regarding environmental performance scores and company fundamentals from private entities. Moreover, the overlap between firms with both environmental performance scores and company fundamentals available is limited. These further restrict the sample size later used in regressions. A more detailed breakdown and description of the sample is provided in the next section.

3.3 Descriptive statistics

Table 1 provides bond-level descriptive statistics of our final sample for each green bond type. The final sample includes 2106 self-labelled, 4304 CBI-aligned and 233 CBI-certified green bonds. Based on the summary statistics, on average, CBI-aligned and CBI-certified bonds experience lower yield spreads at issuance than self-labelled bonds, statistically significant at 1% level, providing preliminary evidence on lower borrowing costs for bonds that are more formally recognised green.

CBI-aligned and CBI-certified bonds are also significantly larger in size, CBI-certified being the largest with a mean notional amount issued of $362M compared to $185M of self-labelled bonds. Green bond practices create additional costs for green issuers which can be challenging for smaller issuers, and the process of obtaining an official certification or compliance with official standards increase these costs (Hyun et al., 2020). Larger issuers, who also tend to issue larger volumes, are better positioned to meet the requirements of green bond frameworks and absorb these costs. Moreover, there is a significant reputational risk related to green bonds, particularly related to greenwashing (Bachelet et al., 2019). Larger issuers, due to their visibility and broader stakeholder exposure, are especially sensitive to such risk and therefore may have a stronger incentive to obtain certification to enhance credibility. In addition, both CBI-aligned and CBI-certified bonds have slightly longer maturities of 7 years compared to 6 years of self-labelled bonds, statistically significant at 1% and 5% levels, respectively.

Table 2 presents the distribution of bonds in each green bond category based on currencies included in the sample, reported both in absolute numbers of bonds as well as in notional amounts issued in US Dollars ($B). For self-labelled and CBI-aligned bonds, Chinese Yuan, Euro, and US Dollar stand out both in terms of numbers and notional amounts. For CBI-certified bonds, most bonds are issued in Euros and US dollars, dominating the notional amounts as well. Specifically, bonds issued in Thai Baht seem to concentrate towards CBI-certified bonds, however in smaller issuance sizes compared to CBI-certified bonds issued in Euros or US Dollars.

Table 1. Bond-level summary statistics. This table summarises bond-level characteristics for self-labelled, CBI-aligned and CBI-certified bonds in the sample. The first column presents the number of observations with available data in each category, and then the median, standard deviations and mean values are in the subsequent columns for yield spreads, amount issued in US dollars, coupon rate in percentages, years to maturity and credit rating. Yield spread is defined as the difference of yield to maturity at issuance and linearly interpolated maturity-matched government bond yield curve for the bond's currency and date of issuance and reported in percentages. Each credit rating score is assigned with a number, ranging from 1 (AAA) to 21 (Default). The last column reports the t-statistics of the mean values for CBI-aligned and CBI-certified bonds using self-labelled bonds as the base category.

Self-labelled	Observations	Median	S.D.	Mean	Difference in means (t-stat)	
Yield spread (%)	2,106	0.98	1.74	1.17	-	
Amount issued ($M)	2,106	82.82	280.63	184.97	-	
Coupon (%)	2,106	3.43	2.13	3.37	-	
Years to maturity	2,106	5.00	5.01	6.12	-	
Rating	581	5.00	2.74	6.34	-	
CBI-aligned						
Yield spread (%)	4,304	0.82	1.98	0.92	-4.70	***
Amount issued ($M)	4,299	137.73	397.88	298.49	11.73	***
Coupon (%)	4,304	2.75	2.05	2.83	-9.76	***
Years to maturity	4,304	5.01	5.31	6.92	5.78	***
Rating	1,882	6.00	3.18	6.45	0.79	
CBI-certified						
Yield spread (%)	233	1.07	3.23	0.66	-3.73	***
Amount issued ($M)	233	284.25	374.29	362.24	7.06	***
Coupon (%)	233	3.41	2.17	3.38	0.06	
Years to maturity	233	5.50	4.22	6.97	2.36	**
Rating	105	6.00	3.99	7.06	2.17	**

Significance: *p<0.1,**p<0.05,***p<0.01

Table 2: Bonds by currency and green bond type. This table presents the absolute numbers of bonds, denoted by N, and the notional amounts issued in billions of US dollars per currency in the sample separately for self-labelled, CBI-aligned and CBI-certified categories.

	Self-labelled		*CBI-aligned*		*CBI-certified*	
Currency	N	Volume ($B)	N	Volume ($B)	N	Volume ($B)
Australian Dollar	26	1.2	35	5.6	13	2.3
Brazilian Real	8	0.7	80	5.7	19	0.7
British Pound	37	3.2	67	28.1	2	0.3
Canadian Dollar	19	6.1	57	18.9	-	-
Chinese Yuan	821	136.9	845	225.8	17	6.2
Euro	359	99.1	1,299	554.3	55	38.4
Hong Kong Dollar	16	1.2	39	3.7	4	0.3
Indian Rupee	2	0.0	26	0.4	10	0.3
Japanese Yen	164	13.1	332	26.6	11	0.9
Norwegian Krone	26	1.6	97	6.8	-	-
South Korean Won	155	9.5	171	11.1	-	-
Swedish Krona	72	3.2	228	18.9	2	2.1
Swiss Franc	28	4.2	122	23.2	3	0.7
Taiwanese Dollar	11	0.9	120	10.6	-	-
Thai Baht	12	0.6	23	1.1	35	2.4
US Dollar	350	108.3	763	342.3	62	29.9

Furthermore, Table 3 provides summary statistics at issuer-year level. An issuer-year observation represents a year an issuer has issued at least one green bond. The final sample is limited to 1,668 firm-year observations, including 433 self-labelled, 1,148 CBI-aligned and 87 CBI-certified observations that have ESG scores available pre-issuance. The descriptive statistics are from the year preceding the issuance.

There are no statistically meaningful differences between issuers of CBI-aligned and self-labelled bonds for the most parts, however, CBI-aligned seem to be more leveraged compared to self-labelled, statistically significantly at 10% level. There are more differences between issuers of CBI-certified and self-labelled bonds, CBI-certified being larger based on total (log) assets, significant at 10% level, supporting our bond-level observation on larger sizes as well. They are also more leveraged, statistically significantly at 5% level. They have higher social pillar scores but lower emissions scores pre-issuance, both statistically significantly at 5% level. Otherwise, the issuers seem to be fairly similar based on these metrics.

Table 3. Issuer-year level summary statistics. This table summarises issuer-level characteristics for each issuer-year observation pre-issuance. Issuer-year observation corresponds to each year an issuer has issued a green bond. The first column presents the number of observations with available data in each category, and then the median, standard deviation and mean values are in the subsequent columns for ESG-score, environmental, social and governmental pillar scores, emissions score, total log assets, return on assets and leverage. The last column reports the t-statistics of the mean values for issuers of CBI-aligned and CBI-certified bonds using issuers of self-labelled bonds as the base category.

Self-labelled	Observations	Median	S.D.	Mean	Difference in means (t-stat)	
ESG-score	433	65.20	18.02	63.52	-	
Environmental pillar score	433	73.92	20.72	70.87	-	
Social pillar score	433	66.32	21.29	63.23	-	
Governmental pillar score	434	61.48	22.45	59.65	-	
Emissions score	433	79.44	24.10	72.44	-	
Total assets (log)	451	23.72	1.90	23.83	-	
Return on assets	439	0.04	0.06	0.06	-	
Leverage	450	0.30	0.16	0.32	-	
CBI-aligned						
ESG-score	1,148	66.48	17.64	63.19	-0.33	
Environmental pillar score	1,148	74.71	19.93	70.52	-0.31	
Social pillar score	1,148	67.59	21.21	63.99	0.64	
Governmental pillar score	1,148	60.72	22.03	58.58	-0.85	
Emissions score	1,148	77.92	24.26	71.71	-0.53	
Total assets (log)	1,148	23.61	1.97	23.81	-0.22	
Return on assets	1,120	0.05	0.06	0.06	0.88	
Leverage	1,146	0.33	0.17	0.33	1.92	*
CBI-certified						
ESG-score	87	66.93	18.04	65.17	0.79	
Environmental pillar score	87	75.08	21.86	71.45	0.24	
Social pillar score	87	72.25	19.51	68.22	2.01	**
Governmental pillar score	87	64.66	22.79	60.50	-0.33	
Emissions score	87	69.44	25.23	65.11	-2.57	**
Total assets (log)	53	23.96	2.41	24.38	1.93	*
Return on assets	53	0.06	0.05	0.06	0.37	
Leverage	53	0.25	0.22	0.37	2.24	**

Significance: *p<0.1, **p<0.05, ***p<0.01

4 Methodologies and empirical results

In this section, we proceed to set out methodologies for analysing our research questions and testing our hypotheses defined in section 2.5 and present the empirical results for each model, starting with yield spreads at issuance and continuing with post-issuance environmental performance.

4.1 Measuring yield spread at issuance

In the first part of the study, we investigate whether bonds that are aligned with CBI standards or received a CBI-certification have differential yield spreads at issuance compared to self-labelled green bonds. Further, we also incorporate an alternative indicator for the green label, an external review that we defined in section 3.1.1. Finally, we include models for examining time and sector variation in yield spread differences. This part of the study is conducted at bond-level with an unbalanced sample of green bonds we constructed in section 3.2, including all three types of green bonds – self-labelled, CBI-aligned and CBI-certified green bonds.

Overall, it seems that investors are willing to pay premium for green bonds that include enhanced information on the greenness of the bond, potentially lowering the information costs. Our main findings suggest that CBI-aligned and CBI-certified bonds are associated with lower yield spreads at issuance relative to self-labelled bonds; however, with varying significance, while an external review offers a particularly robust signal associated with a yield spread reduction of 24 basis points. The combined effect of CBI-alignment and external review yields in reduction of 40 basis points in yield spreads, suggesting that CBI-alignment and external review may serve as partially substitutive signals of green credibility rather than fully additive.

4.1.1 Baseline regression

For the baseline model, we follow a fixed-effect regression methodology suggested by Caramichael and Rapp (2024) in their recent study concerning green bond issuance premium compared to conventional bonds, with certain adjustments made to account for the differences in our study designs. This approach is chosen over matching methods used in various studies (see Larcker & Watts, 2020; Zerbib, 2019) as our primary model as it allows a broader and more representative sample of corporate green bonds, as mentioned by Caramichael and Rapp as well. This is a particularly relevant concern since our sample includes green bonds only and we are studying the differences between different types of green bonds instead of comparing them to conventional bonds in general. Despite the scaling of the market in recent years, the universe of corporate green bonds remains rather limited compared to conventional bonds. Matching requires a balanced sample of comparable bonds which would significantly reduce the number of green bonds included in the study (Caramichael & Rapp, 2024).

Following Caramichael and Rapp (2024), we use a regression model to compare borrowing costs of different types of green bonds, with yield spread at issuance as a dependent variable and dummy variables for identifying bonds with CBI-alignment or CBI-certification. Our baseline regression model is defined as follows:

$$Yield\ spread_{b,f} = \alpha_1 CBI\ Aligned_b + \alpha_2 CBI\ Certified_b + \beta\ Controls_{b,c,t} + \mu_{m,c,s,r,o,i} + \varepsilon_{p,m} \quad (1)$$

where yield spread of bond b of firm f is defined as the difference of yield to maturity at issuance and linearly interpolated maturity-matched government bond yield curve for the bond's currency and date of issuance. The main variables of interest, CBI Aligned and CBI Certified, equal one if the bond is CBI-aligned or CBI-certified, respectively. Coefficients α_1 and α_2 measure the difference in yield spreads compared to self-labelled bonds.

The regression model also incorporates several bond and market controls for bond b in currency region c on issue date t. Our bond-level controls include variables for bond size and years to maturity. More specifically, bond size is calculated by taking the natural logarithm of the notional amount issued in USD. Similarly, we take the logarithm of years to maturity. As for market-level controls, we have three variables reflecting the general bond market conditions. Firstly, we control option-adjusted spreads of ICE BofA global investment-grade corporate bond index and ICE BofA global high-yield corporate bond index to measure the aggregate credit risk on bond's issuance date. The third market control is the 30-day realized volatility of the 10-year government bond yield for the bond's currency and issuance date.

Lastly, we have several fixed effects in the regression in case of possible non-linear effects. We have the year-month of bond issuance m, bond's currency c, average credit rating r, bond's seniority s, bond options o and the industry of the bond's issuer i. Bond options include callability, putability and sinking funds. Issuer's sector is based on the 11 most relevant industries in our green bond sample as described earlier in section 3.1.1. Standard errors are clustered on year-month and issuer ultimate parent level, and they are robust to cross-sectional dependence and serial correlation (Caramichael & Rapp, 2024).

The baseline regression results for yield spreads, according to Equation 1, are presented in Table 4. In all six specifications, progressively introducing several control and fixed effects, both CBI-aligned and CBI-certified bonds experience negative coefficients, suggesting lower yield spreads relative to self-labelled bonds. The effect appears particularly strong only in simpler specifications (regressions 1-3), amplifying in columns 2 and 3 after introducing basic bond-level controls and year-month fixed effect. In column 3, the coefficient for CBI-aligned bonds is -0.37, suggesting a reduction of 37 basis points in yield spreads, and -0.81 for CBI-certified bonds, suggesting a reduction of 81 basis points in yield spreads relative to self-labelled bonds, both statistically significant at 1% level.

After introducing currency fixed effect from column 4 onwards, the adjusted R^2 increases significantly, indicating that currency explains a significant portion of the variation in yield spreads. The explanatory power of the model continues to increase after incorporating rating, industry, seniority and bond options fixed effects. The effect of CBI-alignment and CBI-certification weakens substantially when market-level controls and these fixed effects are introduced. For CBI-aligned bonds, the coefficients remain statistically significant and negative at -0.18 (-18 basis points) in column 4 and -0.16 (-16 basis points) in column 5, significant at 5% and 1% levels, respectively. Coefficients for CBI-certification decline significantly in magnitude and lose statistical significance. In the final column 6, the coefficient for CBI-alignment is -0.07, implying a reduction of 7 basis points, and -0.10 for CBI-certification, implying a reduction of 10 basis points in yield spreads relative to self-labelled bonds, however, both are statistically insignificant. When examining the fixed effects included in column 6 more in detail, it appears that seniority is especially driving the diminishing magnitude of coefficients and lost significance from column 5 to column 6. This may indicate that the observed pricing premium of CBI-aligned and -certified bonds may rather reflect their structural safety compared to self-labelled bonds.

Overall, these results suggest that CBI-alignment and -certification may initially appear to have a lowering effect on yield spreads compared to self-labelled bonds and indicate that bonds with more credible green signalling mechanism may receive more favourable pricing, up to -35 and -81 basis points, respectively. However, these effects are not robust for the most comprehensive version of the model including all bond-, firm- and market-level controls and fixed effects. While CBI-aligned and CBI-certified bonds seem to have consistently lower yield spreads to some extent relative to self-labelled bonds, the initial differences may reflect unobserved heterogeneity across bonds, markets and issuers, and a systematic “greenium”, particularly with CBI-certification, diminishes.

Table 4: Baseline regression results for yield spreads. This table reports the baseline regression results according to Equation 1 with yields spread at issuance as a dependent variable. Columns 1-6 present results for different model specifications, progressively introducing bond- and market-level controls and fixed effects. Statistical significance is indicated after each coefficient and corresponding t-statistics are reported under the coefficient in parentheses. Standard errors are clustered at issuer ultimate parent and year-month levels.

Baseline regression model

	Yield spread					
	(1)	(2)	(3)	(4)	(5)	(6)
CBI-Aligned	-0.22*	-0.35***	-0.37***	-0.18**	-0.16***	-0.07
	(-1.73)	(-3.95)	(-4.32)	(-2.54)	(-2.95)	(-1.41)
CBI-Certified	-0.51	-0.70**	-0.81***	-0.01	-0.11	-0.10
	(-1.43)	(-2.24)	(-2.64)	(-0.03)	(-0.94)	(-0.77)
Amount		0.29***	0.30***	0.14*	0.07	0.05
		(4.76)	(5.22)	(1.94)	(1.39)	(1.13)
Maturity		-0.34**	-0.42***	-0.00	0.01	-0.13
		(-2.38)	(-2.85)	(-0.01)	(0.10)	(-1.34)
Realized volatility						0.36
						(0.93)
IG Index Spread						-0.01
						(-0.85)
HY Index Spread						0.00
						(0.62)
Year-Month FEs			Yes	Yes	Yes	Yes
Currency FEs				Yes	Yes	Yes
Rating FEs					Yes	Yes
Seniority FEs						Yes
Bond Option FEs						Yes
Industry FEs						Yes
Observations	6,163	6,158	6,158	6,158	6,158	6,158
Adjusted R^2	0.003	0.056	0.089	0.528	0.604	0.625

T-values reported in parentheses.
Standard errors clustered on the issuer ultimate parent and year-month levels.
Significance: *p<0.1,**p<0.05,***p<0.01

4.1.2 External review

In addition to the baseline regression with indicator variables for CBI-alignment and CBI-certification, we use an alternative measure for assessing the credibility of the green bond by incorporating a variable for *External review* as described in section 3.1.1. This extension helps us to further assess whether the observed differences in yield spreads across different green bond types reflect the perceived credibility of the green signal. More specifically, we include a dummy variable indicating whether bond has received an independent second-party opinion prior to issuance. This measure captures an additional layer of market-perceived environmental credibility beyond CBI classification. Further, we explore the interaction between external review and CBI-alignment and CBI-certification to examine possible dual effects. Similarly to the baseline regression, these specifications are defined as follows:

$$Yield\ spread_{b,f} = \alpha_1 External\ review_b + \ \beta\ Controls_{b,c,t} + \ \mu_{m,c,s,r,o,i} + \ \varepsilon_{p,m} \tag{2}$$

$$Yield\ spread_{b,f} = \alpha_1 CBI\ Aligned_b\ x\ External\ Review_b + \\ \alpha_2\ CBI\ Certified_b\ x\ External\ review_b + \ \beta\ Controls_{b,c,t} + \ \mu_{m,c,s,r,o,i} \ + \ \varepsilon_{p,m} \tag{3}$$

where External review equals one if bond has received an independent second-party opinion pre-issuance. All other variables are defined as in the baseline regression model (Equation 1).

Table 5 presents the regression results with additional specifications defined in Equations 2 and 3, including a variable for external review and interaction terms between external review and CBI-alignment and -certification. Columns 1, 4 and 7 include baseline regression results according to Equation 1 from previous section for comparison, columns 2, 5 and 8 report results according to Equation 2 and columns 3, 6 and 9 according to Equation 3, progressively introducing controls and fixed effects.

The results suggest that external review on its own is associated with a statistically significant reduction in yield spreads in most model specifications. The effect is highly significant at 1% level even in the strictest forms of the regression in columns 5 and 8. Thus, the effect is robust to bond-, market- and issuer-level characteristics. After controlling for bond- and market-level effects and introducing all fixed effects, the coefficient for external review is -0.24, and significant at 1% level, implying 24 basis points reduction in yield spread. The effect on yield spread is larger in magnitude to the one of CBI-alignment or -certification, and the robustness of the effect may reflect more consistent and powerful signal of greenness from external review on its own compared to CBI-alignment or -certification.

A more detailed understanding of the credibility of the green signal comes from the interaction terms between external review and CBI classifications. These interaction terms allow us to assess whether the initial pricing impact of CBI-alignment or -certification depends on the external review or whether the effects are additive or substitutive. In column 3, the coefficient for CBI-alignment is -0.79 and -0.75 for external review, both statistically significant at 1% level, but the interaction term of these two is positive, 0.99, also statistically significant at 1% level. Interestingly, this implies that while the individual effects of these two signals are similar, bonds with both CBI-alignment and external review do not get the full combined benefit of the individual effects of -1.54 but instead a more moderate benefit of -0.55, implying a yield spread reduction of 55 basis points. This pattern remains robust across all model specifications. In column 9 including all bond and market controls as well as fixed effects, the coefficients for CBI-alignment and external review are -0.29 and -0.49, respectively, and 0.38 for their interaction, all of which statistically significant at 1% level, leading to an estimated joint effect of -0.40 (-40 basis points) on the yield spreads at issuance relative to self-labelled bonds without external review.

These results suggest non-additive signalling effects. Investors may consider both green signals credible but there may be a partial overlap in the signalling value of CBI-alignment and external review, and they are not fully independent. In contrast, the coefficients for CBI-certification and interaction term with external review are consistently small and statistically non-significant across all model specifications. CBI-certified bond already undergoes formal external validation so the external review variable may be less relevant for this group. Moreover, CBI-certified bonds are a clear minority with only a couple hundred observations in the whole sample which may reduce the statistical power of the model for these bonds.

Table 5: Baseline regression results for yield spreads with external review variable. This table reports the baseline regression (Equation 1) results with specifications according to Equations 2 and 3 with yield spread at issuance as a dependent variable. Columns 1-9 present results for different model specifications, progressively introducing bond- and market-level controls and fixed effects. Columns 1, 4 and 7 report results according to Equation 1, columns 2, 5 and 8 according to Equation 2 and columns 3, 6 and 9 according to Equation 3. Statistical significance is indicated after each coefficient and corresponding t-statistics are reported under the coefficient in parentheses. Standard errors are clustered at ultimate parent and year-month levels.

Baseline regression model, external review added

	Yield spread								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
CBI-Aligned	-0.22*		-0.79***	-0.18**		-0.47***	-0.07		-0.29***
	(-1.73)		(-3.88)	(-2.54)		(-3.54)	(-1.41)		(-3.22)
CBI-Certified	-0.51		-0.66	-0.01		0.10	-0.10		-0.22
	(-1.43)		(-1.28)	(-0.03)		(0.36)	(-0.77)		(-0.10)
External review		-0.11	-0.75***		-0.30***	-0.61***		-0.24***	-0.49***
		(-1.04)	(-6.83)		(-4.29)	(-6.02)		(-4.42)	(-5.19)
CBI-Aligned x External review			0.99***			0.52***			0.38***
			(5.63)			(4.03)			(3.830)
CBI-Certified x External review			0.18			-0.29			0.22
			(0.31)			(-0.93)			(0.83)
Bond Controls				Yes	Yes	Yes	Yes	Yes	Yes
Market Controls							Yes	Yes	Yes
Year-Month FE				Yes	Yes	Yes	Yes	Yes	Yes
Currency FE				Yes	Yes	Yes	Yes	Yes	Yes
Rating FEs							Yes	Yes	Yes
Seniority FEs							Yes	Yes	Yes
Bond Option FEs							Yes	Yes	Yes
Industry FEs							Yes	Yes	Yes
Observations	6,163	6,163	6,163	6,158	6,158	6,158	6,158	6,158	6,158
Adjusted R^2	0.003	0.001	0.016	0.528	0.53	0.535	0.625	0.627	0.629

T-values reported in parentheses.
Standard errors clustered on the issuer ultimate parent and year-month levels.
Bond and market controls are the same as in the baseline regression models.
Significance:
*p<0.1,**p<0.05,***p<0.01

4.1.3 Time and sector variation

Finally, we study the annual time variation and sector-specific differences in the yield spreads, following Caramichael & Rapp (2024). According to also Zerbib (2019), sector is a significant driver for the green premium. Again, we construct similar regressions to the baseline model (Equation 1) with interaction terms between CBI Aligned and CBI Certified dummy variables and yearly fixed effect. Similarly, for studying sector-specific differences we construct the same regression model and replace the yearly fixed effect with sector fixed effect.

The regression results for time variation in the effects of CBI-alignment and -certification are presented in Appendix A. The results reveal that the reductions in yield spreads for CBI-aligned bonds concentrate between years 2017-2024. Coefficients in these years are all significantly negative at least at 5% level, most of them at 1% level, peaking at -0.95 in 2020 in columns 1 and at -0.84 in 2018 in column 2. This suggests that the pricing benefits emerged in 2017, potentially reflecting growing investor awareness, increasing concerns for greenwashing and demand for bonds with enhanced information on the greenness. The consistent pattern from 2017 onward could also reflect broader institutionalization of ESG investing and increasing standardization of the green bond market with clearer guidelines. CBI-certified bonds seem to experience more volatility over time, potentially due to smaller sample size. In column 2, coefficients are negative and statistically significant only for years 2017-2018 and 2021-2023, mostly significant at 1% level.

The regression results for sectoral variation analysis are presented in Appendix B. The results suggest that the pricing benefits of CBI-alignment and -certification are not uniform across industries. In the industry categories we defined earlier, the negative and statistically significant reduction in yield spreads for CBI-aligned bonds are most evident in Energy & Utilities (-0.51), Real Estate (-0.32), and Transportation & Logistics (-0.49) compared to Banks (baseline). However, the statistical significance disappears in column 2 after including market controls and fixed effects.

CBI-certification yields even larger reductions in the same sectors, as well as in Construction & Infrastructure. After market controls and fixed effects are taken into account, the coefficients remain significantly negative for Construction & Infra (-1.09) and Real Estate (-0.71), at 1% level. In contrast, Non-bank Financials has statistically significant positive coefficient in column 2, at 10% level.

Battiston et al. (2017) identified fossil fuel, utilities, energy-intensive, housing, and transportation as climate-policy relevant sectors. Similarly, according to Fatica et al. (2021), in addition to the financial sector, energy, utility, real estate and transportation sectors are particularly active in the green bond market. Our findings on the sector variation align well with these industries identified as climate-policy relevant or active in the green bond market, suggesting that the pricing benefits associated with CBI-alignment or -certification are concentrated in industries that are more directly exposed to climate-related risks or play a central role in the low-carbon transition. This sectoral variation may reflect greater investor scrutiny and stronger environmental commitment in these industries, with potentially high greenwashing concerns. In these industries, certification standards may play a particularly important role.

4.2 Measuring post-issuance environmental performance

While the first part of the study aims to capture the perceived credibility of the green labels through pricing, the second part focuses more on the actual greenness by examining the issuer-level outcomes post-issuance. Specifically, we study the evolution of environmental pillar score and emissions score as they are especially relevant in the context of green bonds. The second part is conducted at issuer-year level rather than bond-level since the environmental scores are reported on an annual basis for the issuers. This reduces the number of observations as there are issuers with several bond issuances per year. Here, we apply three different models, first focusing on a simple within-firm variation before incorporating more granular approaches with difference-in-differences specifications to compare the development between the issuers of green-labelled versus self-labelled bonds.

Similarly to the previous section, we also provide the empirical results after each model specification. Our main findings suggest that generally, green bond issuers tend to improve their environmental scores post-issuance regardless of the label. While our initial DiD approach indicates that the issuers of CBI-aligned bonds outperform the issuers of self-labelled bonds post-issuance, a more detailed model reveals that these issuers have higher scores already before the issuance and the post-issuance difference may instead reflect the already existing outperformance before the bond issuance. The incremental post-issuance effect of CBI-alignment diminishes or in some specifications, even turns negative.

4.2.1 Within-firm post-issuance performance

We begin our analysis of post-issuance environmental performance with an issuer-level regression model adapted from Tang and Zhang (2020) for each green bond category. Tang and Zhang study liquidity after green bond issuance and we modify their approach to examine whether firms experience improvements in environmental performance scores following the issuance of a green bond. The model is implemented using a balanced sample of issuer-year panel data, separately for each green bond type, over a four-year window (the year preceding issuance, the year of issuance and one- and two-years post issuance) with issuer-level controls and fixed effects. A post-issuance dummy variable captures the years after the issuance. This initial approach does not include a control group or matching procedure used in treatment studies and therefore doesn't allow direct comparisons between the groups. However, it serves as a useful starting point by providing evidence of within-firm changes in environmental pillar scores or emissions scores without introducing assumptions about the comparability of issuers. Following Tang and Zhang (2020), the regression model is defined as follows:

$$Score_{f,t} = \alpha\, Post_{f,t} + \beta\, Controls_{f,t-1} + \mu_{f,t,d,i} + \varepsilon_f \tag{4}$$

where Score is the environmental pillar score (emissions score) for firm *f* at year *t*. The main variable of interest, an indicator variable Post, equals one from bond issuance year onward. The vector of controls includes firm-level numeric controls for firm size, ROA and leverage, at year *t-1,* lagged by one year. Fixed effects $\mu_{f,t,d,i}$ include firm, year, domicile *d* and industry *i*. Standard errors are clustered at firm level. All firm controls are winsorised at the 1st and 99th percentiles of their empirical distributions to mitigate the effect of potential outliers in the data.

Our within-firm model according to Equation 4 is applied to three sub-samples based on green bond issuer type (self-labelled, CBI-aligned and CBI-certified) in order to examine the environmental performance over a four-year window around the event of bond issuance, with environmental pillar scores and emissions scores as performance indicators. Table 6 reports regression results separately for each group, Panel A containing results for the issuers of self-labelled bonds, Panel B for CBI-aligned and Panel C for CBI-certified.

The issuers of self-labelled bonds seem to consistently improve both environmental pillar and emissions scores post-issuance across all model specifications with statistical significance. The coefficient for Post ranges from 2.16 to 3.15 for environmental pillar score and from 2.19 to 4.72 for emissions score. The effect decreases as controls and fixed effects are introduced; however, they stay positive and significant even in the strictest form of the model in column 3 – coefficient for Post for environmental pillar score is 2.16 and statistically significant at 5% level, and 2.19 for emissions score, statistically significant at 10% level. These results suggest some short-term improvement in environmental performance even for the issuers without a formal alignment or certification for their green bonds.

The results are similar for the issuers of CBI-aligned bonds. The coefficients for Post, both with environmental pillar score and emissions score, are positive, highly significant and robust for all model specifications, however, smaller in magnitude relative to issuers of self-labelled bonds. For environmental pillar scores, the coefficients for Post start from 2.90 in column 1, statistically significant at 1% level, and ends up at 1.05 after controls and fixed effects are included in column 3, still significant at 1%. For emissions score, the Post coefficient in column 1 is 3.86, significant at 1% level, and it decreases to 1.27 in column 3, significant at 5% level. These coefficients imply that both scores improve post-issuance.

The results for the issuers of CBI-certified bonds in turn are less clear. The Post coefficient for environmental pillar score starts from 3.41 in column 1 but turns even negative for the most controlled model, however, all specifications lacking statistical significance. In the simplest model specification, there seems to be an improvement in emissions score with a positive Post coefficient of 4.07, statistically significant at 10%, but the effect diminishes after controls and fixed effects are included. These results may suggest that the highest tier of certification may not correlate with stronger environmental performance, however, they are also likely to reflect the small sample size of CBI-certified bond issuers which limits the statistical power.

The adjusted R^2 are relatively high across all the models and across all subsamples, ranging from 0.79 to 0.93, providing evidence on the general fit and robustness of the model. Overall, these findings suggest that environmental performance improves to some extent through environmental pillar scores and emissions scores post-issuance regardless of the green label, and the effect is particularly visible for issuers of CBI-aligned and self-labelled bonds. However, it is important to note that this model does not provide meaningful comparisons between the issuer groups as it only focuses on within-firm variation.

Table 6: Within-firm post-issuance environmental performance results. This table provides regression results according to Equation 4 with environmental pillar score in columns 1-3 and emissions score in columns 4-6 as a dependent variable, during a four-year time window from t-1 until t+2. Columns 1-3 and 4-6 present results for different model specifications, progressively introducing bond- and market-level controls and fixed effects. Panel A reports results for self-labelled bond issuers, Panel B for CBI-aligned bond issuers, and Panel C for CBI-certified bond issuers. Statistical significance is indicated after each coefficient and corresponding t-statistics are reported under the coefficient in parentheses. Standard errors are clustered at firm level.

Within-firm post-issuance environmental performance

	Environmental performance					
Panel A	Environmental pillar score			Emissions score		
Self-labelled	(1)	(2)	(3)	(4)	(5)	(6)
Post	3.15***	2.36**	2.16**	4.72***	2.33**	2.19*
	(3.35)	(2.25)	(2.07)	(3.18)	(2.16)	(1.97)
Log size			2.20			6.69
			(0.45)			(1.00)
ROA			52.78**			37.51
			(2.21)			(1.17)
Leverage			28.82			19.31
			(1.57)			(0.81)
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects		Yes	Yes		Yes	Yes
Country fixed effect			Yes			Yes
Industry fixed effect			Yes			Yes
Observations	432	432	432	428	428	428
Adjusted R^2	0.894	0.899	0.893	0.817	0.851	0.839
Panel B	Environmental pillar score			Emissions score		
CBI-aligned	(1)	(2)	(3)	(4)	(5)	(6)
Post	2.90***	1.03**	1.05***	3.86***	1.25**	1.27**
	(7.11)	(2.59)	(2.64)	(6.24)	(2.00)	(2.05)
Log size			-0.92			1.62
			(-0.45)			(0.62)
ROA			13.26			17.14
			(1.05)			(0.84)
Leverage			1.72			12.76
			(0.17)			(0.88)
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects		Yes	Yes		Yes	Yes
Country fixed effect			Yes			Yes
Industry fixed effect			Yes			Yes
Observations	1,468	1,468	1,468	1,448	1,448	1,448
Adjusted R^2	0.909	0.913	0.910	0.844	0.851	0.845
Panel C	Environmental pillar score			Emissions score		
CBI-certified	(1)	(2)	(3)	(4)	(5)	(6)
Post	3.41	0.96	-0.13	4.07*	2.06	1.13
	(1.52)	(0.67)	(-0.07)	(1.89)	(1.34)	(0.76)
Log size			18.09*			14.63
			(1.87)			(1.10)
ROA			-25.72			-20.94
			(-0.63)			(-0.23)
Leverage			34.60			-10.11
			(0.66)			(-0.22)
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects		Yes	Yes		Yes	Yes
Country fixed effect			Yes			Yes
Industry fixed effect			Yes			Yes
Observations	108	108	108	104	104	104
Adjusted R^2	0.927	0.926	0.919	0.827	0.831	0.793

T-values reported in parentheses. Standard errors clustered at firm level.
Significance: *p<0.1,**p<0.05,***p<0.01

4.2.2 Matching and difference-in-differences

While our initial regressions offer general insights into post-issuance trends, there are concerns on selection bias and endogeneity. Since firms do not randomly issue green bonds (Flammer, 2021), there is a risk that unobservable characteristics drive the decision to issue green bonds and the subsequent changes in environmental performance.

To address these concerns, we implement another approach, adapted from a methodology proposed by Flammer (2021) as a more sophisticated method for estimating the impact of green bond issuance and green label on environmental performance. This model improves our baseline model by introducing a matching method and difference-in-differences (DiD) specification, allowing us to compare the post-issuance performance between different types of green bond issuers with otherwise similar characteristics before bond issuance. Matching helps us to address a potential concern of endogeneity (Tang & Zhang, 2020; Flammer 2021). Creating homogenous sub-groups by pairing a treated group with a control group and examining the treatment effect is argued as the best available method for approximating this scenario (Yeow & Ng, 2021).

For the rest of the study, we only include the issuers of CBI-aligned and self-labelled bonds in the sample. Since CBI-certified bonds were already rare in our bond-level sample, the sample size becomes a challenge when we are trying to find comparable issuers for our issuer-year observations. Thus, we are only focusing on the issuers of CBI-aligned bonds as a treatment group and the issuers of self-labelled bonds as a control group to ensure a meaningful number of observations per green bond category.

Flammer's model leverages the full time-series structure of our data, and we use all available issuer-year observations for environmental pillar and emissions scores between 2013-2024. The treatment effects are identified through dummy variables. While the basic version only flags observations for the issuers of CBI-aligned bonds post-issuance, the dynamic version of the model includes three separate year-specific indicator variables: pre-issuance year, one year following the issuance and two or more years following the issuance of a CBI-aligned green bond. The dynamic model allows us to distinguish the timing of potential changes and separate short- and long-term responses (Flammer, 2021). The inclusion of a broader panel allows for more precise estimation of fixed effects and standard errors and enhances the statistical power of the model.

We compare firms issuing CBI-aligned green bonds with propensity score-matched issuers of self-labelled green bonds. Since the issuers in our sample tend to issue green bonds of only a certain type, matching requires finding comparable issuers instead of matching CBI-aligned and self-labelled bond observations from the same issuer. First, we require the matched pairs to be from the same year, same geographical region and same industry. Then, for propensity scores we have 11 firm-level variables, including the average size of the bonds issued by the firm during that year, and ESG score, environmental, social and governance pillar scores, and emissions score pre-issuance as well as the pre-trends of these scores, measured as the change from t-2 (two years prior to bond issuance) to t-1 (one year prior to bond issuance).

This procedure is a simplified version of Flammer's original Mahalanobis distance-based approach and is modified to ensure sufficient sample size given our data availability constraints. Propensity score matching is also used in similar studies (Yeow & Ng, 2021; Zhou & Cui, 2019). The overlap between issuers that have both ESG scores and company fundamentals available is limited and thus, we focus here on the similarity in terms of ESG scores pre-issuance instead of company fundamentals. However, we use average bond size to get a proxy for firm size. Following Flammer, we have two specifications for the DiD regression after matching, defined as follows:

$$Score_{f,t} = \alpha\ CBI\ Aligned\ Post_{f,t} + \mu_{t\ x\ d} + \mu_{t\ x\ i} + \varepsilon_i \quad (5)$$

$$Score_{f,t} = \alpha_1\ CBI\ Aligned\ Pre_{f,t} + \alpha_2\ CBI\ Aligned\ ST\ Post_{f,t} + \alpha_3\ CBI\ Aligned\ LT\ Post_{f,t} + \mu_{t\ x\ d} + \mu_{t\ x\ i} + \varepsilon_i \quad (6)$$

where Score is the environmental pillar score (emissions score) for firm *f* at year *t*. In Equation 5, an indicator variable CBI Aligned Post equals one if the firm has issued a CBI-aligned bond by year *t*. Similarly, in Equation 6, a dummy CBI Aligned Pre equals one for the year preceding the issuance, CBI Aligned ST Post equals one for the year after the issuance (short-term effect) and CBI Aligned LT Post equals one for years two or more after the issuance (long-term effect) of a CBI-aligned bond. These are the main variables of interest since they measure the difference-in-differences in outcome variable, environmental pillar score or emissions score, between treated and control issuers. Both equations include interaction terms for fixed effects: domicile *d* by year *t* and industry *i* by year *t*. Standard errors are clustered at industry level.

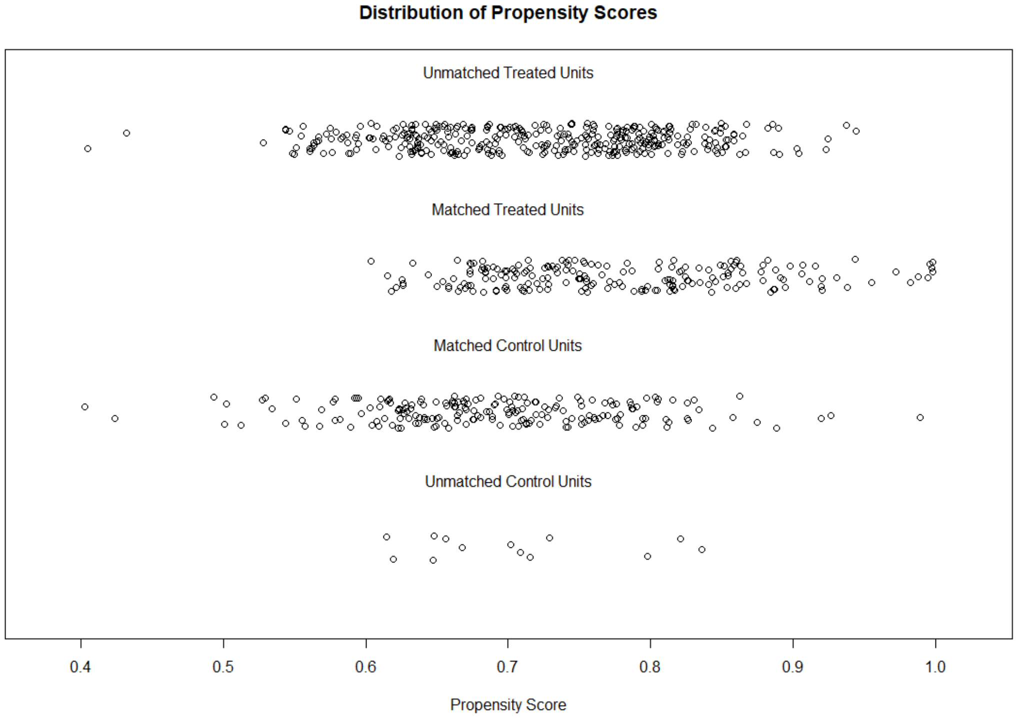

Figure 4. Distribution of propensity scores for unmatched and matched treatment and control units for the baseline and dynamic models.

Figure 4 presents the distribution of propensity scores for matched and unmatched treatment and control units and reflects the quality of our matching process. There is a fairly good overlap in propensity scores between 0.6-0.9 for matched treatment and control units. However, the matched treatment group is skewed towards the right compared to the matched control group, meaning that a perfect balance is not achieved. Matching mitigates the observable bias, but some imbalance could still remain.

Table 7 presents the actual regression results for our difference-in-differences model. The baseline results are reported in columns 1 and 3 for environmental pillar scores and emissions scores, respectively, and columns 2 and 4 report the dynamic effects, respectively. Based on the single post-treatment indicator, the results show that post-issuance, the issuers of CBI-aligned green bonds significantly outperform the issuers of self-labelled bonds, by 4.96 points in environmental pillar scores, significant at 5% level, and by 2.29 points in emissions scores, significant at 10% level. Based on these metrics, the coefficients suggest that issuers of CBI-aligned bonds outperform the issuers of self-labelled bonds in environmental performance post-issuance.

The dynamic effects specify the timing of the effects more in detail, including indicators for pre-issuance, 1-year post and +2-years post CBI-aligned bond issuance. Both environmental pillar and emissions scores differ already before the issuance – the pre-issuance scores are higher for the issuers of CBI-aligned bonds on average by 3.87 points for environmental pillar scores and by 3.92 points for emissions scores, both significant at 1% level. For environmental pillar scores, the coefficient rises to 4.08, significant at 5% level, one year after the issuance and continues to increase +2 years after the issuance, reaching 7.29, still significant at 5% level. Emissions scores follow a similar pattern, and the post-issuance coefficients are positive, although statistically insignificant.

Despite the seeming increase in coefficients over time, we formally test whether these observed improvements differ significantly from the pre-issuance baseline. We apply a linear hypothesis test for comparing the pre-issuance and 2+ years post coefficients and the resulting p-values are 0.20 and 0.70 for environmental pillar scores and emissions scores, respectively. This implies that the increase is not statistically significant and even the 2+ years post coefficient of 7.29 for environmental pillar score does not differ significantly from the pre-issuance coefficient of 3.87. This suggests that the higher post-issuance scores for CBI-aligned issuers may merely reflect their already superior performance pre-issuance. While the scores remain higher, they do not significantly improve post-issuance.

Table 7: Difference-in-differences baseline and dynamic effects results. This table provides regression results according to Equations 5 and 6 with environmental pillar score in columns 1-2 and emissions score in columns 3-4 from the whole time-series as a dependent variable. Columns 1 and 3 presents results for the baseline model (Equation 5) and columns 2 and 4 for the dynamic model (Equation 6). Statistical significance is indicated after each coefficient and corresponding t-statistics are reported under the coefficient in parentheses. Standard errors are clustered at industry level.

Difference-in-differences regression, baseline and dynamic effects

	Environmental performance			
	Environmental pillar score		Emissions score	
	(1)	(2)	(3)	(4)
CBI-aligned bond (post)	4.96**		2.29*	
	(2.90)		(2.09)	
CBI-aligned bond (pre-issue year)		3.87***		3.92***
		(3.77)		(8.67)
CBI-aligned bond (short-term, 1 year post)		4.08**		1.73
		(2.68)		(1.73)
CBI-aligned bond (long-term, 2+ years post)		7.29**		3.21
		(2.38)		(1.50)
Country-year fixed effects	Yes	Yes	Yes	Yes
Industry-year fixed effects	Yes	Yes	Yes	Yes
Observations	3,760	3,760	3,663	3,663
Adjusted R^2	0.372	0.372	0.324	0.324

T-values reported in parentheses. Standard errors clustered at industry level.
Significance: *p<0.1,**p<0.05,***p<0.01

These findings indicate that both pre- and post-issuance, the issuers of CBI-aligned green bonds outperform issuers of self-labelled bonds, particularly in terms of environmental pillar scores. Importantly, the significant and positive coefficients for pre-issuance year may imply that the selection to treatment is not random – the issuers of CBI-aligned bonds show stronger environmental performance compared to the issuers of self-labelled bonds already before issuing green bonds, consistent with our concerns with endogeneity discussed in section 3.5.2. While the continuing post-issuance increase in environmental pillar scores of the CBI-aligned bond issuers, especially in longer-term, provides evidence that CBI-alignment may have a positive impact on the development of environmental performance after green bond issuance, the increase from pre-issuance is not statistically significant.

4.2.3 Decomposed treatment effect

While Flammer's (2021) model is an improvement to the within-firm regression model in section 4.2.1 and allows comparisons between the issuers of self-labelled and CBI-aligned bonds, the design structure of the DiD regression creates certain limitations. Specifically, in Equation 5, the treatment effect is captured through a single indicator variable that aggregates the post-issuance effect, baseline differences between treatment and control firms, and the true incremental effect of CBI-alignment.

To address these concerns, we follow Tang and Zhang (2020) further and apply a third model that offers a more detailed approach for estimating the impact of CBI-alignment on post-issuance environmental performance. This model also uses difference-in-differences specification but introduces separate indicator variables for the treatment group, post-issuance period, and their interaction. The interaction term isolates the differential change in environmental performance for CBI-aligned bond issuers relative to comparable self-labelled bond issuers post-issuance, thereby offering a more granular decomposition of the effect.

We construct the matched sample by using propensity score matching with the same variables as previously in section 4.2.2 – again, we focus on ensuring similarity of ESG performance pre-issuance and use average bond size as a proxy for firm size.[7] This analysis covers the same four-year window around the bond issuance as in the first within-firm model in section 4.2.1. The DiD model is defined as follows:

$$Score_{f,t} = \alpha_1 \, CBI\ Aligned_{f,t} + \alpha_2 \, Post_{f,t} + \alpha_3 \, CBI\ Aligned_{f,t} \, x \, Post_{f,t} + \mu_{t,d,i} + \varepsilon_f \qquad (7)$$

[7] Variables used in propensity score matching include average bond size and ESG score, environmental, social and governance pillar scores, and emissions score pre-issuance as well as the pre-trend of these scores, measured as the change from t-2 to t-1.

where variables are defined similarly to Equation 4. This model includes indicator variables CBI Aligned, Post and their interaction term which is the main variable of interest when analysing the differences in post-issuance environmental performance and the incremental effect of CBI-alignment. Standard errors are clustered at firm level.

Again, starting with the quality of matching, Figure 5 presents the distribution of propensity scores for unmatched and matched treatment and control units. Although the matching procedure and variables are similar, the narrower timeframe limits the number of observations available for matching. Even so, the overlap between propensity scores remains similar in a range between 0.65-0.95. However, the matched treatment units clearly concentrate towards higher scores relative to the matched control units, so perfect balance is not achieved.

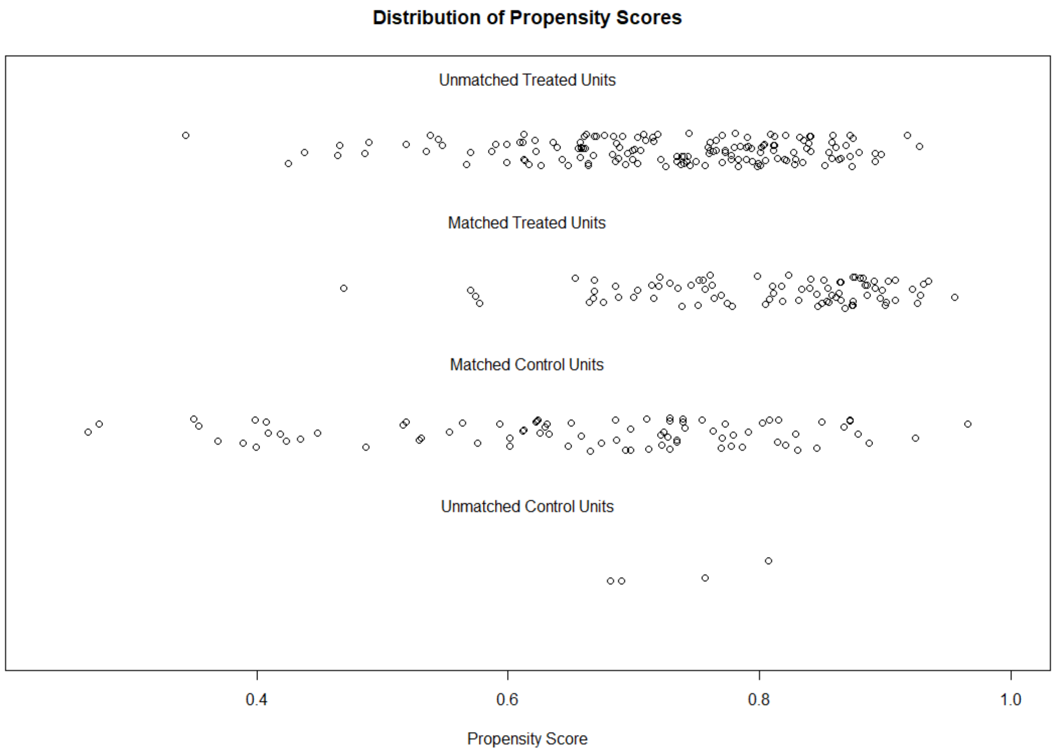

Figure 5. Distribution of propensity scores for unmatched and matched treatment and control units for decomposed treatment model. This figure presents the matching results according to availability of environmental pillar scores for a balanced sample; however, the distribution is nearly identical according to availability of emissions score.

The regression results for the balanced, matched sample are presented in Table 8. The results indicate that both environmental pillar scores and emissions scores improve post-issuance in general. The coefficient for Post is highly significant at 1% level for both measures across all the model specifications and varies between 4.27-8.16 for environmental pillar scores and 5.26-10.12 for emissions scores. This finding implies that both the issuers of

CBI-aligned and self-labelled bonds experience improvement in environmental performance after bond issuance.

Like results in Table 7 already indicated, the coefficient for Aligned in Table 8 suggests that there indeed is a baseline difference in the “greenness” of the issuers – the issuers of CBI-aligned bonds have higher scores already before the issuance. This applies particularly to environmental pillar scores where the coefficients are positive and statistically significant across all the model specifications, the most so in the strictest form where the coefficient is 8.78 and statistically significant at 1% level. The coefficients for Aligned are also positive with emissions scores, however, statistically insignificantly.

The interaction term between Aligned and Post captures the differential change post-issuance, after accounting for baseline differences and overall post-issuance change. Interestingly, for both environmental pillar scores and emissions scores, these coefficients are actually negative, however, only significantly so for emissions scores. The interaction term for emissions scores yields negative coefficient of -2.96, statistically significant at 10% level across all the models. These findings suggest that issuers of CBI-aligned bonds actually improved less in their environmental performance following bond issuance relative to their matched self-labelled counterparts when controlling for pre-existing differences. An important observation is that the adjusted R^2 increases significantly in the third model, from 0.040 to 0.396 after introducing country and industry fixed effects with environmental pillar score as a dependent variable. Similar pattern is also observable with emissions scores.

Overall, all our model specifications imply similar observations. The issuers of the green bonds tend to improve their environmental pillar and emissions scores post-issuance regardless of the label. Interestingly, the issuers of CBI-aligned bonds appear to have higher scores already before the issuance and improve less post-issuance than the issuers of self-labelled bonds. A fundamental difference between the models is that Flammer’s (2021) baseline model combines the baseline differences and post-treatment effects and the third model decomposes these more in detail. However, in the dynamic version of the Flammer’s model, we already saw some evidence of pre-issuance differences between the issuers of CBI-aligned and self-labelled bonds and the findings from this model support the observation that CBI-aligned bond issuers’ outperformance in environmental scores appears attributable to selection effects. While the issuers of CBI-aligned bonds show strong performance in terms of environmental pillar and emissions scores, the incremental gain after issuance seems limited, even negative or statistically insignificant.

Table 8: Difference-in-differences and decomposed treatment effect results. This table provides regression results according to Equation 7 with environmental pillar score in columns 1-3 and emissions score in columns 4-6 as a dependent variable, during a four-year time window from t-1 until t+2. Columns 1-3 and 4-6 present results for different model specifications, progressively introducing fixed effects. Statistical significance is indicated after each coefficient and corresponding t-statistics are reported under the coefficient in parentheses. Standard errors are clustered at firm level.

Difference-in-differences and decomposed treatment effect

	Environmental performance					
	Environmental pillar score			Emissions score		
	(1)	(2)	(3)	(1)	(2)	(3)
Post	4.27***	8.16***	6.56***	5.26***	10.12***	7.89***
	(3.83)	(3.75)	(3.96)	(4.43)	(4.64)	(4.03)
Aligned	6.91*	6.91*	8.78***	3.48	3.48	4.04
	(1.94)	(1.96)	(3.01)	(0.94)	(0.97)	(1.32)
Aligned * Post	-1.77	-1.77	-1.77	-2.96*	-2.96*	-2.96*
	(-1.13)	(-1.11)	(-1.11)	(-1.83)	(-1.80)	(-1.80)
Year fixed effects		Yes	Yes		Yes	Yes
Country fixed effect			Yes			Yes
Industry fixed effect			Yes			Yes
Observations	664	664	664	648	648	648
Adjusted R^2	0.026	0.040	0.396	0.004	0.029	0.381

T-values reported in parentheses. Standard errors clustered at firm level.
Significance: *p<0.1,**p<0.05,***p<0.01

4.3 Robustness tests

Finally, to validate the reliability and consistency of our main results, we conduct several robustness checks addressing potential concerns of sample construction and model design. Again, we start by checking the robustness regarding the results of the yield spread analysis and then continue to examine the robustness of our results concerning environmental performance.

In the baseline regression model for comparing the yield spreads at issuance, described in section 4.1, we rely on fixed-effect regression model with an unbalanced sample in order to maintain a meaningful sample size. However, as mentioned already, various studies in this field (e.g. Larcker & Watts, 2020; Zerbib, 2019; Bachelet et al.,2019) use matching methods instead. As a robustness test, we apply a matching approach to examine the differences in initial yield spreads with a more comparable set of bonds to reduce the risk of selection bias. We match the bonds based on issuer- and bond-level characteristics following Bachelet et al. (2019) and run the same baseline regression models, including external review, with the matched sample.[8] Here, we only focus on comparing CBI-aligned bonds to self-labelled bonds since the sample size of certified bonds does not allow meaningful matching.

[8] The issuer- and bond-level characteristics used in matching include: same currency, same coupon type, same credit rating bucket, amount issued (± 400%), coupon rate (± 0.25 %-points), maturity date (± 2 years). Callable bonds have been dropped from the sample.

The results for this test are presented in Appendix C. While the coefficients remain consistently negative for CBI-alignment alone, they reduce notably in magnitude and significance compared to the original baseline results. However, even in the original results, the reduction in yield spread was not robust to the strictest form of the regression. Although we apply the same baseline fixed effect model, the matching effectively narrows the sample variation, making the simpler regression specifications behave more similarly to the stricter forms in the baseline analysis. These findings suggest that part of the pricing benefit observed in the original unbalanced sample may be attributed to differences in bond or issuer characteristics rather than the green labelling alone.

The effect of external review remains significant even after matching and incorporating all controls and fixed effects, although the yield spread reduction is reduced to -9 basis points. Similarly, the interaction effects of CBI-alignment and external review remain somewhat robust, however, with smaller magnitude, and significance disappears in the strictest form. With bond controls and time and currency fixed effects, the combined effect is -15 basis points, while the individual effects were -13 and -17 basis points for CBI-alignment and external review, respectively, all significant either at 5% or 10% levels. This provides evidence for the earlier observation, that issuers cannot add up the information and signals of CBI-alignment and external review.

For our issuer-level analysis on environmental performance, we had to make certain decisions regarding our initial matching approach due to data availability constraints. As demonstrated by our main results, there seems to be an initial difference between the issuers of CBI-aligned and self-labelled bonds and as already pointed out by Flammer (2021), the issuance of the bond is not random and there are concerns of endogeneity. To test the sensitivity of our results, we apply a different approach for constructing the sample. We run the regression specifications according to Equation 7 with decomposed treatment effect, and apply an entropy balancing approach, as proposed by Hainmueller (2012), to address the issue of imbalance in matching characteristics and differences pre-treatment. Entropy balancing reweights the control group so that the mean of the covariates matches with the treatment group, improving the balance on all covariate moments included in the reweighting process (Hainmueller, 2012). This ensures that the treatment and control groups are comparable by construction. Entropy balancing is also used in similar studies (e.g. Yu et al., 2024).

The results for reweighted sample with entropy balancing are reported in Appendix D. The coefficient for Post remains positive and statistically significant across all the model specifications, both for environmental pillar and emissions scores, quite aligned with our original results, with slightly smaller magnitude. Baseline difference disappears with entropy balancing, as indicated by Aligned coefficient, since that is exactly what this balancing method is designed to do – it forces the control group to resemble the treatment group in characteristics preceding the treatment, in this case ESG scores before the green bond issuance. The incremental effect of alignment post-issuance, through the interaction term of Aligned x Post, is insignificant, as we concluded in the baseline results already.

Finally, we study the association of our findings to first-time issuances. Flammer (2021) suggested that the positive investor reaction to green bond issuances is especially prevalent in first-time issuers and bonds. We include an indicator variable flagging first-time green bond issuances in yield spread analysis or first-time issuer-years in the case of environmental performance, to assess whether the observed effects of alignment or certifications in bond pricing and environmental performance are particularly driven by initial engagement with the green bond market. [9]

The results are presented in Appendix E for yield spreads and in Appendix F for environmental performance. Interestingly, first-time issuances seem to have around 40-70 basis points higher yield spreads than the subsequent issuances, depending on the model specifications. This effect remains statistically significant at 1% level across all variations. Moreover, the interaction term CBI aligned x First issuance is significantly negative in all models, varying from -23 to -44 basis points. This implies that even if the first-time issuances in general would have higher yield spreads than the subsequent issuances, CBI-aligned first issuances would still have significantly lower yield spreads at issuance compared to self-labelled first issuances. Although in different context than Flammer's finding on more positive investor reactions to first time issuances, our results align with her findings as the yield spread reduction for CBI-aligned bonds compared to self-labelled bonds seems to be particularly prevalent in first-time issuances. Yield spread reduction in subsequent CBI-aligned or certified bonds appears insignificant in most specifications. For environmental outcomes, first-time issuances do not seem to have a significantly different effect compared to subsequent issuances.

[9] We define first-time green bond issuance according to our sample. There may be some issuers with even earlier green bond issuances; however, broader scaling of the market started from 2016 onwards and these earlier issuances are relatively few.

5 Findings and discussion

This section provides more detailed analysis on the main findings presented in section 4 and discussion on their broader implications and connections to existing literature. Lastly, we consider the limitations of this study and discuss potential further research on this topic.

5.1 Thesis overview

This thesis examined the role of green bond labelling on bond pricing at issuance and issuer's environmental performance. Using a global sample of green bonds issued since 2016, we studied the effect of CBI-alignment and CBI-certification on yield spreads at issuance relative to self-labelled bonds, as well as the role of external review. We extended the baseline models with an analysis of time and sector variation. Moreover, we studied the effect of green bond issuance on environmental performance using environmental pillar scores and emissions scores and further examined the effect of CBI-alignment on post-issuance environmental performance relative to self-labelling.

5.2 Discussion on main findings

5.2.1 Yield spread at issuance

Our results provide partial support for the existing findings of "greenium" in the market (Caramichael and Rapp, 2024; Baker et al., 2022; Zerbib, 2019). However, it is important to note that our study does not refer directly to the traditional definition of greenium as the pricing difference between green bonds and conventional bonds that is used in most studies. Instead, we interpret greenium more broadly as investors' willingness to pay premium for sustainable impact. Since we compare only different types of green bonds, our focus is more on the perceived greenness signalled through green labelling. While the pricing benefit was less prevalent with CBI-certified bonds, possibly due to limited sample size, CBI-aligned bonds and bonds with external review showed more robust reduction in yield spreads at issuance in our sample.

It has been suggested that green bonds act as a credible signal of issuer's environmental commitment and the credibility can be reinforced by third-party certifications (Flammer, 2021; Yu et al., 2024). External review may have a comparable role to green bond certification in reducing information asymmetry and preventing greenwashing as a market-based solution relying on a third-party verifying the alignment with green bond standards, also suggested by previous studies (Fatica et al., 2021; Caramichael & Rapp, 2024); however, it may be a less costly process to obtain than a full certification. Indeed, in our results external review appeared to have the most consistent lowering effect on yield spreads, aligning with the previous findings on external review strengthening the pricing effect for green bonds (Caramichael and Rapp, 2024; Fatica et al., 2021).

In most model specifications in our study, the effect of external review was stronger than the one from CBI-alignment, supporting the interpretation that external review may have more credibility than the mere alignment with standards. The small sample size of CBI-certified bonds limits meaningful conclusions for this group. However, considering the lack of consistent regulation across the green bond market, even the alignment with CBI standards appears to boost the credibility of the green signal compared to just self-labelling the bonds as green without further validation. Thus, CBI-aligned bonds may receive more favourable pricing as well. As mentioned by Hyun et al. (2020), investors tend to rely on information enhancers like green bond labels and end up with a limited number of premium issuers to decrease their information costs. For investors to allocate their funds efficiently, globally recognized common green bond standards would therefore be essential.

Our regression models including all three indicator variables for CBI-certification, CBI-alignment and external review, provided interesting insights on the joint-effect of CBI-alignment and external review. While external review showed stronger effect on yield spreads on its own, the interaction term still suggests a substitutive nature of their relationship – the combined effect of having both CBI-alignment and external review is less than directly additive. Investors may perceive some overlap in their information and credibility, potentially explaining this phenomenon.

Flammer (2021) reported that the positive investor reactions to green bond announcements were particularly strong for first-time issuers. Our robustness test results revealed some interesting observations regarding the impact of first-time issuances on bond pricing. On average, first issuances of both self-labelled and CBI-aligned bonds are associated with higher yield spreads at issuance relative to following bond issuances. This may indicate investor cautiousness or scepticism toward the true environmental intentions of the issuer and reflect the uncertainty regarding the credibility of the first green bond when issuers lack history of prior green bond activity. As issuers continue to issue more green bonds over time, they may build trust and credibility, leading to improved confidence among investors and higher willingness to pay premium.

However, we find that CBI-aligned first-time bond issuances have significantly lower yield spreads than first-time self-labelled bonds. This may imply that the information and signalling value of the green label may be particularly relevant when green bonds are first issued – they help to mitigate the uncertainty around first-time issuances regarding the credibility of greenness when no previous evidence exists yet. In fact, the yield spread reduction relative to self-labelled bonds seems to mainly associate to first-time issuances with regards to green labelling based on CBI standards. The effect of CBI-alignment appears robust only with first-time bonds and become less visible in subsequent issuances. These findings imply that alignment with established green bond standards may serve as a credible signal of environmental commitment and help to reduce the perceived risk of greenwashing, resulting in more favourable pricing, especially when there is no previous evidence on green bond activity and environmental commitment of the issuer.

5.2.2 Post-issuance environmental performance

Previous literature on the real effects of green bonds remains rather limited and the existing studies come with mixed findings. Post-issuance improvement in environmental scores seems consistent across our models for CBI-aligned and self-labelled issuers; however, with limited significance for CBI-certified issuers. While our initial DiD model suggested superior environmental performance post-issuance for CBI-aligned bond issuers, the dynamic and decomposed versions of the model revealed that the outperformance exists already before the green bond issuance, diminishing the actual incremental effect of CBI-alignment on post-issuance performance. This somewhat contradicts with the findings of Yu et al. (2024) on third-party certification improving issuer's ESG ratings following the issuance compared to non-certified bond issuances, however, their study focused solely on Chinese markets and certification effect instead of alignment.

Our findings suggest that issuers of CBI-aligned green bonds are already "greener" in terms of environmental pillar scores before the bond issuance. Thus, the environmental performance after issuance may not be linked with alignment or certification status of the bond itself but rather reflect pre-existing firm characteristics and endogenous selection of issuers, meaning that firms with stronger environmental performance would be more likely to seek alignment or certification for their green bonds. The more significant post-issuance performance improvement seems to come from self-labelled bond issuers with lower environmental scores. This could be a natural consequence in a sense that there is more room for improvement and even self-labelling green bonds may act as a credible signal of environmental commitment for these issuers with weaker pre-issuance performance. Further, this could imply that self-labelled bonds would rather signal some form of environmental commitment as opposed to being used as merely a way of greenwashing. Meanwhile, CBI-aligned bond issuers may face a ceiling effect with their already strong environmental scores.

Christensen et al. (2022) provide another relevant perspective in their study regarding ESG disclosure and ESG rating disagreement. They conclude that rating agencies disagree more on the outcome-based metrics than input-based ones and suggest that ESG disclosure is associated with higher disagreement, particularly for the outcomes. Their findings could provide support for our results and help to explain why CBI-alignment, arguably a stronger signal of environmental commitment than self-labelling, would not simply lead to incremental improvement in environmental scores relative to self-labelling. CBI-alignment is a stricter form of green label and likely comes with higher transparency and scrutiny along with increased reporting and disclosure. Following Christensen et al. (2022), this may lead to higher disagreement in post-issuance environmental scores, potentially diminishing the observed improvements.

Nevertheless, we must be cautious when interpreting the post-issuance development of environmental performance as a direct cause of green bond issuance. Our analysis identifies association between the issuance and subsequent changes in environmental scores, but it does not establish a causal link between these two. Flammer (2021) argues that green bond issuance alone would likely be too small to have a material impact on issuer level environmental performance. Improvements in environmental scores may reflect an overall positive trend in scores along with increased awareness and corporate environmental agendas, broader strategic shifts, regulatory changes or pre-existing trends in firm's environmental efforts rather than the green bond issuance itself. Therefore, our findings should be viewed as correlational, rather than indicative of green bonds triggering environmental improvement.

5.3 Limitations and future research

While this study sheds light on the role of green bond labelling and provides new evidence on its effects on green bond pricing and environmental outcomes, it is by no means conclusive. The study is conducted with available approaches feasible given the limitations of the study.

A key limitation of the study regards the availability and granularity of the data. Our sole data source is LSEG, and we were not able to complement our dataset from other financial data sources. While we have quite comprehensive set of green bonds in the sample, the number of CBI-certified bonds is small which restricts the meaningfulness of the study regarding certification and steered the focus toward CBI-alignment effects instead. Furthermore, the lack of consistent coverage of ESG-scores led to exclusion of many bond issuers in the second part of the study regarding environmental outcomes. Moreover, the granularity of ESG metrics stayed on annual level, which constrained our ability to capture the precise timing of changes in environmental scores relative to bond issuance. Finally, the overlap between issuers with both ESG metrics and company fundamentals available was limited. These restrictions affected the methodologies feasible in the study.

Despite using methodologies designed for mitigating endogeneity, this remains a concern in our sample. Even after matching, our findings suggest that the issuers of CBI-aligned bonds differ from the issuers of self-labelled bonds already before the green bond issuance in terms of environmental scores. Green bond issuance is not random, and our findings indicate a possibility of selection effects where greener firms are more likely to seek alignment or certification. While matching and entropy balancing help to address these issues, they do not fully eliminate the endogeneity bias arising from unobserved factors.

One of the common challenges in empirical research is establishing causal relationships. While our methodologies, particularly difference-in-differences models, aims to approximate causal inference, ultimately our results remain correlational. While including several bond-, issuer- and market-level factors help to control observable characteristics, unobservable factors may still influence the results, making it difficult to fully isolate the effect of green label itself. Furthermore, while our results point to statistical significance in both pricing and environmental outcomes, they do not necessarily speak to their economic significance. More specifically, we are not able to account for costs of obtaining CBI-alignment, certification or external review, or internal resources to comply with green standards. This limits our ability to assess whether the observed pricing benefits outweigh the associated direct and indirect costs. As highlighted by Caramichael and Rapp (2024), certification costs can be especially burdensome for first-time issuers or smaller firms. Without detailed costs associated with different levels of green bond labels, it is difficult to evaluate whether our findings translate into net economic benefits for the issuers.

Overall, the findings of our thesis suggest that green labels, certifications, and alignment with market standards do influence green bond pricing at issuance, as well as the environmental outcomes post-issuance. As the green bond market continues to evolve and mature, the role and development of regulatory frameworks will be interesting to witness. The recent introduction of the EU Green Bond Standard (EU GBS), effective since the end of 2024, already introduces a new shift in market expectations. Under this standard, issuers are faced with stricter alignment and information disclosure requirements, and mandatory external review. (European Commission, 2025b) We could expect a growing number of bonds being issued under this EU GBS, which could offer new more meaningful research opportunities on the effects of certification in the future. Moreover, increasing number of certified bonds could also shift the market dynamics with investors placing more emphasis on certification, thus reinforcing some of the effects found in this thesis.

There are various possibilities for future research that could utilize the increasing number of certified bonds issued under the new EU regulation and the advancing standards in the green bond markets. Even so, as new regulations emerge to standardize the fragmented governance of the green bond market, currently relying on voluntary standards, the optimal governance structure remains an interesting question. While our study was unable to evaluate the actual economic value of green labels, future research could try to collect or estimate the costs of obtaining certification to better evaluate the economic trade-offs of green labels. Such analysis would help to understand the cost-effectiveness of green certification. As for the environmental outcomes, we used environmental pillar scores and emissions scores as a proxy for environmental performance. There remain some concerns of subjectivity with regards to these scores and future research could aim for purely objective metrics for evaluating environmental performance, such as the raw amount of emissions or the carbon footprint of the issuers.

Furthermore, future research could explore why firms choose to issue certain types of green bonds and seek certification, alignment or external review, or merely self-label their green bonds. While our study focuses on the outcomes of such decisions, understanding the underlying issuer motivations would add an important behavioural dimension. In addition, surveying market participants could reveal further insights on the perceived credibility of green labels. These extensions would help to understand the drivers behind green labels - whether they are economic benefits, regulatory compliance, market expectations or genuine environmental intents.

6 Conclusion

This thesis explores the role of green bond labelling on bond pricing and issuers' environmental performance. We use a global sample of green bonds issued by listed and private corporates between 2016 and 2025 and conclude that different levels of green labels are indeed associated with differences in pricing and performance but with varying magnitudes and significance. We find that bonds with more credible green signalling such as CBI-alignment and most consistently external reviews are associated with lower yield spreads at issuance compared to self-labelled green bonds or bonds without such review. However, the joint effect of alignment and external review appears not fully additive but partially substitutive, indicating potential overlapping signals. Furthermore, the pricing benefit of CBI-alignment appears significant only for first-time issuances, implying that the information and signalling value of the green label may be particularly relevant when green bonds are first issued, mitigating the uncertainty when no previous evidence on green bond activity and environmental commitment of the issuer exist yet.

Our results also suggest that issuers improve their environmental performance post green bond issuance, regardless of the bond label. Issuers of CBI-aligned bonds seem to have higher scores post-issuance; however, there is a significant baseline difference between the issuer types. The issuers of CBI-aligned bonds appear already greener pre-issuance relative to self-labelled bond issuers while the incremental effect of alignment on post-issuance environmental outcomes is limited and insignificant, even negative. This may indicate that post-issuance performance rather reflects pre-existing firm characteristics and endogenous selection of issuers, meaning that firms with stronger environmental performance would be more likely to seek alignment or certification for their green bonds.

Overall, the findings of this study are particularly relevant and interesting in the current landscape of green bonds, characterized by growing investor demand, low regulation of the market and certification emerging as an important way for issuers to signal their true environmental commitment to investors. The maturing market of green bonds offers various possibilities for future research on this topic regarding the optimal governance of the market, credible labelling practices and the underlying drivers behind the choice of green labelling. Finally, the results of this thesis underscore the need for continuous efforts to improve the comparability of green bond standards to ensure that capital is effectively steered toward genuinely sustainable practices.

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Appendix

A: Regression results for yield spreads with time-variation. This table reports the regression results with yields spread at issuance as a dependent variable and interaction terms between indicator variables CBI-aligned and CBI-certified and yearly fixed effect. Year 2016 is set as a baseline year. CBI-certified bonds are missing year 2025. Other variables are defined according to Equation 1. Columns 1 and 2 present results for different model specifications, column 2 introducing bond- and market-level controls and fixed effects. Statistical significance is indicated after each coefficient and corresponding t-statistics are reported under the coefficient in parentheses. Standard errors are clustered at issuer ultimate parent and year-month levels.

Yield spread and time variation

	Yield spread	
	(1)	(2)
CBI-Aligned x 2016	0.35	0.53***
	(1.20)	(3.90)
CBI-Aligned x 2017	-0.89**	-0.74***
	(-2.30)	(-2.82)
CBI-Aligned x 2018	-0.81**	-0.84***
	(-2.25)	(-4.05)
CBI-Aligned x 2019	-0.86**	-0.67***
	(-2.19)	(-3.49)
CBI-Aligned x 2020	-0.95**	-0.68***
	(-2.57)	(-3.78)
CBI-Aligned x 2021	-0.76**	-0.75***
	(-2.17)	(-4.74)
CBI-Aligned x 2022	-0.64**	-0.41**
	(-1.99)	(-2.30)
CBI-Aligned x 2023	-0.71**	-0.54***
	(-2.30)	(-2.83)
CBI-Aligned x 2024	-0.65**	-0.67***
	(-2.32)	(-4.81)
CBI-Aligned x 2025	-0.51	-0.34
	(-1.48)	(-1.57)
CBI-Certified x 2016	-0.23	0.70***
	(-0.86)	(3.84)
CBI-Certified x 2017	-2.95**	-1.08***
	(-2.31)	(-3.38)
CBI-Certified x 2018	-0.97	-0.98**
	(-1.21)	(-2.01)
CBI-Certified x 2019	-0.12	-0.54
	(-0.17)	(-1.56)
CBI-Certified x 2020	-0.93*	-0.50
	(-1.68)	(-1.24)
CBI-Certified x 2021	-0.50	-1.01***
	(-1.02)	(-3.77)
CBI-Certified x 2022	-0.03	-0.89***
	(-0.07)	(-2.95)
CBI-Certified x 2023	-0.97	-1.49***
	(-1.21)	(-3.61)
CBI-Certified x 2024	-0.01	-0.69
	(-0.03)	(-1.65)
Bond controls	Yes	Yes
Market controls		Yes
Year-Month FEs		Yes
Currency FEs		Yes
Rating FEs		Yes
Seniority FEs		Yes
Bond Option FEs		Yes
Industry FEs		Yes
Observations	6,158	6,158
Adjusted R^2	0.083	0.626

T-values reported in parentheses. Standard errors clustered on the issuer ultimate parent and year-month levels.
Significance: *p<0.1,**p<0.05,***p<0.01

B: Regression results for yield spreads with sector-variation. This table reports the regression results with yields spread at issuance as a dependent variable and interaction terms between indicator variables CBI-aligned and CBI-certified and sector fixed effect. Banks are set as a baseline sector. Other variables are defined according to Equation 1. Columns 1 and 2 present results for different model specifications, column 2 introducing bond- and market-level controls and fixed effects. Statistical significance is indicated after each coefficient and corresponding t-statistics are reported under the coefficient in parentheses. Standard errors are clustered at issuer ultimate parent and year-month levels.

Yield spread and sector variation

	Yield spread	
	(1)	(2)
CBI-Aligned x Banks	-0.02	-0.03
	(-0.13)	(-0.32)
CBI-Aligned x Construction & Infrastructure	-0.44	0.16
	(-0.83)	(0.39)
CBI-Aligned x Energy & Utilities	-0.51*	-0.04
	(-1.76)	(-0.29)
CBI-Aligned x Finance	-0.13	0.03
	(-0.50)	(0.12)
CBI-Aligned x Manufacturing & Industrials	-0.39	-0.10
	(-1.46)	(-0.51)
CBI-Aligned x Mining & Extractives	0.69	0.49
	(1.48)	(1.63)
CBI-Aligned x Non-bank Financials	-0.42	-0.01
	(-1.11)	(-0.04)
CBI-Aligned x Public Services & Government	0.23	-0.20
	(0.36)	(-0.54)
CBI-Aligned x Real Estate	-0.32*	-0.28
	(-1.71)	(-1.53)
CBI-Aligned x Transportation & Logistics	-0.49**	-0.18
	(-2.13)	(-1.37)
CBI-Aligned x Other	-0.09	-0.08
	(-0.24)	(-0.30)
CBI-Certified x Banks	-0.20	-0.02
	(-0.97)	(-0.12)
CBI-Certified x Construction & Infrastructure	-6.00*	-1.09***
	(-1.74)	(-2.81)
CBI-Certified x Energy & Utilities	-2.76**	-0.30
	(-2.36)	(-0.99)
CBI-Certified x Finance	0.52	-0.29
	(1.18)	(-0.71)
CBI-Certified x Manufacturing & Industrials	0.89	0.20
	(1.10)	(0.28)
CBI-Certified x Mining & Extractives	1.46	0.79
	(1.63)	(0.78)
CBI-Certified x Non-bank Financials	-0.06	1.10*
	(-0.05)	(1.68)
CBI-Certified x Public Services & Government	0.29	-0.55
	(0.42)	(-1.13)
CBI-Certified x Real Estate	-0.94***	-0.71***
	(-3.98)	(-3.76)
CBI-Certified x Transportation & Logistics	0.70**	-0.03
	(2.38)	(-0.10)
CBI-Certified x Other	0.06	0.07
	(0.17)	(0.14)
Bond controls	Yes	Yes
Market controls		Yes
Currency FEs		Yes
Rating FEs		Yes
Seniority FEs		Yes
Bond Option FEs		Yes
Industry FEs		Yes
Observations	6,158	6,158
Adjusted R^2	0.110	0.626

T-values reported in parentheses. Standard errors clustered on the issuer ultimate parent and year-month levels.
Significance: *p<0.1,**p<0.05,***p<0.01

C: Robustness test 1 – baseline regression results for yield spreads with an external review variable and matched sample. This table reports the regression results with specifications according to Equations 2 and 3 with yield spread at issuance as a dependent variable. Matching procedure is described in section 4.3. Columns 1-9 present results for different model specifications, progressively introducing bond- and market-level controls and fixed effects. Columns 1, 4 and 7 report results according to Equation 1, columns 2, 5 and 8 according to Equation 2 and columns 3, 6 and 9 according to Equation 3. Statistical significance is indicated after each coefficient and corresponding t-statistics are reported under the coefficient in parentheses. Standard errors are clustered at ultimate parent and year-month levels.

Baseline regression model with external review and matched sample

	Yield spread								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
CBI-Aligned	-0.02		-0.04	-0.03		-0.13*	-0.01		-0.02
	(-0.59)		(-0.52)	(-0.82)		(-1.71)	(-0.15)		(-0.36)
External review		-0.21***	-0.23**		-0.09	-0.17**		-0.09*	-0.11
		(-2.88)	(-2.47)		(-1.59)	(-2.44)		(-1.91)	(-1.65)
CBI-Aligned x External review			0.04			0.15**			0.04
			(0.47)			(2.26)			(0.57)
Bond Controls				Yes	Yes	Yes	Yes	Yes	Yes
Market Controls							Yes	Yes	Yes
Year-Month FE				Yes	Yes	Yes	Yes	Yes	Yes
Currency FE				Yes	Yes	Yes	Yes	Yes	Yes
Rating FEs							Yes	Yes	Yes
Seniority FEs							Yes	Yes	Yes
Bond Option FEs							Yes	Yes	Yes
Industry FEs							Yes	Yes	Yes
Observations	2,514	2,514	2,514	2,514	2,514	2,514	2,514	2,514	2,514
Adjusted R^2	0.000	0.012	0.012	0.338	0.339	0.341	0.435	0.437	0.436

T-values reported in parentheses.
Standard errors clustered on the issuer ultimate parent and year-month levels.
Bond and market controls are the same as in the baseline regression models.
Significance:
*p<0.1,**p<0.05,***p<0.01

D: Robustness test 2 – difference-in-differences and decomposed treatment effect results with entropy balancing. This table provides regression results according to Equation 7 with environmental pillar score in columns 1-3 and emissions score in columns 4-6 as a dependent variable, during a four-year time window from t-1 until t+2. The sample is constructed using entropy balancing as described in section 4.3. Columns 1-3 and 4-6 present results for different model specifications, progressively introducing fixed effects. Statistical significance is indicated after each coefficient and corresponding t-statistics are reported under the coefficient in parentheses. Standard errors are clustered at firm level.

Difference-in-differences and decomposed treatment effect - unmatched sample with entropy balancing

	Environmental performance					
	Environmental pillar score			Emissions score		
	(1)	(2)	(3)	(1)	(2)	(3)
Post	3.37***	4.98***	3.16**	6.01***	7.34***	5.22***
	(3.03)	(3.24)	(2.54)	(3.14)	(3.68)	(2.71)
Aligned	0.00	0.13	1.74	0.00	0.32	0.85
	(0.00)	(0.05)	(0.78)	(0.00)	(0.10)	(0.26)
Aligned * Post	-0.15	-0.70	-0.40	-2.13	-2.81	-2.62
	(-0.12)	(-0.60)	(-0.33)	(-1.06)	(-1.43)	(-1.31)
Year fixed effects		Yes	Yes		Yes	Yes
Country fixed effect			Yes			Yes
Industry fixed effect			Yes			Yes
Observations	2,560	2,560	2,560	2,532	2,532	2,532
Adjusted R^2	0.006	0.013	0.346	0.013	0.022	0.305

T-values reported in parentheses. Standard errors clustered at firm level.
Significance: *p<0.1,**p<0.05,***p<0.01

E: Robustness test 3 – regression results for yield spreads with an indicator variable for first-time issuances. This table reports the regression results according to Equation 1 with yields spread at issuance as a dependent variable and an additional first-time issuance specification described in section 4.3. Columns 1-6 present results for different model specifications, progressively introducing bond- and market-level controls and fixed effects. Statistical significance is indicated after each coefficient and corresponding t-statistics are reported under the coefficient in parentheses. Standard errors are clustered at issuer ultimate parent and year-month levels.

Baseline regression model with first-time issuance dummy variable

	Yield spread					
	(1)	(2)	(3)	(4)	(5)	(6)
CBI-Aligned	-0.02	-0.18*	-0.22**	-0.05	-0.03	0.03
	(-0.13)	(-1.92)	(-2.39)	(-0.59)	(-0.36)	(0.38)
CBI-Certified	-0.16	-0.39	-0.47	-0.13	-0.10	-0.18
	(-0.36)	(-0.98)	(-1.26)	(-0.76)	(-1.04)	(-1.21)
First issuance	0.71***	0.55***	0.39***	0.69***	0.51***	0.40***
	(3.54)	(4.44)	(3.01)	(6.06)	(5.01)	(4.06)
CBI-Aligned x First issuance	-0.44**	-0.36***	-0.32**	-0.23*	-0.31***	-0.23**
	(-2.41)	(-2.63)	(-2.31)	(-1.98)	(-2.99)	(-2.32)
CBI-Certified x First issuance	-0.78	-0.64	-0.60	0.04	-0.10	0.01
	(-1.45)	(-1.36)	(-1.30)	(0.18)	(-0.55)	(0.06)
Bond Controls		Yes	Yes	Yes	Yes	Yes
Market Controls						Yes
Year-Month FEs			Yes	Yes	Yes	Yes
Currency FEs				Yes	Yes	Yes
Rating FEs					Yes	Yes
Seniority FEs						Yes
Bond Option FEs						Yes
Industry FEs						Yes
Observations	6,163	6,158	6,158	6,158	6,158	6,158
Adjusted R^2	0.015	0.063	0.092	0.543	0.609	0.628

T-values reported in parentheses.
Standard errors clustered on the issuer ultimate parent and year-month levels.
Significance: *p<0.1,**p<0.05,***p<0.01

F: Robustness test 4 – difference-in-differences and decomposed treatment effect results with an indicator variable for first-time issuer-years. This table provides regression results according to Equation 7 with an additional first-time issuance specification described in section 4.3. The model has environmental pillar score in columns 1-3 and emissions score in columns 4-6 as a dependent variable, during a four-year time window from t-1 until t+2. Columns 1-3 and 4-6 present results for different model specifications, progressively introducing fixed effects. Statistical significance is indicated after each coefficient and corresponding t-statistics are reported under the coefficient in parentheses. Standard errors are clustered at firm level.

Difference-in-differences and decomposed treatment effect with first-time issuer-years

	Environmental performance					
	Environmental pillar score			Emissions score		
	(1)	(2)	(3)	(1)	(2)	(3)
Post	3.24	7.35**	5.60**	3.50*	8.64***	6.61***
	(1.36)	(2.55)	(2.47)	(1.87)	(3.52)	(2.80)
Aligned	6.80*	6.81*	8.71***	2.89	2.91	3.48
	(1.78)	(1.78)	(2.90)	(0.75)	(0.77)	(1.12)
Aligned x Post	-1.64	-1.67	-1.65	-2.73*	-2.76*	-2.75*
	(-0.99)	(-0.99)	(-0.98)	(-1.68)	(-1.67)	(-1.66)
First Issuance	-1.08	-0.92	-0.51	-5.28	-5.12	-5.91*
	(-0.22)	(-0.17)	(-0.14)	(-1.26)	(-1.12)	(-1.88)
First Issuance x Post	1.20	0.94	1.09	2.06	1.74	1.87
	(0.55)	(0.45)	(0.52)	(1.10)	(0.91)	(0.99)
Year fixed effects		Yes	Yes		Yes	Yes
Country fixed effect			Yes			Yes
Industry fixed effect			Yes			Yes
Observations	664	664	664	648	648	648
Adjusted R^2	0.023	0.037	0.394	0.006	0.031	0.385

T-values reported in parentheses. Standard errors clustered at firm level.
Significance: *p<0.1,**p<0.05,***p<0.01