The green bond premium and non-financial disclosure:

Financing the future, or merely greenwashing?

Master's Thesis

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Abstract

This paper identifies the existence of a green bond premium by showing that investors are willing to receive a lower yield of -23.2 basis points compared to otherwise similar conventional bonds in the secondary market. The results show that the green bond premium varies significantly across bond ratings, currencies, and issuer sectors. Additionally, this paper studies the relationship between the variation of the green bond premium and bond non-financial disclosure. A matching method is used to compare the yield spread of a green and an otherwise similar synthetic conventional bond. This paper charts the landscape of green bond voluntary non-financial disclosure by constructing a proprietary dataset in which all bond-specific non-financial disclosures are recorded. A two-step regression procedure is used to identify that green bond non-financial disclosure is the primary determinant in the variation of green bond yield spreads. External review is shown to have the strongest effect on the size of the green bond premium, while alignment with alignment with the Green Bond Principles and CBI certification show no additional effect. The results provide evidence against the argument that green bonds are merely a tool for greenwashing, as investors seem to value the credibility of the green bond signal.

Preamble

This thesis is part of a collaborative research project conducted together with two other students from Maastricht University, Wouter Geerlings, and Martijn Verberne. The project is based on a research proposal by prof. dr. Piet Eichholtz and dr. Nils Kok named *Green Bonds – Solution or Hype?* The purpose of this research project is to identify whether the market for green bonds can be characterized by greenwashing. The process up to and including the construction of the unique dataset used for the purposes of the three independent theses was a joint effort. Three theses were created based on the proprietary dataset, each focussing on a different aspect of the green bond market. The purpose of these studies is to provide an overview of the green bond market, green bond non-financial disclosure and to identify whether the green bond market is plagued by greenwashing. Similar to the study by Wouter Geerlings, this paper analyzes the effect of green bond non-financial disclosure on bond pricing in the secondary bond market in order to determine whether investors care about the projects financed through green bond issuance. The study by Martijn Verberne focusses on the equity market and examines whether shareholders of green bond issuing firms value the extent to which they can verify the greenness of a bond.

I want to thank prof. dr. Piet Eichholtz and dr. Nils Kok for including me in their research topic and sparking my interest in the topic of green bonds. Additionally, my thanks go out to Nagihan Mimiroglu, Ph.D. candidate, for advice on the methodology and analyses. Lastly, I would like to thank my colleagues at Finance Ideas B.V. for their support throughout the writing of this thesis and the opportunity to put the findings of this thesis into a practical perspective.

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1. Introduction

The fight against global warming is increasing in urgency. The recent report published by the Intergovernmental Panel on Climate Change (2018) warned of the significant negative impact on the world should global warming exceed the threshold of 1.5 degrees Celsius above pre-industrial levels. The panel estimates that, in order to not exceed this threshold, 2.4 trillion USD (roughly 2.5% of the global GDP) will need to be mobilized annually until 2035 (IPCC, 2018). The likely suppliers of this significant increase in demand for green finance are financial investors, as they can mobilize the amount of capital needed for investments of this size (FSB, 2018). In response to this, institutional investors are starting to invest increasingly more capital in sustainable projects, with green-bond specific investment mandates growing steadily over time[1]. Anecdotal evidence from investors confirms that the bottleneck in the market for green bonds is not demand but supply, with the average green bond issuance facing more oversubscription than conventional bond issuances (Climate Bonds Initiative, 2017).

Several new financial instruments have been introduced in order to meet the increasing demand for green finance, among which the green bond is one of the fastest growing. Green bonds are bonds issued with the explicit promise that the proceeds of the issuance will be used to finance green projects. Examples of these projects include green buildings, energy efficiency, and clean transportation.

Issuances have risen drastically throughout the years since the inception of the market in 2007, with the total market value of outstanding green bonds equal to 542 billion USD as of January 2019[2]. Anecdotal evidence from industry practitioners[3] confirms that issuing a green bond sends a strong signal to the market demonstrating the issuer's commitment to environmental concerns. Indeed, some practitioners identify the issuance of a green bond as a "must" for any environmentally friendly firm. Other reasons for issuing a green bond include wanting to attract a more environmentally conscious (Flammer, 2018), and long term oriented (Baker et al., 2018) clientele.

[1] For example: https://www.environmental-finance.com/content/news/zurich-completes-2bn-green-bond-mandate.html
[2] Environmental Finance, https://www.bonddata.org/
[3] Interviews were conducted with officials from Rabobank, amongst others.

Investor motives for investing in a green bond can be classified into financial and non-financial motives. These are similar to the profit-seeking and values-driven investors identified by Derwall et al. (2011). Financial motives include the expectation of better financial performance (Bauer & Smeets, 2015) or lower risk (Krüger, 2015). Non-financial motives are related to ethical considerations and a sense of "doing right" (Hong & Kacperczyk, 2009; Riedl & Smeets, 2017). These mechanisms affect the pricing of green bonds. Most prior publications on green bond pricing show that green bonds are priced at a premium compared to otherwise similar conventional bonds (Baker et al., 2018; Barclays, 2015; Ehlers & Packer, 2017; Zerbib, 2018).

However, green bonds are not created equal. Flammer (2018) argues that green bonds may constitute a form of greenwashing, allowing a firm to portray an environmentally positive image without doing so. The unregulated nature of the green bond market is the cause of these concerns. Any bond can be self-labeled as a green bond without the need for any further verification. As the market matured, a varied landscape of green bond specific non-financial disclosure including bond standards, external reviews, and bond certification has sprung up (EY, 2015).

Flammer (2018) finds that certified green bonds have a stronger impact on a firm's financial and environmental performance post-issuance and that certification leads to increased ownership by long-term and environmentally conscious investors over non-certified green bonds. In the same vein, Baker et al. (2018) identify a higher green bond premium and more long-term ownership for certified green bonds. Except for these publications, few studies analyze the determinants of the variation in green bond premia. Zerbib (2018) identifies a green bond premium and concludes that the height of the premium is more pronounced for low-rated and financial green bonds. However, Zerbib (2018) does not include non-financial green bond disclosure in the analysis.

The (non-)existence of a variation in the green bond premium due to green bond non-financial disclosure might provide new insights into investor motivations. Finding no such relationship would provide support for the greenwashing argument, as this would imply that investors do not value the extent to which the bond's uses of proceeds are traceable to sustainable projects. On the other hand, a negative relationship would imply that investors do value this information. Financial (bond risk) or non-financial (ethical) motivations are the driving factors behind this negative relationship. The goal of this paper is to paint the landscape of green bond non-financial disclosure and to identify to what extent the presence of a green bond premium is dependent on these

disclosures. The research question is therefore defined as follows: To what extent is the (existence of the) green bond premium dependent on bond-specific non-financial disclosure?

In order to empirically examine the existence of a green bond premium and the bond-specific variation therein, all types of green bond non-financial disclosure are identified and ranked in a hierarchy based on intensity. Four green bond disclosure categories are distinguished: alignment with the green bond principles, second party opinion issuance, assurance provision, and CBI certification. A dataset containing 536 green bonds is manually constructed. This dataset contains information about the bond-specific non-financial disclosure of each bond. This data is manually recorded by parsing the green bond-specific publications of green bond issuers. This is the first time this type of categorization has been applied to the green bond market.

Based on the matching criteria of Zerbib (2018) the bonds are matched to two conventional bonds. Due to the stringent matching criteria, this procedure is successful for 95 of the bonds in the database. In order to determine the yield-spread between a green and otherwise similar conventional bond, the yield of a synthetic bond with the same maturity as the green bond is extrapolated (or interpolated) based on the matched conventional bonds. Bloomberg is used to extract daily pricing information for all matched bonds. The resulting panel data contains 26,697 bond-day observations.

Controlling for residual liquidity effects by using the bonds' bid-ask spread as a proxy (Fong et al., 2017) this study identifies that the yield of green bonds is, on average, –23.2 basis points lower than that of otherwise similar conventional bonds. Investors are willing to pay a premium in order to be able to invest in green bonds. The difference in yield is significant for all but one of the subsamples in the analysis and differs in scale across these samples. In order to observe the variation in bond-specific yields, the time-fixed effects of the regression are predicted, and considerable variation in premia is observed.

In the second step of the analysis, the effect of bond non-financial disclosure on the green bond premium is identified by regressing the bond-specific premium against the bond's disclosure score, controlling for other bond pricing determinants. The results show that for each step up in disclosure score, the green bond premium increases with – 24 basis points. The final analysis identifies the individual effects of bond non-financial disclosure. Both types of external review significantly increase the green bond premium. However, due to its voluntary nature, alignment with the green

bond principles does not change the size of the green bond premium. CBI certification has no additional labeling effects beyond the effects already captured by external review. Including external review in the regression leads to the results showing a "hurdle:" yields of green bonds with no type of external review are higher than those of conventional bonds, hinting at the existence of a green bond discount for these bonds. When an external party reviews a bond, the likelihood of the existence of the green bond premium is much greater. Various robustness tests, including a Heckman test for sample-selection bias, are performed in order to confirm the robustness of these findings.

This paper contributes to the body of academic literature on green bond pricing by charting the previously unknown landscape of green bond non-financial disclosure and finding that the amount of disclosure varies widely amongst green bonds. In line with previous publications (Baker et al., 2018; Barclays, 2015; Ehlers & Packer, 2017; Zerbib, 2018), this paper provides further evidence on the existence of the green bond premium. This paper adds to the literature on green bonds by showing that green bond non-financial disclosure is the main determining factor of the green bond premium, and providing evidence against the greenwashing hypothesis first proposed by Flammer (2018).

The findings have several implications for policymakers and industry practitioners. First, the existence of a green bond premium shows a difference between green and otherwise similar conventional bonds. This difference can either be related to financial motives, such as lower risk which is not fully captured by credit scores (i.e., the reduction of stranded-asset risk), or non-financial motives such as pro-environmental attitudes. The existence of a green bond premium is evidence for demand being greater than supply in the market for green bonds. Policymakers wishing to facilitate sustainable investment can leverage this untapped potential by incentivizing issuers to issue more green bonds through fiscal incentives.

Contrary to the greenwashing argument, investors seem to value the extent to which the uses of the proceeds of a green bond are traceable. The importance of external review is reaffirmed: investors only value the greenness of a bond if it is confirmed by an external party, not doing so will lead to green bond prices which are lower than conventional bond prices. CBI certification does not increase the yield spread between green and conventional bonds, despite added costs.

Investors are sufficiently versed in the market to depend on the underlying requirements of CBI certification (external review), rather than valuing the label itself.

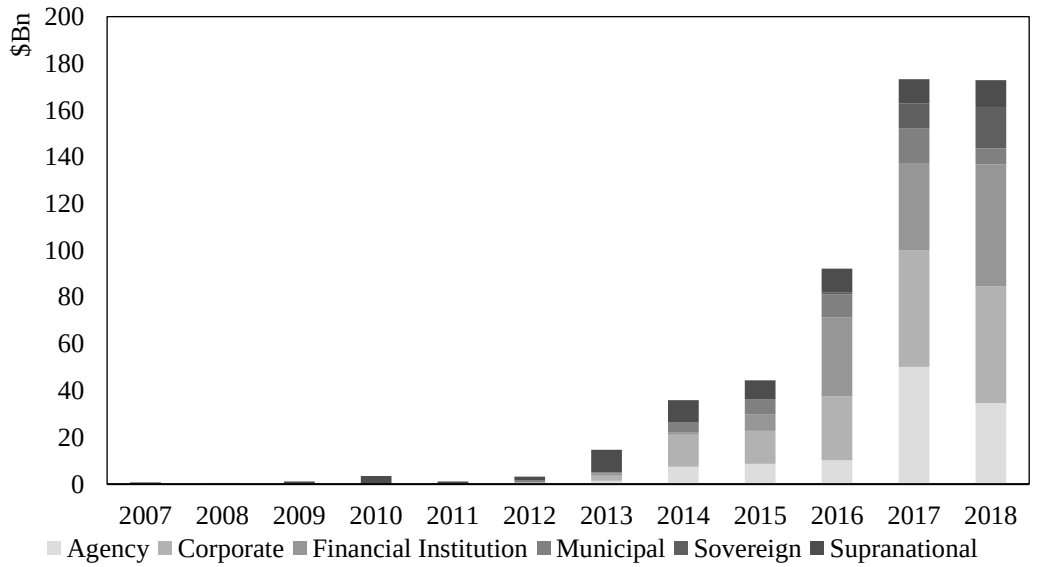
The rest of this paper is organized as follows: Section 2 describes the green bond market, including all actors and information intermediaries active therein. Section 3 provides a review of the relevant literature. Section 4 develops five hypotheses based on the research question and the literature review. Section 5 outlines the data collection method, the construction of the unique dataset, and provides descriptive statistics. Section 6 describes the methodology. Section 7 checks the robustness of the findings, while section 8 discusses the findings. Implications for bond issuers, investors and future research are discussed in section 9 alongside the limitations of this study. Section 10 concludes the paper.

2. The green bond market

2.1 Inception and growth

The 600 million USD issuance of a climate awareness bond by the European Investment Bank marks the inception of the green bond market in 2007. Supranational entities were the only active issuer within the market until French municipalities started issuing green bonds in 2012. Most of the activity within the market remained small-scale. The market started proliferating once corporations, financial institutions, and agencies started issuing their green bonds in 2013. Figure 1 shows the rapid growth of the green bond market over time. Issuances rose to 173 USD billion in 2017, constituting an 87.9% increase when compared to 2016.

Figure 1: Green bond issuances



Note: Data from Environmental Finance, https://www.bonddata.org/. Foreign currency converted using the exchange rate at the day of issuance.

The growth of the market for green bonds is mostly a result of new issuers. 61% of the capital raised through green bond issuance in 2017 was done so by parties issuing their first green bond. (CBI, 2018). Indeed, anecdotal evidence from industry practitioners confirms that green bond issuance is an important signal to the market. Corporations feel significant pressure to signal their commitment to sustainable strategies through the issuance of a green bond.

In order for the green bond market to sustain these levels of growth, it is important that there is sufficient demand for green bonds. Research by the Climate Bonds Initiative (2018b) shows that the average green bond oversubscription rate is 2.3 in Europe and 2.8 in the de United States. This

oversubscription shows a significant demand surplus in the market, indicating that supply is the bottleneck for market growth.

In the early stages of green bond market development, green bond issuances were limited to issuances by (supra)national institutions. However, as the market matured local governments, corporations and financial institutions started entering the market. Financial institutions and corporations now make up for the majority of issuances within the market, as evidenced by figure 1.

Next to philanthropic arguments for issuing a green bond, anecdotal evidence confirms that green bond issuance is an important signal to the market if one wishes to demonstrate a commitment to the environment. Additionally, issuing a green bond will allow access to a previously untapped market of potential investors, which are more long-term oriented (Baker et al., 2018; Flammer, 2018) and more environmentally-conscious (Flammer, 2018). Additionally, Flammer (2018) shows that green bond issuance yields positive announcement returns, improvements in firm long-term value and operating performance, better environmental performance, and more green innovations. Next to the evidence on positive announcement returns, anecdotal evidence confirms that issuing a green bond is seen as a "must" for companies with a commitment to sustainable development.

Investor appetite for green bonds has increased significantly, as evidenced by significant growth in institutional mandates for green bond investments (IFC, 2018). Motivations for investments in green bonds can be driven by two channels, as identified by Derwall et al. (2011). First, the values-driven investor is driven by ethical considerations for which they may be willing to sacrifice bond yield. These considerations can also take the form of constraints imposed by stakeholders, as is the case for large institutional investors and their increasing green investment mandates. Hong and Kacperczyk (2009) show that due to investment constraints of institutional investors the price of "sin" (alcohol, tobacco, and gaming) is higher than that of non-sin stocks. Zerbib (2018) finds that investors in green bonds are willing to sacrifice 2 basis points due to these non-financial environmental considerations.

The other type of investor, the profit-seeking investor, is not constrained by environmental considerations. Instead, they only seek to maximize profit given a certain level of risk. Green bonds might be a suitable investment for these investors as traditional credit scores fail to capture the full

effects of environmental risks (Oikonomou et al., 2014), as well as serving for as a potent tool for diversification (Climate Bonds Initiative, 2017). Due to the limited project eligibility of green bonds, the stranded-assets risk of the investment decreases. Stranded assets within the context of climate change are assets which face sudden devaluation or write-downs due to risks which are not priced by investors. An example of a stranded asset is the sudden devaluation of a coal reserve if regulation starts to prohibit the use of fossil fuels.

2.2 The need for verification and standardization

Flammer (2018) observes concerns for greenwashing within the green bond market. Any bond issuer can simply label a bond as green. For example, Chinese bond issuers have financed "clean coal" projects by issuing a green bond[4]. A lack of public governance for green bonds implies that the use of proceeds as laid out in the bond prospectus are not legally binding. In the same vein, Talbot (2017) also emphasizes the need for transparency and standardization, by arguing that the dangerous consequence of greenwashing in the green bond market would be the undermining of its credibility. Moreover, in the case of an investor finding out that a green bond issuer is performing an act of greenwashing, there is no legally binding recourse that the investors could pursue. Thus, the lack of accountability and transparency poses a risk to a socially-responsible investor. The proposed solution is an increase in regulation and standardization (Flammer, 2018; Talbot, 2017).

A primary consideration when discussing standardization in the green bond market is the definition of which projects (use of proceeds) should be eligible for green bond finance. There is currently no regulation concerning the labeling a bond issuance as green. Any issuer can issue a bond with a green label, even if the projects which will be financed with the proceeds raised through the issuance of a bond do not fall within any widely held definition of sustainability. A report issued by the European Union's High-Level Expert Group on Sustainable Finance identifies the lack of a common definition of what constitutes a green bond and which projects should be eligible through green bond finance as one of two bottlenecks hampering the growth of the green bond market. The second bottleneck is the lack of a single unified framework for issuing such green bonds. As a response, a Technical Expert Group has been formed which is currently analyzing the

[4] For more information, see: https://www.reuters.com/article/china-power-financing/china-coal-fired-power-plant-issues-green-bonds-idUSL4N1KP3RQ

lack of standardization in the market and which will produce its own standards, impact benchmark, taxonomy and disclosure guidelines in the beginning of 2019 in order to assist the development of the green bond market within the European Union (EU HLEG, 2018).

2.3 Industry Standards

As concerns for greenwashing grow with investors, institutions, and scholars, so does the demand transparency through a combination of standards and regulation. In response to this, several industry guidelines have been created. Issuers can comply with these guidelines on a voluntary basis. Lacking legal enforceability, the voluntary nature of alignment with green bond standards has lead to different standards competing for adoption within the market (Park, 2018). This competition was most prevalent during the early years of the green bond market, with many guidelines and principles springing up on a national level which, although leading to increased transparency, is not beneficial in terms of international harmonization of the market (Ehlers & Packer, 2017).

Green Bond Principles

Over the years the Green Bond Principles (GBP), developed by the International Capital Market Association, have become the most widely adopted green bond standard in the market. GBP alignment has risen steadily as the market matured. 10.3 % of bond issuances were GBP aligned in 2012, compared to 63.6% alignment of issuances in 2018[5]. The GBP focus on the transparency, accuracy, and integrity of the information reported to stakeholders under the GBP aligned bond. It does so by building on four fundamental principles. First, the uses of the proceeds of the bond should be clearly defined and categorized by the issuer to show that proceeds are used to finance green projects with clear environmental benefits. Where possible, these benefits should be quantified. Following this, a GBP aligned green bond should clearly describe the process for project evaluation and selection, with particular attention to the environmental sustainability objectives and the eligibility/exclusion criteria of projects financed through proceeds of the bond. Next, the management of proceeds component asks that issuers track the management of the use of proceeds through either tracking the balance of net proceeds or using a sub-account or portfolio for the un-allocated proceeds. Lastly, the reporting pillar requires issuers to ensure timely

[5] Environmental Finance, https://www.bonddata.org/

information provision up until the full allocation of the proceeds of the bond next requiring issuers to disclose any material developments (ICMA, 2018).

Now the de-facto standard, the GBP have become a key catalyst in the development of the green bond market and the basis for many green bond label providers, rating agencies, consultants, and reviewers (Ehlers & Packer, 2017). The GBP are the now the main industry framework offering prospective issuers advice on how to issue a credible green bond, how to provide an environmentally friendly investment opportunity with transparent green credentials, and how to ensure integrity in the green bond label. Lacking regulation stating otherwise, the voluntary nature of adherence to the green bond principles implies that the ICMA does not ensure alignment. The GBP advise, but do not require, external reviewers to check alignment with the GBP.

Climate Bonds Standard

The Climate Bonds Standard is created by the Climate Bond Initiative. They are more rigorous than the GBP as they go beyond being mere voluntary guidelines by including several requirements for alignment. Next to this, the Climate Bonds Standard also provides a bond certification scheme. In order for a bond to receive CBI certification, a bond issuer needs to ensure alignment with the Climate Bonds Standard. Importantly, the Climate Bonds Standard is a step up in robustness and effectiveness from the GBP. As such, the schemes do not compete with each other. Instead, all Climate Bonds Standard aligned bonds are implicitly also aligned with the GBP. The most critical difference between both standards is that the Climate Bonds Standard demands a higher level of detail and maintains stricter requirements for issuers to adhere to concerning the eligibility of the proposed assets or projects, the use- and management of proceeds, and non-financial reporting (CBI, 2018a).

Unlike the GBP, the requirements for Climate Bonds Standard alignment (and by proxy CBI certification) are split into pre-issuance and post-issuance requirements. Pre-issuance the bond has to meet four requirements: use of proceeds documentation, a transparent process for evaluation and selection of projects and assets, management of proceeds, and reporting pre-issuance reporting. The main difference between the GBP and Climate Bonds Standard is that the GBP advises engaging an external reviewer to verify alignment with the GBP, whereas the Climate Bonds Standard requires the engagement of an external reviewer in order to verify the validity of the reporting (CBI, 2018a).

After the issuance of a green bond, the Climate Bonds Standard defines four post-issuance requirements. These requirements focus on tracking the impact (i.e., sustainability performance) of the green bond compared to the claims made at issuance. Issuers are required to report to which projects they allocate the proceeds of the issuance. Additionally, the issuer needs to provide qualitative and, where possible, quantitative assessments of the environmental impact of the projects financed through the issuance (i.e, the reduction in greenhouse gas emissions). These reports need to be verified by a CBI approved external party.

As long as all requirements are met and verified by an external verifier, the issuer can opt for CBI certification, which costs $1/10^{th}$ of a basis point on top of the cost of the external review (CBI, 2018a). The goal of this certification is to provide investors, governments and other stakeholders with the security that CBI certified bonds are issued with the goal of working towards a low carbon and climate resilient economy (CBI, 2018a).

European Bond Standards

As mentioned previously, the European Union is attempting to centralize the regulation of green bond market governance to an even greater extent. In July 2017, the European Commission's High-Level Expert Group (HLEG) on Sustainable Finance published a report arguing that urgent action to harmonize the European sustainable financial system is required. The High-Level Expert Group introduced roadmap with clear recommendations on how to fund the transition to a low-carbon economy. It does so by establishing EU sustainability standards and considers the green bond market as a starting point. This roadmap includes the establishment of an EU Sustainability Taxonomy, including sector-specific criteria, in order to define the areas where investments are required most. It aims to introduce an official *EU Green Bond Standard* and label to foster more trust and confidence in green products. Once implemented prospective green bond issuers may only use the term 'EU Green Bond' if three conditions are met (EU HLEG, 2018). First, the bond's proceeds are solely used to (re)finance new and/or existing eligible projects that can be categorized under the (future) EU Sustainability Taxonomy. Second, submitted documentation prior to issuance confirms the alignment with the EU Green Bond Standard. Third, alignment with the EU Green Bond Standard is confirmed by an accredited external verifier. In this regard, the European Green Bond Standards will be very similar to the GBP, with the main difference being that the GBP recommend, and the EU Bond Standards require, external verification and impact reporting

to take place. In this regard the EU Bond Standards will be similar to the CBI standards, even going beyond their requirements by requiring impact reporting.

2.4 Non-financial disclosure

In essence, the label green bond only constitutes a promise that a bond's proceeds are only used to finance "sustainable" projects. The only way for investors to check whether issuers keep these promises is by reading reports issued by the green bond issuer. In this way, reporting is an essential requirement in assessing the extent to which issuers keep their promises. Reports concerning a green bond can be filed either pre- or post-issuance. Within this categorization, reports usually focus on either the framework followed for issuing the green bond (pre-issuance), the allocation of funds to projects (use of proceeds, post-issuance), or the impact of the projects financed by the proceeds of the bond (post-issuance). Being the least strict framework, the GBP only requires investors to report on the allocation of proceeds up until all proceeds have been allocated to specific projects. The Climate Bonds Standard is more specific in its requirement for post-issuance reporting, as it requires annual reporting upon full allocation of proceeds, as well as reporting of the potential impact of the projects financed. Reporting is not uniform across the green bond universe. Using their standards for what constitutes best-practice reporting, the Climate Bond Initiative finds that only 27% of bond issuances meet these criteria (CBI, 2017).

External Review

As an essential pillar of green bond quality, external review requires the engagement of a third party to advise upon the issuance of a green bond in order to verify the claims made by the issuer. Most widely adopted frameworks for green bond issuance provide best-practices for engaging an external reviewer. External review ranges from strongly advising the engagement of an external reviewer (ICMA, 2018), to requiring it for alignment (CBI, 2018a).

Industry practitioners widely use external review as a catch-all term for engaging a third party, covering the issuance of second party opinions and assurance provision. Unexperienced investors use the terms verification, assurance, and review interchangeably. Despite this, experts and industry practitioners confirm the importance and distinction between these, posing that there is a difference in the extensiveness and degree of commitment by the third party involved in the review.

Second party opinion

This type of external engagement usually constitutes checking a green bond's compliance with a green bond reporting framework, such as the GBP. Second party opinion (SPO) issuance is mainly performed by consultancy firms with a specific focus on sustainability. Next to assessing compliance with principles, an SPO publishes an opinion on the underlying sustainability of the green bond's uses of proceeds. In practice, an SPO provider is engaged by an issuer as a consultant in order to advise the issuer on the creation of a (GBP) aligned green bond issuance framework. The largest second party opinion providers are CICERO, Vigeo Eiris, Oekom Research[6], DNV GL, and Sustainalytics. SPO issuance has increased consistently over the years, with the number of bonds issued alongside external review increasing from 53% in 2014 to 83% in 2018[7].

Although all SPO issuers check the bond's alignment with principles, the methodologies vary widely. As the question of alignment has a binary outcome – a bond is either aligned or not – SPO issuers can differentiate themselves by providing more granular analyses. For instance, CICERO, and Vigeo Eiris provide a *green bond rating* of the bond issuance by rating the sustainability and ESG components of bond issuance (Vigeo Eiris, 2018). CICERO created a green bond rating scale, ranging from brown (non-green bond) to dark green (CICERO, 2016). Such a rating allows for comparison between not only green and brown bonds but also between green bonds with varying levels of sustainability.

Assurance

Assurance practices provide independent verification of the robustness of the green bond issuance. Unlike the SPO, they go beyond merely advising upon the issuance of a green bond, by providing a legally binding assessment of green bond disclosure. Assurance can be provided on the bond criteria, project selection and evaluation, internal processes for tracking proceeds, and non-financial data on environmental outcomes. In a sense, assurance provision confirms that a green bond has or will deliver upon what the issuer promisses.

Assurance provision can be either pre- or post-issuance, with pre-issuance assurance focusses on the robustness of frameworks and the issuance pipeline, whereas the post-issuance assurance

[6] As of May 15th, 2018, Oekom Research has been renamed ISS-Oekom after a merger with ISS. See: https://www.issgovernance.com/oekom-research-ag-join-institutional-shareholder-services
[7] Data from Environmental Finance, https://www.bonddata.org/

provides a level of confidence concerning the validity of post-issuance (impact) reporting of the green bond. The degree of assurance provided can vary between bonds but is limited to two levels: *reasonable* and *limited assurance.* Both provide an acceptable level of assurance, but the level of confidence is lower for limited assurances then for reasonable assurances.

Importantly, green bond assurance does not speak to the degree of sustainability of a green bond. For instance, if an issuer specifies a use of proceeds in the bond prospectus, an assurance provider will confirm that the correct reporting mechanisms are in place in order to verify that the actual allocation of proceeds will indeed go to these projects. An SPO might instead issue an opinion on the actual sustainability of the use of proceeds. Moreover, an SPO is not legally binding; an assurance report is. A risk for green bond issuers is investors challenging the greenness of the bond. Having an external party provide assurance, essentially putting their reputation on the line, will allow issuers to circumvent these potential reputational concerns (KPMG, 2015).

Certification

Certification signals to potential investors that a bond and its corresponding framework adheres to industry standards regarding integrity and transparency (Climate Bonds Initiative, 2018a). A certificate is a label (a "seal of approval") granted by an external party. The most widely adopted international certificate is the Climate Bonds Certification Scheme, which verifies climate bonds standards aligned bonds. Currently, only 132 green bonds are CBI certified[8]. For investors, a certified bond will ideally require that less subjective judgments and due diligence processes from investors in order to ensure the soundness of the credentials of the green bond.

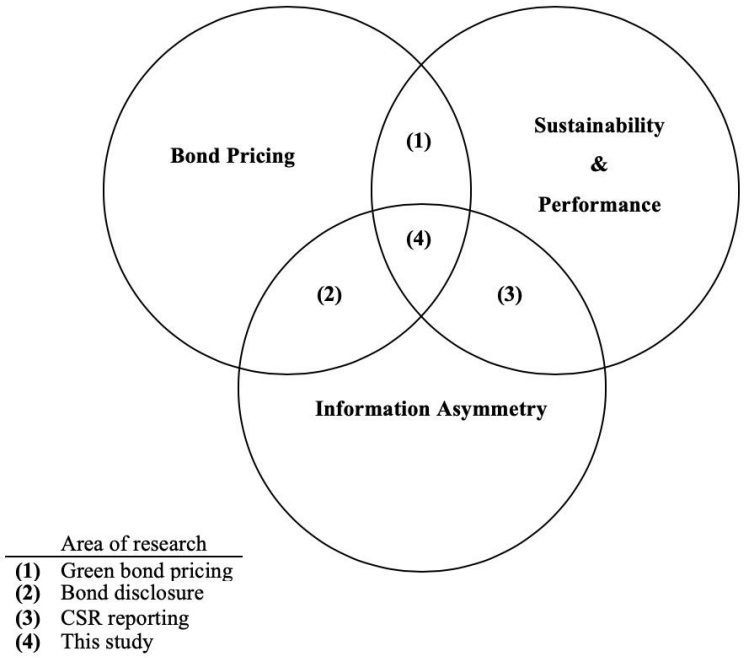
The CBI certification scheme has stringent requirements for bonds. The requirements are split into pre- and post-issuance criteria. A bond can be labeled "certified green" when it has met the pre-issuance criteria of the Climate Bonds Standard. If during the years after issuance it fails to meet the post-issuance criteria, the certification will be repealed. A CBI-approved external verifier must verify all certification requirements. The verifier assures compliance with the CBI requirements (CBI, 2018a).

[8] According to the Climate Bonds Initiative website: https://www.climatebonds.net/certification/certified-bonds

3. Literature Review

This section provides an overview of the relevant literature within the context of green bonds, bond pricing, and disclosure. Three areas of academic research intersect in this paper. The overlap and relevance of these bodies of literature are shown in figure 2.

Figure 2: Overlap of academic literature



The first subsection reviews the academic literature concerning sustainability, with a particular focus on the impact of firm environmental performance and sustainable strategies on financial performance. The emphasis lies on how these policies translate to debt. The second subsection summarizes prior research into the market for green bonds. The third section provides a brief overview of bond pricing literature, thereby laying the groundwork for the methodology. Lastly, the hypotheses are grounded in economic theory by using signaling theory and information asymmetry to characterize the market for green bonds. An overview of methods to reduce information asymmetry and their effects is provided.

3.1 The impact of environmental performance

Research on the impact of corporate social performance (CSP) practices within companies is pervasive. CSP differs from corporate social responsibility (CSR) practices in that it refers to stakeholders' assessments of the quality of CSR investments, and that it can be a proxy for a firm's

increasing involvement in CSR (Luo & Bhattacharya, 2009). Derwall et al. (2005) find that a portfolio with high SRI scores produces significantly higher returns than an otherwise similar portfolio with a low SRI score. Similarly, Konar & Cohen (2001) find that bad environmental performance is directly related to company valuation. In the same vein, environmental practices are found to have a similar effect on the cost of equity capital: findings suggest that firms with strong environmental performance have a lower cost of equity capital (Dhaliwal et al. 2011; Ghoul et al. 2011) Most articles published suggest a positive relationship between the environmental and financial performance of a company.

In the case of green bonds, Zerbib (2018) raises the question to what extent these equity-side findings apply to the debt market. Indeed, investors in fixed-income securities have little to no upside potential when a firm is "doing well by doing good." In this sense, the reason for investing in green bonds as opposed to brown bonds is more likely a measure to prevent downside risks, including environmental hazards and the risks of assets becoming stranded is essential. Prior research shows that improved CSP activities lead to better credit ratings (Jiraporn et al., 2014) and reduces default company default risk (Sun & Cui, 2014).

A number of academic publications focus on the pricing of CSP in bond markets, but these studies have failed to reach consensus concerning the effect of sustainability on bond prices. Oikonomou et al. (2014) argue bond issuers with good CSP are rewarded with a higher bond yield spread and are more likely to receive a higher bond rating. Good CSP is therefore related to financial risk. Klock et al. (2005) and Ghouma et al. (2018) find that bond yield spreads are negatively related to corporate governance quality for the U.S.A. and Canada, respectively. Hasan et al. (2017) show that US-based firms with more social capital can issue debt at a lower cost. Bauer & Hann (2010) research the effect of environmental performance on the cost of debt. They find that better environmental performance leads to a lower cost of debt.

However, not all studies find that improved CSP has a positive impact on bond pricing. In line with shareholder theory, Magnanelli and Izzo (2017) show that CSP increases a firm's cost of debt. Menz (2010) finds that European corporate bonds from socially responsible issuers suffer from a greater credit-spread than bonds from non-socially responsible issuers.

A key difference between these studies and the identification of the green bond premium is that a green bond does not need to be issued by a firm with high CSP. Indeed, green bond issuance serves

as a way to differentiate the finance of sustainable projects for other projects within the same company. In this sense, pricing effects due to preferences from green investments should be related to the projects funded through the green bond issuance, rather than to the CSP of the issuer.

3.2 Green Bonds

As one of the earliest publications studying the effects of corporate green bond issuance, Flammer (2018) examines the effect of a green bond issuance on the financial performance of a firm. The study presents evidence that issuing a green bond leads to positive announcement returns, improvements in long-term company value and operating performance, improved environmental performance, more green innovations, and an increase in ownership by long-term and green investors.

Studying the primary market, Ehlers & Packer (2017) investigate the pricing difference of green bonds by comparing them to conventional bonds issued by the same company while minimizing the time between issuances. They find that the yield spread for green bonds is lower than that of conventional bonds by 18 basis points. Ehlers & Packer (2017) posit that investor demand must be sufficiently high to influence issue pricing. In four reports released throughout 2017, the CBI (2017) attempts to identify a difference in pricing between green and conventional bonds. Using a limited dataset of 14 bonds, they find that identify no yield differential between green and conventional bonds. Similarly, HSBC (2016) fails to identify any pricing difference in the primary market using a sample of 30 bonds.

Partridge & Medda (2018) investigate the existence of a green bond premium for US Municipal bonds in both the primary and secondary markets. They highlight the possibility of additional expenses related to the more intensive disclosure requirements associated with the issuance of a green bond. A matching procedure is used to isolate the effect of the green label. The authors find evidence for the existence of a green bond premium with a weighted average of -4 basis points. Notably, this premium seems to be increasing over the years. Also studying the US municipal bond market, Baker et al. (2018) analyze a sample of 2,083 green municipal and 643,299 conventional municipal bonds. They find evidence for the existence of a green bond premium between after-tax yields of green and conventional bonds equal to -6 basis points. According to anecdotal evidence provided by Baker et al. (2018), this discount would be substantial enough to justify the higher costs faced when issuing a green bond.

Several studies further the green bond market by quality through the inclusion of an indicator for CBI certified green bonds. Baker et al. (2018) find that the premium for certified green bonds is even higher, totaling -14 basis points, suggesting that investors do not merely want to invest in green bonds for the label, but that they value traceability and external review as well. Next to finding evidence for the existence of a green bond premium, Baker et al. (2018) find that green bond ownership tends to be more concentrated than conventional bond ownership. They posit that only a subset of investors is willing to sacrifice return in order to hold a green bond, finding a higher degree of ownership by long-term investors compared to conventional bonds. This finding is in line with the evidence presented by Flammer (2018), who finds that companies who issue a green bond can attract a clientele whose focus is long-term and who are environmentally motivated, such as large institutional investors.

Wulandari et al. (2018) pose that the green bond premium is driven by a lack of supply, driving up bond prices. In turn, a lack of fiscal incentives for green investments (Zerbib, 2018), and the lack of a universal classification system such as the Green Bond Principles (Cochu et al., 2016) drives this lack of supply, causing the issuance of a green bond to be less attractive when compared to issuing a conventional bond. According to Wulandari et al. (2018), the shortage of supply and excess demand in the green bond market might cause the existence of a liquidity premium, rather than a green bond premium. Wulandari et al. (2018) identify this liquidity effect in the secondary market: bond liquidity is positively related to green bond yield spread, indicating the existence of a bond liquidity premium. Despite this, they note that the liquidity premium is decreasing over time. They posit that this may be because the green bond market is maturing, and that supply and market demand are starting to match more closely (Wulandari et al., 2018).

Also studying the green bond premium and the effects of liquidity in the secondary market, Zerbib (2018) investigates the yield spread between conventional and green bonds for the period 2013-2016. By matching a green bond to two otherwise similar conventional bonds, Zerbib (2018) calculates the yield of a synthetic conventional bond with the same maturity as the green. After controlling for liquidity differences between the green and conventional bonds, evidence is found for an average green bond premium of -2 basis points, although the study documents considerable variation within the sample. As one of the few studies that analyze the determinants of the green bond premium, Zerbib (2018) shows that the main determinants of the green bond premium are

credit rating and issuer type: the green bond premium is more pronounced financial and low rated bonds.

Barclays (2015) study the yield spread between green and conventional bonds in the secondary market between 2013 and 2014 and find that green bonds are priced 17 basis points lower than expected compared to conventional bonds. In a similar report, Nationale Nederlanden Investment Partners (2018) calculate the yield spread between green and conventional bonds in the secondary market. Using a sample of 27 bonds, they identify a -1.1 basis point green bond premium between 2014 and 2017. The main argument for the existence of this premium is the supply and demand mismatch in the market. In the case of a decreasing green bond premium, the increasing maturity of the green bond market and the significant increase in issued green bonds would explain a decreasing premium over time (Wulandari et al., 2018). An alternative explanation to this observation is that green bond investors might be buy-and-hold investors, who do not care about bond liquidity as they only purchase a bond once and aim to hold it until maturity. In this case, the decreased volatility of buy-and-hold investing in the immediate secondary market drives the lower yield of the bond. Despite the limited sample size, the Climate Bonds Initiative (2017) finds that a majority of green bonds is priced more tightly compared to conventional counterparts.

3.3 Bond pricing

In order to be able to isolate the effect of the green bond premium, it is important to consider all other factors determining the price of a bond. Merton (1974) identifies three drivers to be the main determinants of the price of a bond. The first determinant is the rate of return on a riskless asset, defined as an investment grade government bond. Second, characteristics of the bond issuance, such as maturity date, coupon rates, callability of the bond, and seniority lead to varying bond prices. Bonds with a higher maturity are seen as riskier compared to bonds with a shorter time to maturity. In the same vein, bonds with a lower coupon rate are more volatile. The last determinant of bond pricing as identified by Merton (1974) is the probability of default of the bond issuer. These criteria are also used to control for bond pricing in publications attempting to discover the green bond premium (Baker et al., 2018; Ehlers & Packer, 2017; Karpf & Mandel, 2017; Zerbib, 2018), and the effect of corporate disclosure (Sengupta, 1998).

However, yields of corporate bonds are higher than they should be based solely upon the determinants identified by Merton (1974), as evidenced by, amongst others, Collin-Durfnese et al.

(2001), and Huang and Huang (2012). Many studies argue that bond liquidity is the solution to this so-called "credit-spread puzzle," with researchers finding that bond liquidity proxies are significant explanatory variables for bond yield spreads (de Jong & Driessen, 2006; Houweling et al., 2005; Lin et al., 2011). This liquidity effect can be proxied by issue amount and issue date (Bao, Pan, & Wang, 2011; Houweling et al., 2005), or the bid-ask spread of a bond (Fong et al., 2017). Within the context of research into the existence of the green bond premium the following proxies have been used: number of transactions in the past 30 days (Karpf & Mandel, 2017), issue amount (Baker et al., 2018; Karpf & Mandel, 2017; Zerbib, 2018), and bid-ask spread (Zerbib, 2018).

3.4 Information asymmetry

The motivation for issuing a green bond is a crucial question concerning the green bond market. In the absence of reputational effects and a green bond premium, a wealth-maximizing issuer will not choose to issue a green bond, as this voluntarily restricts their investment policies when compared to a conventional bond. Investors can also achieve sustainability targets without limiting investment opportunities by issuing a conventional bond and investing the proceeds of this issuance in sustainable projects. The higher cost and complexity of issuing a green bond amplifies this effect (Baker et al., 2018; Flammer, 2018; Wulandari et al., 2018). In this situation, there must be an alternative motivation for issuing green bonds. Issuing a green bond may serve as a signal to the market that the issuer will invest the proceeds of the bond issuance in sustainable projects, and that the company issuing the bond is positioning itself as an environmentally conscious firm. The investment decision for green bonds can be related to the signaling theory of Spence (1973), as investing in a bond is subject to uncertainty: An investor cannot be certain of the project financed by the proceeds raised through the issuance of a bond. Due to this uncertainty, an investor with specified preferences, such as a values-driven as defined by Derwall et al. (2011) will be less willing to invest in a bond regardless of the use of proceeds of the bond. In other words: due to uncertainty, it is possible for an investor with a sustainability constraint to not invest in a bond whose proceeds will ultimately be dedicated to financing sustainable projects. Limiting the possible uses of proceeds of the bond issuance (by issuing a green bond) sends a signal to potential investors. If the signal is perceived to be credible, the green bond will be successfully differentiated from other (conventional) bonds and may be priced accordingly (Spence, 1973).

Green bond issuance is akin to the lemons problem first described by Akerlof (1970): in a market with information asymmetry, an investor will be unable to differentiate high- and low-quality investments efficiently. As a result, the investor will only be willing to pay the market average for an investment, regardless of the inherent quality of the product. If there is no information asymmetry (i.e., if the true value of the investment is known), the investor would be willing to pay a higher price for the high-quality investment. This paper identifies many instances of signaling within the context of the green bond market. First, green bond issuance shows the intent of an investor to use the proceeds of the issuance for sustainable investment only, providing the investor with more information. Second, alignment with the GBP can serve to differentiate the quality of the green bond further. External reviewers can confirm the quality of the green bond issuance, thereby reducing information asymmetry through information intermediaries. Lastly, certification might be a final "seal of approval" that serves to differentiate credible green bonds from green bonds that face a higher risk of greenwashing.

The notion of credibility is important within this context as the use of proceeds statement laid out in a green bond prospectus is not legally enforceable, and alignment with the GBP is voluntary. In order for a signal to transfer information to the investor, it needs to be credible. A signal is credible if it is difficult to recreate by someone with less favorable conditions (Spence, 1973). Because of this Flammer (2018) argues that green bonds could be a form of greenwashing: by issuing a green bond an issuer can reap the reputational rewards without actually investing the use of proceeds into sustainable projects. Seeing as there are no legal repercussions for doing so,[9] issuing a green bond might not constitute a credible signal in the absence of reputational effects. Moreover, the voluntary nature of alignment with the GBP might make it easy for a green bond issuer to claim alignment, without any external verification having taken place. A lack of verification reduces the credibility of the signal sent through aligning a bond issuance with the GBP.

Hahn & Kühnen (2013) argue that sustainability is a clear example of information asymmetry, given the existence of an information gap between the management of the company and external parties regarding sustainability practices. In this context, it is difficult to obtain credible information regarding the company. Healy & Palepu (2001) argue that the demand for (financial) disclosure is driven by information asymmetry, which is re-affirmed by Hahn & Kühnen (2013),

[9] The use of proceeds statement as laid out in a green bond's prospectus is not legally enforceable (Flammer, 2018).

who further emphasize the importance of providing an investor with trustworthy and plausible information by sending a credible signal. Simultaneously, Hahn & Kühnen (2013) emphasize the importance of disclosure and reporting for reducing this asymmetry. The findings are corroborated by Brown & Hillegeist (2007), who proxy for information asymmetry by looking at the probability of trading on private information. They find that more disclosure reduces information asymmetry. Information intermediaries, such as financial analysts, can enhance the credibility of disclosure reports. Within the green bond market, these intermediaries are external reviewers (SPO issuers and assurance providers) and certifiers.

Healy & Palepu (2001) provide a comprehensive overview of empirical disclosure literature and identify the different types of corporate disclosure. In particular, they differentiate between mandatory disclosure (such as financial reports, financial statements, and regulatory filings) and voluntary disclosure and communication (such as impact reporting and other corporate reports). Following this framework, and in the absence of any regulation, green bond disclosures, and other CSR reporting frameworks can be characterized as voluntary reporting. As public awareness and concern for ESG issues increases, there will be an increase in pressure on regulators to draft and enforce regulations with mandatory compliance.

Several academic works analyze the relationship between financial disclosure and the cost of capital. Lambert et al. (2007) find that market risk premia decrease as market regulation with respect to financial disclosure increases. Akhigbe et al. (2009) show that regulation aiming for increased financial transparency has positive wealth effects. Ferrell (2007) finds that increased regulation concerning disclosure reduces stock volatility. Similarly, financial disclosure quality is related to a lower cost of capital (Lambert et al., 2007), higher stock returns (Jiao, 2011), and lower cost of equity (Richardson & Welker, 2001).

The literature on the relationship between financial disclosure and the cost of debt is less pervasive than the analysis of the relationship between financial disclosure and cost of equity. Sengupta (1998) analyses this relationship by assigning firms a disclosure score based on the quality of the documentation as determined by information intermediaries (financial analysts). As disclosure quality increases, cost of debt goes down after controlling for other determinants of cost of debt. This effect is amplified in markets with a high degree of uncertainty. Similarly, Wang et al. (2008) investigate the relationship between *voluntary* disclosure and cost of capital but document no

significant relationship. Despite this finding, Wang et al. (2008) do identify a positive relationship between voluntary disclosure and firm performance.

A similar effect can also be observed in the green bond market where, in the absence of regulation, the green bond principles have become the leading standards. The use of voluntary, non-financial disclosure is pervasive in the green bond market. Indeed, all types of non-financial reporting identified in section 2 are voluntary, non-financial reports. Although not bond-specific, studies have analyzed the effects of non-financial reporting. Although these studies have not reached consensus, most identify a positive relationship between non-financial reporting and firm performance.

Ioannou & Serafeim (2017) study the effect of mandatory CSR reporting on firm valuation. They find that increased regulation surrounding sustainability and CSR reporting increases firm value as proxied by Tobin's Q. Next, the study documents that in the absence of regulation concerning disclosure or assurance provision, firms seek to improve the comparability and credibility of non-financial disclosure. Ioannou & Serafeim (2017) argue that efforts to improve non-financial disclosure, both from a regulatory standpoint as well as by the issuers of the documentation, are effective at improving disclosure quality. Grewal et al. (2017) find that stock price synchronicity (the predictability of a stock price) improves as sustainability disclosure regarding material topics increases. The effect is larger for companies with a specific focus on or exposure to sustainability issues. In line with signaling theory, Dhaliwal et al. (2012) argue that issuing CSR reports will reduce information asymmetry, regardless of a positive or negative impact document therein. Building on this, Dhaliwal et al. (2014) find that increased CSR reporting reduces the cost of equity. This effect is stronger in countries with high financial opaqueness and a higher stakeholder orientation. Several other studies confirm this finding (Bachoo et al., 2013; Ng & Rezaee, 2012). Next to documenting a relationship between CSR reporting and cost of equity, studies also find that an increased in CSR reporting causes a lower cost of debt (Ng & Rezaee, 2012), higher future performance (Bachoo, Tan, & Wilson, 2013), and higher firm valuation (Loh et al., 2017).

Not all publications provide evidence for the existence of a value effect of corporate disclosure. Verbeeten et al. (2016) find no evidence to support a relationship, whereas Bushee and Noe (2000) find that more corporate disclosure leads to increased volatility. A similar positive relationship is identified by Cormier and Magnan (2007) who document that environmental reporting does not

significantly influence stock performance. Despite this, the majority of academic literature seems to argue in favor of the value enhancing effects of (non)financial disclosure.

As described earlier, information intermediaries play a critical role in ensuring a signal is credible, thereby overcoming information asymmetry problems. Healy and Palepu (2001) define information intermediaries as external parties who produce information in order to uncover a manager's superior information. Within the context of the green bond market, external reviewers can be classified as an information intermediary. An independent, external review can play an essential role in increasing the integrity and trustworthiness of the reporting surrounding a green bond issuance.

The body of work concerning the enhancing effects of assurance provision (external review) on sustainability reporting and non-financial reporting is limited. Studies argue for the relevance of verification and assurance provision on carbon disclosure as a vital part of ensuring reliability and credibility of sustainability reporting (Cohen & Simnett, 2015; Simnett & Nugent, 2007). Due to the voluntary nature of sustainability reporting companies which are concerned with building a strong corporate reputation are more likely to engage an assurance provider for their non-financial documentation (Simnett, Vanstraelen, & Chua, 2009). Using financial forecast accuracy to measure information asymmetry, Cuadrado-Ballesteros (2017) find that assured CSR reporting reduces information asymmetry to a greater extent than non-assured reporting. Similarly, Hodge et al. (2009) find that assurance provision improves the perceived reliability of the reporting. The effect is stronger for higher levels of assurance. Within the context of the green bond market, this finding confirms anecdotal evidence that external review is important, but that assurance provision is valued to a greater extent than the second party opinion.

4. Hypothesis development

In this section, this paper defines five hypotheses in order to empirically test the extent to which the existence of the green bond premium varies with green bond non-financial disclosure. The first step in this process is identifying the existence and size of the green bond premium, which leads to the first hypothesis:

> **H1**: Green bonds exhibit lower yields (are priced at a premium) in the secondary market compared to otherwise similar conventional bonds.

As discussed in the literature review, there is no consensus on the existence of a green bond premium, despite several studies in the secondary market. Barclays (2015) find a green bond premium of -17 basis points in the secondary market, whereas Bloomberg (2017) identify a -25 basis points premium for EUR denominated bonds, but fail to identify a premium for USD issued bonds. Zerbib (2018) identifies a -2 basis points premium in the secondary market, which is solely driven by investor non-financial motives. In contrast, Karpf & Mandel (2018) study the pricing of green US municipal bonds and identify a green bond discount of 7.8 basis points.

Most articles focus on identifying a difference between green and conventional bonds. Although the definition of what constitutes a green bond varies for each publication: some choose to only include GBP aligned bonds in their sample while others consider a broader definition of what constitutes a green bond. Most works do not attempt to identify, or indeed explain, variation in the green bond premium among green bonds.

In an interview with Rabobank industry practitioners confirmed that, especially at the inception of the market, a high degree of uncertainty in the market existed. They confirm that non-financial disclosure is a vital part of being able to determine the quality of a green bond and that investors likely price this in the secondary market. Sengupta (1998) studied the effects of corporate disclosure on the cost of debt and finds that firms with more disclosure enjoy a lower cost of debt, while also identifying that this effect is larger for markets with high information asymmetry. Given that the market for green bonds is plagued by information asymmetry (Flammer, 2018), I propose the following hypothesis:

> **H2**: Bonds with more non-financial disclosure enjoy a higher green bond premium in the secondary market.

Chapter two identified four types of green bond non-financial disclosure. Ranked by intensity, these are alignment with the green bond principles, second party opinion issuance, assurance provision, and CBI certification. Interviews with industry experts reaffirm the expectation that the green bond premium is not simply related to the *amount* of green bond disclosure but related to the *type* of disclosure related to the green bond issuance. Therefore, the disclosure metric used for hypothesis two is disentangled.

Despite alignment being voluntary, the Green Bond Principles are the industry standard. The relatively modest requirements of alignment with these standards coupled with the pervasiveness of GBP-aligned bonds, lead to the conclusion that this is the least stringent, most accessible type of green bond non-financial disclosure. Alignment with the GBP might serve to make the signal of a green bond issuance more credible by reducing information asymmetry in the market. Therefore, I consider the GBP to be the first "step" in the green bond disclosure hierarchy.

> **H3**: Bonds aligned with the Green Bond Principles exhibit a higher green bond premium than unlabeled bonds.

The GBP recommend (but don't require) external review of a green bond's framework for issuance (ICMA, 2018). Section two identified two distinct methods through which external review can take place: assurance engagement and second party opinion issuance. The main difference between these types of external review is that only the assurance engagement is a legally binding confirmation of the quality of the green bond issuance framework. Industry practitioners confirm this distinction, placing more trust in assurance engagement. The following hypotheses are therefore defined:

> **H4.1**: External review increases the bond's green bond premium over GBP aligned bonds.
>
> **H4.2**: Second party opinion issuance increases the bond's green bond premium over GBP aligned bonds.
>
> **H4.3**: Assurance provision increases the bond's green bond premium over the GBP aligned bonds by a larger amount than SPO issuance.

The last step in the disclosure hierarchy, CBI certification, is also the most costly and intensive, as it requires the engagement of an external verifier and alignment with the climate bond standards

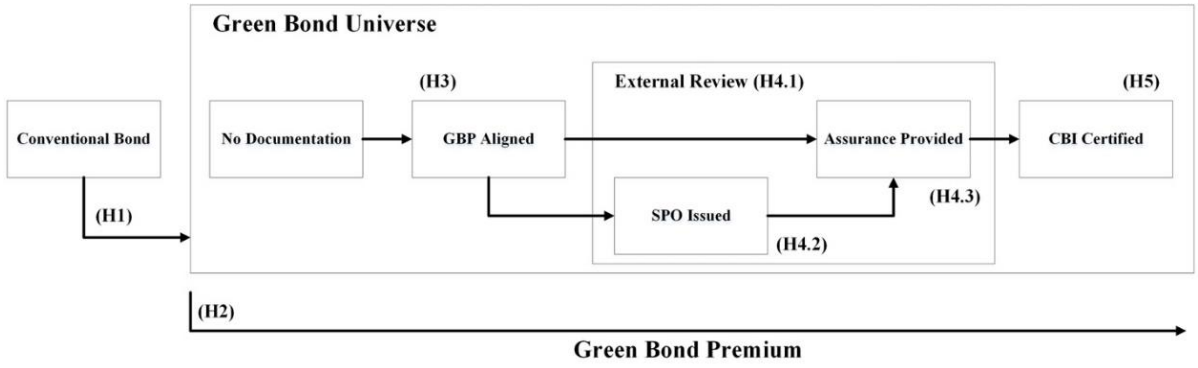
(Baker et al., 2018). Two academic publications attempt to identify the effect of certification on green bond pricing and the issuer. Baker et al. (2018) identify that pricing and ownership effects are stronger for certified green bonds. Flammer (2018) finds that issuing a certified green bond has a stronger impact on financial and non-financial KPIs, as well as increased ownership by long-term oriented investors.

Both studies do not include other measures of non-financial green bond disclosure in their analysis. Because of this, the effect of the green bond *label* is not isolated, as the amplified effects of green bond certification can be due to either the label "CBI certified," or due to the external review, which is required to achieve certification. The certification label might take away the necessity for investors to fully parse all nonfinancial documentation, due to the inherent credibility of the label. If this is true, CBI certification would further reduce information asymmetry. The effect of CBI certification is empirically tested by the following hypothesis:

> **H5**: Bonds labeled "CBI Certified" enjoy a higher green bond premium over externally reviewed and GBP aligned bonds.

Figure 3 shows the relationship between the four hypotheses. Hypothesis 1 attempts to identify the existence of a green bond premium in the secondary market, in line with prior research. The other hypotheses attempt to explain varying green bond-premia according to the disclosure hierarchy *within* the green bond universe. Hypothesis 3 focuses on the distinction within green bond external review

Figure 3: Green bond premia hypotheses



5. Data collection

In order to be able to compare the quality of green bond disclosure, we construct a proprietary dataset containing information on bond-specific voluntary non-financial disclosure. One of the challenges in creating such a dataset is the lack of a common definition of what constitutes a green bond. Prominent database providers such as Bloomberg and the Climate Bond Initiative require all bonds in their database to be aligned with the GBP (ICMA, 2017). The sample should comprise the complete spectrum of the green bond universe: bonds issued alongside (almost) all types of bond non-financial disclosure, but also bonds who fail to provide any non-financial disclosure other than being self-labeled green by the issuer. Despite voluntary alignment, hypothesis 3 argues that alignment with the GBP is an important signal to investors.

We utilize the *Green Bond Database* by Environmental Finance[10] as a starting point for the construction of the dataset in order to combat skewing the sample towards high-quality green bonds by excluding bonds which are not GBP aligned. When constructing this database, Environmental Finance chose not to pass subjective judgment on whether or not a bond is green enough to be included in the database. Instead, Environmental Finance include any bond issuance labeled as green by either the issuer or lead manager in the database.

The database reports 2,938 deals, which is significantly more than the 1,864 issuances recorded in the green bond use of proceeds filter in the Bloomberg fixed income database. An important consideration is that Environmental Finance classifies each deal as an observation. A deal is defined as the collection of issuances on the same date, by the same issuer, with the same lead manager. These requirements imply that, following the methodology of Environmental Finance, two bond issuances with separate currencies, coupons, and ratings are listed as one observation. This merged listing provides further evidence that other database providers do not capture the complete green bond universe, as the total amount of tranches (i.e., bond issuances with a single security identifier) in the database is even higher than the number of reported deals.

To ensure comparability across sectors, we exclude all deals by supranational institutions, governments, and municipalities as their tax treatment varies from corporate (financial) bonds (Baker et al., 2018). The remaining dataset contains 783 deals. In order to be able to measure the

[10] Environmental Finance, https://www.bonddata.org/

effect of a specific bond issuance rather than a deal, we split any deal consisting of multiple tranches into individual observations. The resulting dataset contains 829 observations.

Although the Environmental Finance database provides a more comprehensive sample of the green bond universe and contains more bond non-financial disclosure data, the database is lacking concerning financial information and bond characteristics. A large amount of the observations is missing a security identifier (ISIN or CUSIP). In order to combat this, we manually identify the ISIN code for each observation by searching Bloomberg and FactSet for the correct issuer, issue date, maturity, issue amount, coupon, rating, and currency. Not all issue dates and maturities match precisely with those of the alternative databases, despite other characteristics being the same. We drop any issuances with an issue date and maturity within one week of the dates recorded in Environmental Finance are dropped from the dataset. Any observations for which we do not find the identifier are similarly excluded from the database. The resulting dataset contains 631 bond issuances for which both non-financial disclosure information from Environmental Finance, as well as financial information and bond characteristics are available from Bloomberg.

5.1 Green bond disclosure

In order to measure the extent to which a green bond premium fluctuates with the degree of voluntary non-financial disclosure of a green bond, we manually categorize all available information concerning green bond non-financial disclosure for each of the 631 bonds.

Environmental Finance records the following data: the bond's used of proceeds, alignment with the GBP, bond external review, bond assurance, bond certification, and an ICMA review form surmising all forms of external verification. In line with the hypotheses, we identify four categories of non-financial disclosure which are outlined below.

Green Bond Principles	Bond is aligned with the Green Bond Principles
Second Party Opinion	Second party was consulted, and an opinion was issued
Assurance	A third party assures the contents of the bond's reporting
Certification	Bond has received CBI certification

Interviews with industry professionals confirm that each consecutive document in this categorization is more time and labor intensive, resulting in a green bond disclosure hierarchy. The

bond disclosure hierarchy measures the extent to which investors can verify the green promise of a bond, allowing for greater distinction among green bond non-financial disclosure. To the author's best knowledge, this study is the first of its kind to impose this level of categorization on the green bond market.

The baseline for recording this bond-specific data is the Environmental Finance Database, which provides an overview of all (non-)financial documentation of the bond issuance. Despite using it, several limitations plague the database. On various occasions, the Environmental Finance database mixes up the terms external review, second party opinion, and assurance. On more than one occasion, the database failed to include the documentation altogether, despite these being readily available. To combat this, we download the bond prospectus and supporting documentation for each bond from the investor relations page of the issuer. All documents are manually parsed and used to correct or supplement the Environmental Finance Database. On several occasions, the Environmental Finance database categorizes non-financial disclosure differently than the issuer. In this case, we use the documentation most directly from the issuer.

Next to correcting for mistakes in the database, two other "rules of thumb" are maintained in order to ensure uniformity during the manual construction of the indicators. First, CBI certified bond issuances, as per the definition of the climate bond standards, must be aligned with the Green Bond Principles (CBI, 2018a). Therefore, whenever a bond is CBI certified we automatically record it to be aligned with the GBP, regardless of the publication of GBP documents. Next to this, CBI certification requires that at least reasonable assurance is provided on the issuance by an assurance provider. Because of this, any recording of a CBI certified bond must also be recorded to have limited assurance.

The line between external review, second party opinion, and assurance provision is not clear cut. For example, Sustainalytics mostly issues second party opinions on green bond issuances. However, they are also a Climate Bonds Standard approved verifier (CBI, 2018). Being able to verify bonds implies that, under certain conditions, they are allowed to assure green bonds. In order to distinguish between these reports, and to ensure consistency when categorizing the sample, we base the category in which a specific non-financial disclosure is recorded upon the contents of the specific document. A document is categorized as assurance when it constitutes a legally binding document wherein the assurance provider gives either reasonable or limited assurance. A

document is classified as a second party opinion if it does not provide assurance and does not constitute a legally binding agreement.

Lastly, for issuers who issued more than one green bond: Disclosure concerning the green bond framework works proactively, but not retroactively. A prerequisite for GBP aligned issuances is the publication of a transparent green bond framework. A green bond framework stipulates the process through which the company issues a bond, will report in the future and selects eligible projects. Once in place, this framework is re-used for any future issuances of green bonds by the same company. Second party opinions can be related to the quality and contents of this framework. In turn, this implies that if a second green bond is issued under the same framework as a prior issuance, then a second party opinion applicable to the framework of the prior issuance is also relevant for the following issuance and is recorded as such. Therefore, we record all proceeding issuances under a framework for which a second party opinion was issued as being issued alongside a second party opinion. However, as issuers can change and improve their frameworks along the way, this is not applied retroactively.

Three researchers conducted the manual construction of the disclosure indicators. In order to ensure the same identification criteria, a sub-sample of 100 bonds was analyzed by all three researchers without consultation. The variables recorded were the same across the researchers. We discard any bonds for which the financial documentation was not in English from the sample.

Table 1: Green bond disclosure

	Standards	SPO	Assurance	Certification	N
Percentage	77.7%	64.1%	24.0%	9.5%	
N	401	331	124	49	516

The final sample consists of 516 bonds. Table 1 shows the spread of the disclosure indicators across the sample per region and issuer type. In line with hypothesis 2, we identify a hierarchy where the majority of the bonds in the sample are GBP aligned (77.7%). A significant portion of the sample issues bonds alongside a second party opinion (64.1%). The amount of bonds issued with an assurance provision is smaller (24%). Certification is the rarest among the types of green bond non-financial disclosure (9.5%).

In order to measure the effectiveness of the disclosure hierarchy, a measure for the amount of non-financial green bond disclosure (DISC) is constructed by summing the recorded indicator variables of non-financial disclosure. The resulting variable is a rating on a scale of 0 to 4 which indicates the number of supporting documents provided alongside the bond issuance. For example, a bond which is aligned with the GBP but has no other supporting documentation is given a score of 1, whereas a CBI certified bond which has assurance provision from a third party and is aligned with the GBP is assigned a score of 3. The spread of the DISC score centers around 2, with 60.73% of bonds being assigned this score. There are relatively more bonds with a low ranking of 0 and 1 (18.02% and 13.16%, respectively) than with a high ranking of 3 and 4 (4.66% and 3.44%, respectively). Lacking formal empirical evidence, this already shows some consistency for the green bond hierarchy hypothesis, as 91.1% of assigned DISC scores is equal to 2 or lower.

5.2 Isolating the green bond premium

A considerable concern when attempting to quantify the green bond premium or any sustainability effect is not being able to isolate the effect from other determinants. As identified in section 2, the probability of default, bond characteristics, the risk-free rate, and bond liquidity determine bond prices. Not controlling for these determinants will mask the presence of a green bond premium. Typically an OLS regression is implemented alongside a model specification containing all (known) determinants of a bond yield alongside a dummy variable for disclosure or greenness (Baker et al., 2018). However, in order for such a method to be effective, *all* determinants of the bond price need to be included and explain most of the variation in bond pricing.

In order to circumvent this, this study utilizes a matching procedure following similar specifications as those specified in Zerbib (2018). A matching method, also known as a model-free or direct approach, allows for the isolation of a specific characteristic of a financial instrument. Following this method, green bonds are matched to two otherwise similar conventional bonds. In doing so, it is possible to analyze the difference between bond yield (the yield spread) of these bonds. As all other bond price determinants are the same between the green and conventional bonds, the differences are solely due to the green label.

In line with Zerbib (2018), bonds are matched based on currency, rating, the presence of a call feature, seniority, collateral, and coupon type to account for bond characteristics. Next to this, green bonds are only matched to bonds with the same credit rating in order to ensure a similar

probability of default. The risk-free rate is accounted for by comparing yields which are both priced at according to the risk-free rate, thereby canceling the effect. Zerbib (2018) matches bonds based on issuer as he attempts to isolate the non-financial (i.e., values-driven) effect of issuing a green bond. The limited size of the non-financial disclosure sample and the stringent matching criteria imply that the resulting sample would be too small when matching based on the same issuer. Therefore, bonds are matched based on the same industry instead. Matching based on industry rather than issuer implies that either financial or non-financial motivations can drive findings yield differences in the secondary market.

The final bond pricing determinant which needs to be accounted for is bond liquidity (Chen et al., 2007; Dick-Nielsen et al., 2011). Issue amount and issue date are shown to be reliable proxies for this (Bao et al., 2011; Houweling et al., 2005). Therefore, bond liquidity is accounted for by only matching green bonds to conventional bonds whose issue amount lies between 25% and 400% of that of the green bond. Additionally, we only consider bonds issued within two years of the green bond issuance (i.e., two years before or after) for the matching procedure.

Lastly, bonds are matched based on their maturity. Due to the stringency of the matching criteria, it is not possible to match bonds with the same maturity as the green bond. Instead, each green bond is matched to two conventional bonds whose maturities do not vary by more than two years. A synthetic bond with the same maturity as the green bond is then created by interpolating or extrapolating the yields of the two conventional bonds at the maturity of the green bond.

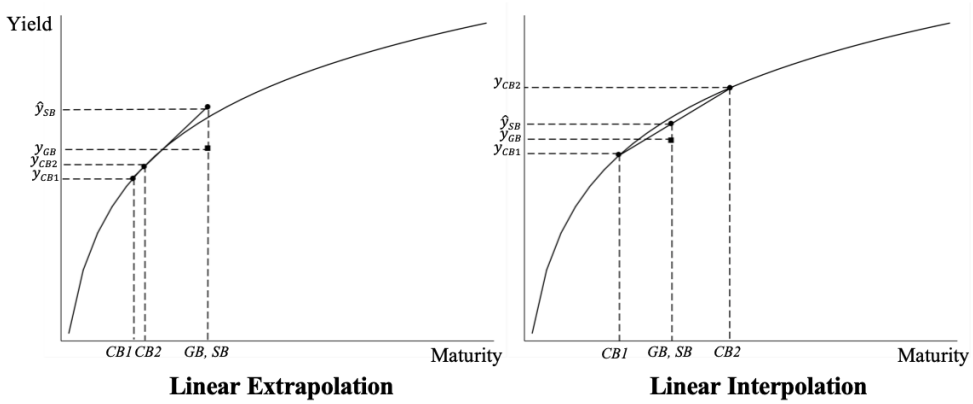
The yield of a synthetic bond $\hat{y}^{SB}$ is calculated by determining the yield of a synthetic bond with the same maturity as a green bond ($Maturity_{GB}$). This yield is calculated by determining the linear relationship between the conventional bonds (CB1 and CB2), which can be defined as:

$$\hat{y}^{SB} = a * Maturity_{GB} + b$$

With a being the slope and b being the intercept op the linear function passing through ($Maturity_{CB1}, y^{CB1}$) and ($Maturity_{CB2}, y^{CB2}$). Figure 4 shows a stylized example of linear interpolation of a synthetic bond yield. Finally, the yield spread between the green and synthetic conventional bond is determined. This spread per bond i at time t is defined as the difference in ask yield between the green bond and synthetic conventional bond.

$$\Delta\hat{y}_{i,t} = y_{i,t}^{GB} - y_{i,t}^{SB}$$

Figure 4: Linear interpolation and extrapolation of synthetic bond yield



The matching procedure is successful for 95 of the original 536 bonds in the sample. Pricing information is downloaded from Bloomberg for each day with information for all three bonds available. Any observation lacking bond pricing information for any of the bonds in the triplet is excluded from the dataset. The resulting panel contains 26,697 bond-day observations. Figure 5 summarizes the sample construction process. Table 2 shows descriptive statistics of the matched green bonds sample. The sample consists of 95 matched green bond triplets categorized by currency, sector, and rating. The dataset contains yields starting January 1st, 2014. The last observation is December 31st, 2018. The majority of data points are from the years 2017 (23.32%) and 2018 (64.05%).

Figure 5: Overview of sample construction

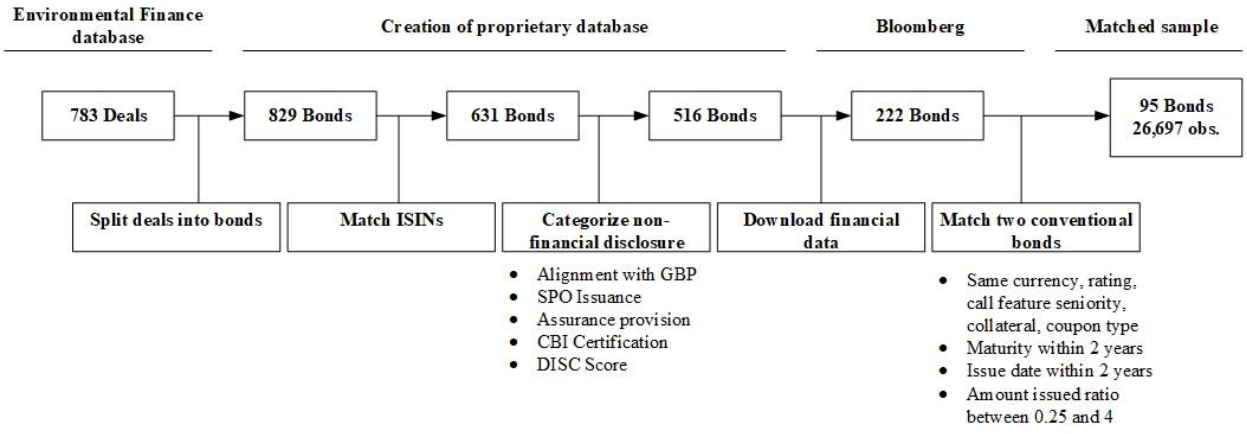


Table 2: Summary statistics of matched green bond sample

		CHF	EUR	GBP	INR	NOK	SEK	USD
Consumer Discretionary								
BBB	Avg. yield GB (%)							2.87
	Avg maturity GB (yrs)							5.00
	No. of GB							1
NR	Avg. yield GB (%)						1.04	2.69
	Avg maturity GB (yrs)						6.51	5.00
	No. of GB						2	1
Energy								
BBB	Avg. yield GB (%)		0.50					
	Avg maturity GB (yrs)		5.00					
	No. of GB		1					
Financials								
AA	Avg. yield GB (%)		0.47				1.01	2.90
	Avg maturity GB (yrs)		5.00				5.00	4.75
	No. of GB		5				1	3
A	Avg. yield GB (%)		0.95				0.90	2.62
	Avg maturity GB (yrs)		6.11				5.00	4.54
	No. of GB		14				3	9
BBB	Avg. yield GB (%)		0.95					3.76
	Avg maturity GB (yrs)		5.47					8.81
	No. of GB		3					5
NR	Avg. yield GB (%)	0.25	0.63	4.98	4.72	1.75	0.57	2.68
	Avg maturity GB (yrs)	7.00	6.82	31.00	5.00	5.00	4.80	4.69
	No. of GB	1	10	1	1	1	4	6
Government								
AA	Avg. yield GB (%)							2.07
	Avg maturity GB (yrs)							5.00
	No. of GB							1
NR	Avg. yield GB (%)							3.49
	Avg maturity GB (yrs)							5.00
	No. of GB							2
Technology								
AA	Avg. yield GB (%)							2.88
	Avg maturity GB (yrs)							8.34
	No. of GB							2
Utilities								
AA	Avg. yield GB (%)							3.68
	Avg maturity GB (yrs)							30.49
	No. of GB							2
A	Avg. yield GB (%)		1.85					4.07
	Avg maturity GB (yrs)		7.94					29.98
	No. of GB		6					2
BBB	Avg. yield GB (%)		2.22					2.91
	Avg maturity GB (yrs)		9.48					8.36
	No. of GB		3					4
NR	Avg. yield GB (%)		1.43					
	Avg maturity GB (yrs)		10.00					
	No. of GB		1					

Note: Table shows the average yield of the 98 green bonds in the sample categorized by currency, industry sector and rating.

The financial sector makes up a sizeable portion of the sample. This is expected due to the focus on corporate bonds and financial institutions in the Environmental Finance database. Of the total sample of bonds, 22 issuances have a call-feature. All bonds in the sample are senior, with the majority of bonds issued being fixed coupon (86%). Similar to Zerbib (2018), table 2 shows large fluctuations in yields between currencies and ratings. For example, an AA rated, USD denominated green bond issued by a financial is issued with an average yield of 2.96%, whereas the same type of green bond denominated in SEK only has an average yield of 0.97%. The total amount issued in the sample is 49.0 billion USD, which is equal to 16.64% of all issuances by corporations and financial institutions since the inception of the green bond market (294.6 billion USD).

Table 3: Sample statistics

	Min	25th Percentile	Median	Mean	75th Percentile	Max
No. days per bond	1	0.74	172	242.61	330	1292
y^{GB} *(%)*	.12	.74	1.85	1.89	2.81	5.7
$\hat{y}^{SB}$ *(%)*	.10	0.83	1.79	2.13	3.26	7.32
y^{CB1} *(%)*	.03	0.63	1.50	1.74	2.55	5.97
y^{CB2} *(%)*	.18	0.9	2.31	2.26	3.31	6.44
$\Delta\hat{y}$ *(%)*	-2.33	-0.50	-0.15	-0.24	0.09	1.42
Maturity GB (years)	3.00	5.00	6.00	7.77	8.00	31
Maturity CB1 (years)	1.49	4.00	5.00	6.78	7.00	30.11
Maturity CB2 (years)	3.00	5.00	7.00	8.17	10.00	31
GB issue amount (USD MM)	10	359	547	598	618	2250
CB1 issue amount (USD MM)	6	338	533.	616	802	3000
CB2 issue amount (USD MM)	9	307	600	674	812	3250

Table 3 shows sample statistics. The table shows the distribution of key variables within the sample of 95 matched bond triplets. The number of days per bond indicates the number of observations in the sample per bond. The distribution of ask yields is shown for the sample of green bonds (y^{GB}), calculated synthetic bond ($\hat{y}^{SB}$), and matched conventional bonds (y^{CB1} and y^{CB2}). The difference between the ask yield of the green bond and the interpolated or extrapolated synthetic bond ($\Delta\hat{y}$) is shown. In order to compare the accuracy of the matching criteria and the accuracy of the interpolation or extrapolation, the distribution of the green and matched bond maturities and amounts issued is shown. The calculated green bond spread is skewed to the left, with 31.4% of calculations showing a positive spread. The mean calculated green bond yield spread in the sample is -24 basis points, with a median of -15 basis points.

6. Methodology

As discussed during the hypothesis development, the first step in identifying the determinants of the green bond premium is to isolate the green bond premium from other determinants of bonds yields (H1). The matching procedure described in the previous section accounts for most of these determinants. Comparing ask-yields between a green and interpolated or extrapolated synthetic bond ensures an "apples to apples" comparison and eliminates the chance of variations in bond yields being determined by the matching criteria, as these are the same for the green and conventional bonds.

Although the matching procedure captures part of the liquidity effects by matching based on maturities and issue amounts as proxies for liquidity (Bao et al., 2011; Houweling et al., 2005), it does not capture all liquidity effects. Therefore, a first step in determining the green bond premium is controlling for residual liquidity. A variable is constructed capturing the difference in liquidity between the green and synthetic bond:

$$\Delta BA_{i,t} = BA_{i,t}^{GB} - BA_{i,t}^{SB}$$

The percent quoted bid-ask spread is used as a proxy for liquidity, as Fong et al. (2017) find this to be the best low-frequency proxy for liquidity. Bond liquidity is therefore calculated based on the following formula:

$$BA_{i,t} = \frac{Ask\ Price_{i,t} - Bid\ Price_{i,t}}{(Ask\ Price_{i,t} + Bid\ Price_{i.t})/2}$$

Since the characteristics of the synthetic bond are determined by the two matched conventional bonds, the bid-ask spread of the synthetic bond is defined as the distance-weighted average of the bid-ask spread of the conventional bonds, based on their maturity. Following the methodology of Zerbib (2018), let $d_1 = |Maturity_{GB} - Maturity_{CB1}|$ and $d_2 = |Maturity_{GB} - Maturity_{CB2}|$. The bid-ask spread of the synthetic bond is then calculated as:

$$BA_{i,t}^{SB} = \frac{d_2}{d_1 + d_2} BA_{i,t}^{CB1} + \frac{d_1}{d_1 + d_2} BA_{i,t}^{CB2}$$

The resulting data is subtracted from the percent-quoted bid-ask spread of the green bond following, resulting in the control variable for liquidity (ΔBA). Table 4 shows the spread of ΔBA over the sample. The distribution is slightly skewed to the left, with the median being close to zero.

This provides some indication that, for most bonds, the matching procedure was adequate for controlling for bond liquidity.

Table 4: Descriptive statistics of ΔBA

ΔBA						
Min	25th Percentile	Median	Mean	75th Percentile	Max	St. Dev
-0.0093%	-.0005%	0.0001%	0.0004%	0.0008%	0.0451%	0.0024%

6.1 The green bond premium

Zerbib (2018) defines the green bond premium as a negative yield difference between green bond and the synthetic bonds after controlling for residual liquidity. The time-invariant bond-specific green bond premium is estimated using a within fixed-effects panel. The specification of the first step regression model (1) is:

$$\Delta\hat{y}_{i,t} = \beta\Delta BA_{i,t} + p_i + \varepsilon_{i,t} \quad (1)$$

$\Delta\hat{y}_{i,t}$ is the yield spread between the matched green and synthetic bond i at time t. ΔBA is the control variable for residual liquidity. p_i is the unexplained time-fixed variation in the green bond premium, and $\varepsilon_{i,t}$ is the error term.

Table 5: Determining the green bond premium

	$\Delta\hat{y}_{i,t}$
ΔBA	2.5058
	(0.89)
Constant	-0.2394***
	(-192.68)
Observations	26797
R^2	0.012
F Statistic	0.7984

Note: Table shows the result of the step 1 regression. The regression equation is: $\Delta\hat{y}_{i,t} = p_i + \beta\Delta BA_{i,t} + \varepsilon_{i,t}$. The panel regression contains 95 groups. The average number of observations per group is 282 days. Robust standard errors are reported. *t* statistics in parentheses. * p<0.10, ** p<0.05, *** p<0.01

Table 5 shows the results of the panel regression. A Hausman test draws into question the efficiency of the fixed effects estimator. Therefore, I specify a random effects model in the robustness checks. Additionally, Woolridge and Breusch-Pagan tests confirm the presence of autocorrelation and heteroskedasticity, respectively. Robust standard errors are specified in order to combat the presence of these effects. Appendix A3 provides an overview of all test results.

The goal of the first step regression is to identify a green bond premium. Within the context of the model specification, a green bond premium is present when the constant in the panel regression is negative and significant, which is the case in for model (1). The independent variable (liquidity proxy ΔBA) is insignificant, showing that the matching procedure performed adequately at controlling for the effect of liquidity on bond yields. Following the weak relationship of the only control variable, the R^2 of the model specification is low. This finding is not consistent with the findings of Zerbib (2018), who shows that a 1% increase in liquidity spreads between a green bond and conventional bond leads to a -9.88 basis points decrease in green bond yield spread.

Following the definition of Zerbib (2018), the green bond premium $(\widehat{Premium_i})$ is the sum of the regression constant ($\varepsilon_{i,t}$) and the time-fixed effect of the regression (p_i). Due to the use of a time-fixed effect, the dataset collapses into a cross-section containing data on the 95 matched bond triplets. Table 6 shows distribution of the predicted, bond-specific green bond yield spreads $(\widehat{Premium_i})$. Large variation in green bond yield spreads is documented, indicating that not all green bonds are priced at a premium by investors. Table 6 shows that the average green bond premium in the sample is equal to yield spread of -23.2 basis points.

Table 6: Distribution of the estimated green bond premium

Green Bond Premium $(\widehat{Premium_i})$							
Min.	25th Percentile	Median	Mean	75th Percentile	Max.	Std. Dev.	N
-2.231	-0.463	-0.148	-0.232	0.083	1.376	0.597	95

Note: This table summarizes the green bond premia per green bond. The premium is defined as the fixed-effect of the step 1 panel regression ($Yield\ Spread_{i,t} = Premium_i + \beta \Delta Liquidity_{i,t} + \varepsilon_{i,t}$).

I perform a subsample analysis in order to assess whether the variation in the estimated premia is constant across subsamples. Table 7 shows the results of this analysis. For most subsamples both the mean and median green bond spreads are negative, providing evidence for the existence of a

green bond premium across sector, rating, and currency subsamples. A test for skewness and kurtosis confirms the suspicion that the sample of green bond premia is not normally distributed. As a non-parametric alternative, the Wilcoxon signed-rank test is used to assess whether the green bond premium is significantly different from zero. This test is only conducted for subsamples larger than 10. Varying degrees of significance for all but the subsample of non-rated bonds are found.

Table 7: Sub-sample analysis of green bond premia

	Mean	Median	*Premium ≠ 0*	No. GB
Total	-0.232	-0.148	***	95
Sector				
Consumer Discretionary	0.144	-0.016		4
Energy	-2.232	-2.232		1
Financials	-0.236	-0.149	***	67
Government	-0.258	-0.477		3
Technology	-0.144	-0.144		2
Utilities	-0.198	-0.019		18
Currency				
CHF	0.147	0.147		1
EUR	-0.179	-0.148	***	43
GBP	-0.65	-0.65		1
INR	-2.172	-2.172		1
NOK	-0.027	-0.027		1
SEK	-0.145	-0.24	*	10
USD	-0.268	-0.133	**	38
Rating				
AA	-0.326	-0.237	**	14
A	-0.131	-0.149	*	31
BBB	-0.386	-0.145	**	17
NR	-0.161	-0.023		30

Note: This table summarizes the mean and median green bond premium for several market segments and sub-samples. For segments with 10 or more observations the significance at which H_0: $premium_i = 0$ is rejected, and the number of observations in the subsample. The test used is the Wilcoxon signed-rank test and is only performed for subsamples with N ≥ 10. * p<0.1; ** p<0.05; *** p<0.01

6.2 The disclosure hierarchy

The next step of the analysis aims to identify the causes of the variation of the green bond premium identified in step 1. In line with the disclosure hierarchy (H2), I expect that bonds with more non-

financial disclosure are valued more by investors, resulting in lower yield spread (a larger green bond premium). Therefore, I specify a model including a bond's disclosure score in order to determine to what extent bond non-financial disclosure causes the size of the green bond premium.

Zerbib (2018) hypothesizes that similar to liquidity, the green bond premium varies with bond risk. In order to explain the variation in green bond premia as fully as possible, and to isolate the effect of bond non-financial disclosure, bond pricing characteristics are also included in the model alongside the DISC variable. The model includes the following variables in the model specification: credit rating, maturity, issue amount, currency, and issuer sector. Model (2) explains the variation in the green bond premium:

$$\widehat{Premium}_\iota = \alpha + \beta_1 DISC_i + \beta_2 Maturity_i + \beta_3 \ln(IssueAmount_i) + \gamma_1' Rating_i + \gamma_2' Currency_i + \gamma_3' Sector_i + \varepsilon_i \quad (2)$$

$\widehat{Premium}_\iota$ is the unobserved bond-specific effect of the fixed-effects panel regression with green bond yield-spread as dependent variable. $DISC_i$ is the rating of green bond non-financial disclosure, $Maturity_i$ and $IssueAmount_i$ are the bond's maturity and issue amount. $Rating_i$, $Currency_i$, and $Sector_i$ are vectors of dummy variables capturing the bond's credit rating, the currency of the issuance, and issuer sector, respectively. ε is the error term. Table 8 provides a detailed description of the independent variables in model (2). In order to reduce the likelihood of an artificially high R^2, the analysis excludes any observations with a subsample smaller than from the analysis. Because of this the model only includes bonds denoted in EUR, USD, and SEK, and rated within the brackets AA, A, BBB, and NR. Bond issuers in the sample are active the sectors financial, consumer goods, government, and utilities.

Table 8: Overview of independent variables in model 2

Variable	Unit	Description
Issue Amount	billion USD	The bond's issue amount denoted in USD
Maturity	Years	The maturity of the bond denoted in years (i.e. maturity of 5 years and 6 months is 5,5)
Rating	Dummy	Variable denoting the rating of the green bond as indicated by the Bloomberg composite rating. Ratings are rounded within each bracket (i.e. Dummy "A" includes A+, A, and A- rated bonds). Sample contains AA, A, BBB, and Non-Rated bonds. The baseline is AA rated bonds.
Currency	Dummy	Currency in which the bond is issued. Sample contains EUR, SEK, and USD bonds. EUR is the baseline.
Sector	Dummy	Industry sector in which the bond issuer is active. Sample contains bonds issued within consumer goods, energy, financial institutions, government, technology, and utilities sectors. Baseline is utilities
DISC	Scale 0 - 4	Scale variable summing the amount of supporting green disclosure documentation recorded for the green bond.

Table 9 shows the results of the analysis. A Breusch-Pagan provides evidence for the presence of heteroskedasticity within the specification. Therefore, table 9 reports robust standard errors. An overview of all tests performed is provided in the appendix (table A6). The resulting sample contains 88 observations. The youth of the green bond market limits the number of observations, and therefore the explanatory power of the model. This effect is amplified by the stringent matching criteria, due to which only 16.3% of the bonds initially contained in the environmental finance database are successfully matched to two conventional bonds. This large reduction in sample size might cause a sample selection bias, which is accounted for by conducting a Heckman analysis.

Specification (1) and (2) only include traditional bond pricing determinants. Specification (3) adds the disclosure score as a scale variable. A highly significant negative relationship is identified, providing evidence for the hypothesis that more green bond non-financial disclosure leads to a higher green bond premium. Specifically, a one-step increase in DISC increases the green bond premium by -24 basis points. Specification (4) splits this rating into several indicators, using a DISC rating of 0 as the baseline. Additionally, specificaion (4) shows no significant difference between the premium of bonds with a disclosure score of 0 and 1. However, the next two steps along the hierarchy lead to significantly higher green bond premia, with a premium of -62 basis points and -95 basis points for scores of 2 and 3, respectively. the final step of the DISC variable leads to a lower green bond premium than identified for the previous step.

Table 9: Results of step 2 regressions

	Dependent variable: $\widehat{premium}_i$			
	(1)	(2)	(3)	(4)
ln Amount	0.01	-0.02	-0.00	-0.01
	(0.13)	(-0.35)	(-0.09)	(-0.27)
Maturity	0.01	0.02	0.01	0.00
	(0.82)	(1.17)	(0.57)	(0.18)
Rating A	0.30	0.33*	0.38**	0.35*
	(1.64)	(1.69)	(2.02)	(1.83)
Rating BBB	0.16	0.22	0.11	0.05
	(0.68)	(0.85)	(0.45)	(0.20)
Rating NR	0.37**	0.33*	0.36*	0.32*
	(1.99)	(1.80)	(1.98)	(1.69)
USD		-0.21	-0.28*	-0.25*
		(-1.40)	(-1.95)	(-1.73)
SEK		-0.17	-0.23	-0.20
		(-1.03)	(-1.35)	(-1.15)
Sector Financial		0.13	0.24	0.22
		(0.63)	(1.39)	(1.25)
Sector Government		0.23	0.42	0.42
		(0.76)	(1.61)	(1.64)
Sector Consumer Discretionary		0.51	0.53	0.49
		(1.52)	(1.52)	(1.32)
DISC			-0.24***	
			(-2.67)	
DISC = 1				-0.32
				(-0.86)
DISC = 2				-0.62**
				(-2.45)
DISC = 3				-0.95***
				(-2.73)
DISC = 4				-0.78**
				(-2.51)
Constant	-0.30	-0.23	0.14	0.39
	(-0.90)	(-0.46)	(0.31)	(0.77)
Observations	88	88	88	88
R^2	0.061	0.106	0.210	0.235
Adjusted R^2	0.004	-0.011	0.096	0.089
F-statistic	1.05	0.95	1.78	1.49

Note: Table shows the results of the 2nd step regressions. Specifications (1) and (2) attempt to explain the green bond premium through bond characteristics. Specification (3) adds the variable DISC as a rating of the amount of green documentation the bond has disclosed. Specification (4) adds dummies for each value of the DISC score, with DISC = 0 as baseline. Amount is in millions and denoted in USD. Maturity is in years. Rating, currency, and sector are dummy variables with AA, EUR, and Utilities as baseline, respectively. Robust standard errors are reported.
t statistics in parentheses, * p<0.10, ** p<0.05, *** p<0.01

In contrast to Zerbib (2018), who shows that the green bond premium is more pronounced for financial and low-rated bonds, the results indicate no logical relationship between bond rating and green bond premium. A and non-rated bonds exhibit a significantly lower green bond premium compared to the baseline of AA rated bonds. Additionally, issuers of USD denominated green bonds face yields that are 25 basis points lower than EUR denominated green bonds. This effect is not observed for BBB rated bonds, leading to the conclusion that the observed effects are due to sampling size rather than a structural effect.

The inclusion of the disclosure variable constitutes a significant improvement over previous model specification. Indeed, including the variable leads to a significant improvement in the overall fit of the model. The model finds some evidence for hypothesis two, as specification (3) shows that the green bond premium increases with -24 basis points for each step in DISC score. However, model (4) shows that this significant relationship is only significant for the final three steps of the disclosure score. Additionally, the final step (DISC = 4) leads to a 17 basis points lower overall green bond premium than the previous step. The inclusion of the individual green bond disclosures as independent variables will provide more insight into this relationship.

6.3 Determinants of the green bond premium

According to table 9, the green bond premium varies significantly with the amount of non-financial disclosure of the green bond. In order to identify the effects of specific types of non-financial disclosure on green bond yield spreads I specify a new model. Rather than constructing a disclosure score (DISC) the model includes the types of disclosure as separate indicator variables and creates model specifications in line with the disclosure hierarchy (figure 2). The regression equation of model (3) is:

$$\begin{aligned}\widehat{Premium}_i = {} & \alpha + \beta_1 GBP\ Aligned_i + \beta_2 SPO\ Issued_i + \beta_3 Assurance\ Provided_i \\ & + \beta_4 CBI\ Certified_i + \beta_5 Maturity_i + \beta_5 \ln(Issue\ Amount_i) \\ & + \gamma_1' Rating_i + \gamma_2' Currency_i + \gamma_3' Sector_i + \varepsilon_i\end{aligned} \quad (3)$$

The control variables are the same between models (2) and (3), with the difference between the models being the split of the variable DISC into its constituents: GBP Aligned, SPO Issued, Assurance Provided, and CBI Certified.

Table 10 reports the results of this analysis. Robust standard errors are reported to account for the presence of heteroskedasticity. An overview of all tests is provided in the appendix (table A6). Specification (1) finds no evidence for hypothesis 3. In a sample consisting of 74 GBP aligned and 14 unaligned green bonds, alignment with the GBP has no significant explanatory power over the green bond premium.

Specification (2) adds the effects of external review to the model, which is a significant predictor of the green bond premium (H4.1). When external review is introduced in the model the constant becomes significant with a similar magnitude, implying that bonds issued without such type of review are likely to be issued at a discount, rather than a premium.

Specification (3) tests hypotheses 4.2 and 4.3. In order to account for the effect of having both types of financial documentation, an interaction effect (SPO * Assurance) is introduced. Although marginal, the analysis identifies a -2 basis points difference between assured and SPO bonds. Moreover, the 2nd type of nonfinancial disclosure increases the green bond premium, but to a lesser extent than the first type of documentation. No evidence is identified for hypothesis 5, as the coefficient of CBI certification in specification (4) does not significantly contribute to the green bond premium.

Table 10: Effect of green bond disclosure on green bond premium

	Dependent variable: $\widehat{premium}_t$			
	(1)	(2)	(3)	(4)
Disclosure variables				
GBP Aligned	-0.17	0.19	0.19	0.21
	(-0.78)	(1.10)	(1.07)	(1.22)
SPO Given			-1.11***	-1.12***
			(-4.38)	(-4.44)
Assurance Provided			-1.13***	-1.08***
			(-4.16)	(-4.23)
External Review		-1.13***		
		(-4.54)		
CBI Certified				-0.17
				(-0.78)
SPO * Assurance			0.91***	0.95***
			(3.00)	(2.97)
Constant	-0.07	1.17**	1.11**	1.04**
	(-0.13)	(2.19)	(2.10)	(2.04)
Control variables				
ln Amount Issued	Yes	Yes	Yes	Yes
Maturity	Yes	Yes	Yes	Yes
Rating	Yes	Yes	Yes	Yes
Sector	Yes	Yes	Yes	Yes
Observations	88	88	88	88
R^2	0.116	0.332	0.347	0.353
Adjusted R^2	-0.012	0.225	0.221	0.218
F-statistic	0.94	2.87	2.52	2.53

Note: Table shows the results of the 2nd step regressions replacing *DISC* with dummy indicators for green bond disclosure documentation. These are alignment with the GBP (all specifications), SPO issuance (2), (5), and (6), assurance provision (3), (5), and (6), External Review, defined as either having an SPO or Assurance (4), the interaction effect of SPO and Assurance (5), and (6), and CBI certification (5). All specifications control for amount issued (million USD), maturity (years), credit rating and sector. Robust standard errors are reported. *t* statistics in parentheses. * p<0.10, ** p<0.05, *** p<0.01

7. Robustness checks

The analysis controls for residual liquidity effects by including the difference in liquidity (ΔBA) as a control variable. Unlike Zerbib (2018), the control for liquidity is not significant when analyzing the complete panel of 26,797 bond-day observations. The literature on the effect of bond liquidity on yield spreads finds evidence for the existence of a liquidity premium. This premium is not constant but fades as bond rating increases (Dick-Nielsen et al., 2011). In order to check whether the analysis supports these findings the sample is split into sub-samples by rating. Only subsamples with 10 or more observations are included in the sub-sample analysis, limiting them to four groups: *AA, A, BBB,* and *Non-Rated* bonds.

Table 11: The stability of the green bond premium across rating subsamples

	Dependent variable: $\Delta\hat{y}_{i,t}$			
	Rating AA	*Rating A*	*Rating BBB*	*Rating NR*
ΔBA	1.9723**	1.1663**	-7.6369	8.6668**
	(2.95)	(2.74)	(-1.65)	(2.30)
Constant	-0.1046***	-0.1108***	-0.4425***	-0.2324***
	(-235.63)	(-20187.30)	(-131.47)	(-62.65)
Observations	3354	9472	4787	7665
R^2	0.017	0.023	0.078	0.076
No. groups	14	31	16	30
Avg. obs. Per group	240	306	282	256
F	8.70	7.50	2.71	5.29

Table shows the result of the step 1 regression across rating subsamples. The regression equation is: $\Delta\hat{y}_{i,t} = Premium_i + \beta\Delta Liquidity_{i,t} + \varepsilon_{i,t}$. The panel regression contains 95 groups. Robust standard errors are reported. *t* statistics in parentheses, * p<0.10, ** p<0.05, *** p<0.01

Table 11 shows the results of the subsample analysis. When ΔBA is positive, it implies that the green bond is less liquid than the conventional bond. In turn, this implies that the bond faces more liquidity risk which, if priced by investors in the secondary market, will lower lead to lower bond prices (higher yields). Although this effect does not materialize when analyzing a complete sample, it does show in the subsample analysis. When analyzing specific subsamples, the measure of the green bond liquidity spread becomes significant for all but the BBB subsample, with non-rated bonds showing significantly larger effects due to ΔBA. Although no conclusions can be drawn from the BBB subsample due to its insignificance, table 11 shows a clear distinction

between investment-grade and junk bonds. The move from junk to investment grade reduces the effects of the liquidity premium (Bao et al., 2011; Chen et al., 2007; Dick-Nielsen et al., 2011) and the magnitude of the green bond premium (Zerbib, 2018). The BBB subsample shows that insignificance of the liquidity control may lead to an over-estimation of the green bond premium, as the magnitude of the regression constant is significantly larger. Zerbib (2018) finds that similar to the liquidity premium, the green bond premium decreases for higher-rated bonds. Table 11 shows similar results: the regression constant becomes larger as the rating decreases from AA to BBB.

Table 12: Subsample analysis of green bond premium determinants

	Dependent variable: $\widehat{premium}_i$	
	Rating A	*Rating BBB*
Disclosure variables		
GBP Aligned	0.12	0.37
	(0.75)	(0.83)
SPO Given	-1.29***	-1.60***
	(-4.00)	(-7.61)
Assurance Provided	-0.95**	-1.50***
	(-2.57)	(-5.05)
CBI Certified	-0.01	-0.46
	(-0.06)	(-0.51)
SPO * Assurance	0.74*	0.00
	(1.86)	(.)
Constant	-0.92	-5.12
	(-0.55)	(-1.46)
Control variables		
ln Amount issued	Yes	Yes
Maturity	Yes	Yes
Sector	Yes	Yes
Observations	31	16
R^2	0.757	0.776
Adjusted R^2	0.636	0.441
F	21.23	2.32

t statistics in parentheses
* p<0.10, ** p<0.05, *** p<0.01

The sub-sample analysis is carried forward into the second step in order to see whether the findings are consistent in an analysis of model (3) specification (4). The second step of the analysis is only reported for the A and BBB subsamples, as these are the only model specifications with significant results. Table 12 shows the results of this analysis, in which similar magnitudes and levels of

significance for the non-financial disclosure indicators are shown. The interaction between SPO and Assurance is excluded from the BBB subsample, as none of the 16 bonds in this subsample are issued alongside both types of documentation. In line with the findings of Zerbib (2018), the subsample analysis documents that the effect of non-financial disclosure as a determinant of the green bond premium increases as credit rating decreases, as the coefficients become more negative when moving from the A to the BBB sample.

Another important consideration for the robustness of the analysis is the potential presence of a sample selection bias due to the limited amount of bonds in the final analysis. The dataset which records the green bond non-financial disclosure contains 536 issuances of green bonds. The analysis is conducted on a sample of 88 bonds. This filtering can occur at three distinct points when constructing the dataset and conducting the analysis. First, only bonds for which pricing information is available in Bloomberg are included in the sample for the analysis. Pricing information is only available for 221 of the bonds from the original sample. Second, the matching procedure requires that each of the remaining bonds is matched to two conventional bonds according to stringent criteria. Due to this procedure, only 95 bonds of the 221 bonds with yield spread and bid-ask spread information available can be matched. Lastly, the model excludes any groups for which less than three observations are available in order to reduce artificially inflating model fit, further reducing the sample size to 88. If sample selection bias is present, then the findings of the analysis cannot be generalized, as they only pertain to a limited (selected) part of the population. In order to check for the presence of sample selection bias, I perform a Heckman two-step analysis (Heckman, 1979).

The Heckman analysis is based on constructing a measure of sample selection bias. This measure is known as the inverse Mills ratio or Heckman's lambda. The analysis is conducted using the original sample of 536 issuances. A binary variable (*insample*) is constructed measuring whether the observation is one of the 88 bonds included in the final analysis. Determinants of inclusion are specified in a probit regression. From the estimates of this regression, the inverse-mills ratio (lambda) is generated. Evidence for the presence of sample selection bias is present if lambda is significantly different from zero. The results of the calculation of lambda are shown in the appendix (Table A5). A chi-squared test indicates that lambda is not significantly different from zero, providing no evidence on the presence of sample selection bias.

Table 13: Results of the model 3 with correction for sample selection bias

	$\widehat{Premium}_i$
Constant	-1.93
	(-0.30)
Maturity	-0.01
	(-0.37)
ln Amount	0.08
	(0.40)
Rating	
A	0.15
	(0.77)
BBB	0.08
	(0.23)
NR	0.09
	(0.20)
Currency	
USD	-0.26
	(-0.70)
SEK	-0.09
	(-0.30)
Sector	
Financial	0.81
	(0.58)
Government	0.41
	(0.84)
Consumer Discretionary	0.66
	(0.86)
Disclosure	
GBP Aligned	0.02
	(0.05)
SPO Given	-0.91**
	(-2.15)
Assurance Provided	-0.97***
	(-3.35)
CBI Certified	-0.22
	(-0.76)
SPO * Assurance	0.81**
	(2.21)
Sample Selection	
Lambda (λ)	0.95
	(0.53)
Observations	88
R^2	0.322
F	2.08

Table shows the results of a two-step regression determining the green bond premium, including a correction for sample selection bias (λ). *t* statistics in parentheses. * p<0.10, ** p<0.05, *** p<0.01

The second step of the Heckman two-step procedure involved includes lambda in the original model specification. Model (3), specification (4) is chosen for the analysis. Table 13 shows the results of this analysis. Although the regression constant is no longer significant, the signs and significance of the non-financial disclosure measures are still similar to that of the original model specification. Moreover, the sample selection bias indicator lambda is not significant in explaining variation in green bond premia. Therefore, the analysis does not suffer from sample selection bias.

The final robustness check pertains to the efficiency of the fixed-effects estimator used in model (1). A fixed effects model is specified in order to determine a bond-specific, time-fixed green bond premium. In order to check the efficiency of the fixed-effects estimator, I perform a Hausman specification test (table A3). As the resulting critical value of 0.099 is above the cut-off for using a fixed-effects estimator, a random effects model is specified to identify whether the findings from the analysis are robust to a different model specification.

In order to specify a random effects model, I construct a panel dataset with the yields of the green bonds and closest conventional bond (CB1) over time as the dependent variable. The bid-ask spreads of each bond, as well as bond maturity, are included as independent variables. Issue amount is not included as a control for bond liquidity is already included through the bid-ask spread. A dummy variable which is equal to 1 if the bond is a green bond and 0 if the bond is CB1 captures the green bond premium. The model indicator variables for bond rating (4), currency (6), sector (5), and issuer (123).

Table 14 shows the results of the random-effects specification. After controlling for bond-risk characteristics, sector, and issuer, the model shows that green bond yields are on average -28 basis points lower than those of similar conventional bonds. The premium is higher than the -23.2 basis points premium identified under the fixed-effects estimator, which implies that the fixed-effects estimator used for the analysis might understate the green bond premium.

Table 14: Results of random effects model specification

	Bond Yield
Green Bond	-0.28**
	(-2.47)
Bid-Ask Spread	-5.95
	(-1.08)
Maturity	0.16***
	(3.37)
Constant	0.19
	(0.40)
Controls	
Rating	Yes
Currency	Yes
Sector	Yes
Issuer	Yes
Observations	56,257
R^2 *(Overall)*	0.957
χ^2 *(df=139)*	2739.57

Note: Table shows the results of a random-effects panel regression of a panel of bond yields. Breusch-Pagan Lagrange Multiplier confirms the efficiency of the random effects estimator. Regression contains 205 groups with an average of 274 observations per group. The dependent variable is bond yield. Green bond is a factor indicating green bonds. Bid-Ask Spread is the bid-ask spread of a bond. Maturity is denoted in years. Controls contain 4, 6, 4, and 111 factor variables for rating, currency, sector, and issuer, respectively. Robust standard errors are reported. *t* statistics in parentheses.* p<0.10, ** p<0.05, *** p<0.01

8. Discussion

The first step of the analysis identifies that investors are willing to sacrifice 23.2 basis points of yield in order to invest in green bonds over otherwise similar conventional bonds. Hypothesis 1, the existence of the green bond premium, is supported. The premium is significantly larger than the -2 basis points premium identified by Zerbib (2018). Both studies account for the main determinants of a bond's price: the risk-free rate (by analyzing the yield spread), the probability of default (by matching based on credit scores), and other bond characteristics. The liquidity effect is captured by matching based on issue date and issue amount, and by controlling for the difference in the bond's bid-ask spread. Although both studies employ similar matching methodologies to determine the green bond premium, they differ in one distinct regard: Zerbib (2018) only matches green bonds with conventional bonds of the same issuer. In doing so, all pricing determinants of the bond are controlled for and the premium identified is solely due to environmental preferences. The large differences in the premia identified suggest that the premium identified in this paper captures bond-risk characteristics as well as the environmental preferences.

The negative green bond premium identified in this paper emphasizes the considerable buying pressure on green bonds, where demand is larger than supply (CBI, 2018a). The demand for green bonds is driven by environmental preferences as identified by Zerbib (2018), who finds that the non-financial, values-driven green bond premium is -2 basis points. A potential explanation of the remaining premium identified in this study is therefore that part of the green bond premium is driven by financial motives. In other words, investors assess a green bond to bear less risk than an otherwise similar conventional bond. The greenness of a bond can be seen as a determinant of bond-risk which is not captured by traditional bond pricing determinants. High environmental performance leads to better credit ratings and reduces a company's default risk (Jiraporn et al., 2014). However, credit rating agencies imperfectly capture this effect (Oikonomou et al., 2014). Sun and Cui (2014) identify a possible relationship between assets with a low environmental impact and decreased firm risk. The findings in this study suggest that credit ratings do not capture all environmental risks. However, these risks are priced by investors in the secondary market, allowing for the existence of a green bond premium.

Although the measure for residual liquidity is insignificant in the general analysis, a sub-sample analysis identifies a positive relationship between bond liquidity spreads and yield spreads. If the

green bond is less liquid than the matched synthetic bond, investors will demand a larger liquidity premium for the green bond compared to the conventional bond, driving up the yield spread between the green and conventional bond.

The next step of the analysis finds evidence for the effect of green bond non-financial disclosure on the size of the green bond premium (H2): as bond non-financial disclosure increases the green bond premium increases. As the amount of green bond non-financial disclosure increases from zero to four, the bond-specific green bond premium increases with -24 basis points per step. Green bonds with a higher amount of non-financial disclosure convey more information concerning greenness to the investor compared to conventional bonds. The reduction in information asymmetry provides the investor with more certainty concerning the greenness of the investment. This reduction in information asymmetry is highly sought after by investors, creating downward pressure on bond prices. This effects is only present for three steps along the disclosure score and is not linearly distributed. Therefore, this study analyzes the impact of the specific types of non-financial disclosure.

The Green Bond Principles (H3)

This paper identifies no significant differences between the green bond premium of GBP aligned bonds and non-aligned green bonds when controlling for traditional bond pricing determinants. The voluntary nature of alignment with the GBP, which mostly recommends practices rather than requires them (ICMA, 2018), is easy to replicate by issuers of a green bond of lesser quality. Indeed, issuers are free to label their bond as GBP aligned without any form of external verification. Because of this, alignment with the GBP cannot be seen as a credible signal and therefore has no effect on bond pricing.

External Review (H4)

The analysis idenfifies some support for hypothesis 4. External review, defined as either second party opinion issuance and assurance provision significantly increases bond yield spreads, confirming the relevance of these information intermediaries in reducing information asymmetry in the secondary market. The effects of SPO issuance and assurance provision on bond yield spreads are -112 and -113 basis points, respectively. Hypothesis 4.2 is supported, but this paper only identify only partial support for hypothesis 4.3. Despite being statistically significant, the

difference between both types of external review is marginal and changes across model specifications. Although industry practitioners find that a legally binding assurance engagement constitutes a stronger commitment (and signal) than SPO issuance, no evidence is identified that investors price this stronger commitment in the secondary market. Instead, the results of this study show that these types of external review serve a similar purpose and investors price them as such. Either type of external review explains a similar amount of variation in the green bond premium. Issuing a bond with both versions of external review does increase the green bond premium by several basis points, but the marginal effect is significantly smaller than that of the first document's issuance (-21 basis points on average).

The inclusion of external review in the model specification leads to the regression constant becoming significant and positive. Given the constant, a bond issued alongside an SPO is traded at a premium of - 8 basis points in the secondary market, while assured green bonds trade at a premium of – 4 basis points. Moreover, bonds issued *without* any form of external review face a green bond discount. In other words: bonds that label themselves as green but provide no source of external verification of this greenness are seen as riskier than otherwise similar conventional bonds. Because of this perceived riskiness, external review is an important signal to investors willing to invest in green bonds.

Certification (H5)

This study finds no support fo hypothesis 5. The green bond premium does not significantly change for certified green bonds when controlling for other determinants in the secondary market. This finding stands in contrast to the findings by Flammer (2018), who finds that firms issuing certified bonds enjoy higher (non-)financial KPIs post-issuance. The limited body of work into the effects of green bond certification also identifies greater ownership by long-term investors (Baker et al., 2018; Flammer, 2018). A difference between these analyses and the findings in this study is that they do not account for other green bond non-financial disclosures. As CBI certification requires external review, it is possible that external review already captures the pricing effects of CBI certification in the analysis. In this regard, the methodology in this paper attempts to identify an additional labeling effect over that of the external review but fails to identify any relationship. According to the analysis in this study, no additional pricing effect of CBI certification exists over the effect already priced by external review

9. Implications and limitations

The existence of a green bond premium shows that the demand for green bonds is greater than supply. For investors, this means that satisfying environmental preferences come at a cost. This cost increases as the traceability of the greenness of a bond increase. Green bonds do not appear to be a tool for greenwashing, as the high demand for green bonds is only present for bonds with at least some form of external review.

For issuers, the existence of a premium implies that investor environmental preferences are not only linked to the performance of a company but are also linked to a bond's use of proceeds. Issuers armed with this knowledge can distinguish sustainable and unsustainable operations within their company, which should help attract capital as the company transitions to a sustainable business.

The importance of external review is also noted, as investors only value green bonds over conventional bonds when an external party reviews them. The lack of a difference among the types external review implies that bond issuers may achieve similar results when issuing a bond alongside a second party opinion, rather than a full assurance engagement. External review costs range from $10,000 to $50,00 depending on the type, intensity, and issue amount (Baker et al., 2018), with second party opinion provision on the lower end of the scale. An issuer would be best suited to opt for the least intensive form of external review, the second party opinion, if investors do not value these differently. This cost analysis also carries into the addition of CBI certification, which costs $1/10^{th}$ of a basis point per bond (CBI, 2018a). Albeit small, the results of this paper indicate that this additional cost does not have any effect on investor perception of the bond's value.

Policymakers can utilize the untapped potential of the green bond market to incentivize sustainable development. The existence of a green bond premium is evidence of excess demand for green bonds. Policymakers can incentivize green bond issuance through, for instance, fiscal incentives. When doing so, it should focus on externally reviewed bonds. The European Union is already starting to do so by introducing the EU green bond standard, which requires external review (EU HLEG, 2018).

Within the body of academic literature concerning the pricing of green bonds, this study is the first to identify that green bond non-financial disclosure is a main determinant of the green bond

premium. Contrary to the greenwashing argument proposed by Flammer (2018), investors are only willing to pay a premium for a bond that differentiates itself as green rather than merely paying for a label in order to satisfy constraints levied by stakeholders. Two other complimentary studies were conducted using the dataset constructed in this paper. The other studies analyze shareholder's appreciations of green bond non-financial disclosure. In line with the results of this paper, the results indicate that the equity market rewards firms that credibly signal environmental commitment by issuing a green bond alongside bond non-financial disclosure. The combined findings of these studies indicate that investors (equity and debt) value the extent to which the green credentials of a bond can be verified and provide evidence against the greenwashing hypothesis.

The most significant limitation to the findings in this study is that due to a lack of data availability the sample size used for the analysis is limited, out of the 516 bonds that received a DISC score, only 95 are used in the analysis determining the green bond premium, and 88 are used for the following cross-sectional regression. Although the total issue amount of the sample of 95 bonds still constitutes 16.64% of all funds raised through green bond issuance by corporations and financial institutions since the inception of the green bond market, the significant amount of observations not included in the analysis is cause for concern. Due to the youth of the green bond market, there is less information available. Unless the U.S. municipal market is studied (Baker et al.. 2018; Karpf and Mandel (2018); Partridge and Madda, 2018), the samples used are comparable to the sample size of the analysis in this paper. The first step of the methodology in this paper is modeled after the methodology of Zerbib (2018). When attempting to explain the determinants of bond-specific variation, Zerbib (2018) uses a sample of 92 green bonds. The sample sizes of other studies into green bond pricing are: 30 (HSBC, 2016), 12 (Bloomberg, 2017), 21 (Ehlers and Packer, 2017), 14 (CBI2017), and 133 (NN Investment Partners, 2018)

To further address the concern for the presence of sample selection bias, a Heckman two-step procedure is performed in order to identify systematic differences between the sample of 516 bonds with a DISC score and the 95 bonds ultimately used for the analysis. Although the sample is biased towards several ratings and sectors, the insignificance of Heckman's Lambda leads to the conclusion that there is no concern for sample selection bias.

A second limitation of this study is that the channel through which the green bond premium is allowed to exist is not fully isolated. Zerbib (2018) isolates non-financial motivations by matching bonds by the same issuer. Since the methodology in this paper matches based on industry, the increased magnitude in the green bond premium compared to the findings of Zerbib (2018) may be due to risk characteristics which are not fully captured by other pricing controls.

The results of this paper lead to several exciting avenues for future research. Adding to the findings of this paper a study investigating the ownership structure of green bonds related to the bond's non-financial disclosure may prove insightful. Do all investors in green bonds value non-financial disclosure equally? Additionally, green bond-nonfinancial disclosure is more homogeneous than the disclosure hierarchy proposed by this paper. For instance, a distinction can be made between limited and reasonable assurance, as well as between the varying intensities of second party opinions. Such a distinction would allow for further differentiation between the quality of green bonds.

Next, the slowing growth of green bond issuances might hint at market saturation, although the green bond premium is evidence for excess market demand. A primary market analysis of externally reviewed green bonds and their oversubscription rate might identify the growth potential of the market. This paper is the first to distinguish among green bonds by introducing bond non-financial disclosure as a measure of bond quality. Quantifying the effects of green bond non-financial disclosure in the primary market, including the costs of non-financial disclosure, will identify the implications of issuing such a bond for bond issuers.

All research into the green bond market has maintained a broad definition of green bonds. Research into the difference between issuing a green bond with and without external review on the firm (non-)financial KPIs and stock prices may further emphasize the importance of external review. As the market continues to mature and more data becomes available, it will be easier to use more selective definitions of a (high quality) green bond. Lastly, the findings of this study can be extended to include social and sustainability bonds.

10. Conclusion

At a time where the risks of pollution and global warming are becoming increasingly urgent, green bonds are an attractive instrument to foster environmentally friendly investment. This paper is part of a collaborative project which aims to identify whether green bonds can be a tool to finance a sustainable future, or whether they are prone to greenwashing. The studies find that, contrary to the greenwashing argument, debt and equity investors value the extent to which the credentials of a green bond can be traced and do not merely invest in green bonds to satisfy investment constraints.

In this paper, a matching procedure is used to match a green bond to two otherwise similar conventional bonds. From these matched bonds a synthetic conventional bond is created with the same maturity as the green bond. Evidence for the existence of a green bond premium is provided by analyzing the yield differential between the green and synthetic conventional bond after controlling for residual bond liquidity. The green bond premium is shown to be equal to -23.2 basis points. Investor environmental preferences and financial (risk) characteristics which are imperfectly captured by bond credit ratings drive this premium.

In order to show how the magnitude of the green bond premium relates to the amount of green bond non-financial disclosure, three researchers charted the landscape of bond non-financial disclosure. The result is a proprietary database which categorizes green bonds based on the quality of their disclosure documentation. To the best knowledge of the author, this is the first time that this type of categorization had been applied to the green bond market.

This study identifies the existence of a green bond non-financial disclosure hierarchy which consists of four types of disclosure, namely: alignment with the Green Bond Principles, issuance of a second party opinion, assurance provision, and CBI certification The amount of non-financial disclosure is shown to be a significant determinant of the height of the -23.2 basis points green bond premium. For each additional type of disclosure, the green bond premium increases by -24 basis points. This effect is not linearly distributed, but dependent on the specific types of bond non-financial disclosure. The study shows that external review (SPO issuance and assurance provision) are the critical determinants of a green bond premium. Indeed, issuing a bond without external review greatly increases the likelihood of a green bond discount (i.e., higher yield spreads).

Due to their voluntary nature, alignment with the Green Bond Principles does not cause a change in green bond premium. The labeling effect of CBI certification does not contribute to the height of the premium.

This paper has several implications. The results show that issuers are willing to forego yield in order to invest in green bonds, but only if the greenness of the bond verified by an external party. The existence of the green bond premium is an indication of excess demand for green bonds. If policymakers wish to stimulate sustainable investment, they could do so by fostering green bond issuance through, for instance, fiscal incentives for issuers of externally verified green bonds.

The main limitations of this paper can be attributed to data: due to the youth of the market for green bonds the sample size of the analysis is small. Due to limited availability of data on bond non-financial disclosure green bonds are matched within the same industry, but not to the same issuer. The data limitations are mitigated by conducting a Heckman analysis and finding no evidence of sample selection bias and by showing that the sample, although small, is representative of the larger green bond market. Due to the stringent matching criteria, it is not possible to fully isolate pro-environmental preferences.

Further research into the topic could investigate the way varying types of investors value bond non-financial disclosure. Building on this study, additional studies can deepen the categorization of green bond non-financial disclosure. Other studies into green bonds and pricing can be recreated using a narrower definition of green bonds while taking into account the effects of external review. Lastly, a primary market study in bond oversubscription might indicate the size of the demand surplus in the green bond market and indicate the market's growth potential.

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Appendix

A1: Overview of green bond guidelines

	Green Bond Principles	Climate Bond Standard	EU Green Bond Standard
Creator	International Capital Market Association (ICMA); a group of over 50 large financial institutions	Climate Bond Initiative (CBI); an international investor-focused non-profit organization	EU High-Level Expert Group (HLEG) on Sustainable Finance
First published	2014	2014	Introduced in 2017, expected to be implemented in 2019
Aim	To promote integrity in the development of the green bond market	To provide the green bond market with trust and assurance	To create more trust and confidence in sustainable and green products
Voluntary Compliance	Yes	Yes, but required if the issuer wants to attain CBI certification	No, required if the issuer wants to use "EU Green Bond Label"
Project Eligibility	Projects must fall under one of the broad green categories	Projects must fall under detailed 'Climate Bonds Taxonomy'	Projects must fall under detailed 'EU Sustainability Taxonomy'
Sector-specific Criteria	No	Yes, projects must meet Sector-specific Criteria	Yes (to be created)
Post-issuance Reporting	Recommended, annually	Required, annually	Required, annually
External Verification	Recommended	Required to receive certification	Required to receive certification
Publication External Review	Recommended	Required if stated in national laws, otherwise recommended	Required
Accreditation Requirements for Reviewers	No	Yes	Yes
Sources	(EU HLEG, 2018)	CBI (2018)	(EU HLEG, 2018)

A2: Overview of External Review options

	Second Party Opinion	Assurance	Certification
Actors	Firms with environmental expertise	Audit firms or specialized environmental verifiers	Climate Bonds Initiative and CBI verified "verifiers" of Climate Bonds Standard alignment
Assessment scope	Assessment of sustainability of use of proceeds	Assessment of pipeline and robustness of issuance framework	Compliance with certification requirements by the verifier
Note			Verifier assess both sustainability and pipeline/framework

A3: Tests of model 1

	$Panel: \Delta\widehat{y_{i,t}} = Premium_i + \beta\Delta BA_{i,t} + \varepsilon_{i,t}$			
	Test	Statistic	P-Value	Conclusion
Fixed vs. Random effect	Hausman	2.71	0.099	Random effect
Auto correlation	Wooldridge	29.792	0.000	Serial correlation
Heteroscedasticity	Breusch-Pagan	$7.1 * 10^6$	0.000	Heteroscedasticity

A4: Distribution of DISC score

	DISC					
	0	1	2	3	4	Total
Frequency	8	10	55	10	5	88
Percentage	9.1	11.36	62.5	11.36	5.68	100

A5: Tests of model 2

		Dependent variable: $\widehat{Premium}_i$			
		(1)	(2)	(3)	(4)
Heteroskedasticity					
Breusch-Pagan	P-Value	0.13	0.057	0.23	0.16
Multicollinearity	VIF				
ln Amount		1.211	1.63	1.63	1.73
Maturity		1.032	1.84	1.93	2.24
Rating					
Rating A		2.15	2.11	2.13	2.23
Rating BBB		1.99	2.00	2.06	2.26
Rating NR		1.69	2.23	2.24	2.35
Currency					
USD			1.39	1.43	1.50
SEK			1.62	1.63	1.64
Sector					
Financial			2.44	2.53	2.56
Government			1.59	1.63	1.63
Consumer			1.60	1.60	1.62
DISC				1.52	
DISC = 1					2.38
DISC = 2					4.78
DISC = 3					2.71
DISC = 4					2.25
Mean VIF		1.61	1.84	1.85	2.28

Note: This table shows the results of all tests performed of model 2. Regression equation: $Premium_i = \alpha + \beta_1 DISC_i + \beta_2 Maturity_i + \beta_3 \ln(IssueAmount_i) + \gamma_1' Rating_i + \gamma_2' Currency_i + \gamma_3' Sector_i + \varepsilon_i$

A6: Tests of model 3

		Dependent variable: $\widehat{Premium}_i$			
		(1)	(2)	(3)	(4)
Heteroskedasticity					
Breusch-Pagan	P-Value	0.066	0.14	0.099	0.12
Multicollinearity	VIF				
ln Amount		1.63	1.65	1.74	1.74
Maturity		1.87	2.45	2.47	2.52
Rating					
Rating A		2.11	2.11	2.14	2.24
Rating BBB		2.15	2.23	2.30	2.50
Rating NR		2.25	2.27	2.28	2.35
Currency					
USD			1.39	1.54	1.84
SEK			1.63	1.66	1.69
Sector					
Financial			2.47	2.48	2.55
Government			1.60	1.60	1.60
Consumer			1.60	1.62	1.65
DISC					
GBP Aligned		1.27	1.56	1.56	1.59
External Review			2.60		
SPO Issued				5.16	5.17
Assurance Provided				4.88	5.12
SPO * Assurance				3.52	3.59
CBI Certified					1.68
Mean VIF		1.82	1.98	2.53	2.54

Note: This table shows the results of all tests performed of model 2. Regression equation: $\widehat{Premium}_i = \alpha + \beta_1 GBP\ Aligned_i + \beta_2 SPO\ Issued_i + \beta_3 Assurance\ Provided_i + \beta_4 CBI\ Certified_i + \beta_5 Maturity_i + \beta_5 \ln(Issue\ Amount_i) + \gamma_1' Rating_i + \gamma_2' Currency_i + \gamma_3' Sector_i + \varepsilon_i$

A5: Results step 1 of the Heckman procedure

	$Premium_i$	
Constant	-1.93	(-0.23)
Maturity	-0.01	(-0.27)
ln Amount	0.08	(0.30)
Rating		
A	0.15	(0.48)
BBB	0.08	(0.16)
NR	0.09	(0.15)
Currency		
SEK	-0.09	(-0.21)
USD	-0.26	(-0.52)
Sector		
Consumer Discretionary	0.66	(0.65)
Financial	0.81	(0.45)
Government	0.41	(0.61)
Disclosure		
GBP Aligned	0.02	(0.03)
SPO Given	-0.91	(-1.54)
Assurance Provided	-0.97**	(-2.25)
CBI Certified	-0.22	(-0.51)
SPO * Assurance	0.81	(1.45)
	insample	
Constant	-24.53	(.)
Maturity	0.02	(0.82)
ln Amount	0.18	(1.19)
Rating		
AA	6.90	(0.01)
A	7.03	(0.01)
BBB	7.20	(0.01)
BB	-22.42	(.)
B	0.10	(.)
NR	6.51	(0.01)
Currency		
CNY	-4.12	(.)
GBP	1.24	(.)
HKD	0.34	(.)
IDR	5.75	(.)
INR	-3.42	(.)
JPY	-4.70	(.)
EUR	6.79	(0.00)
MYR	3.66	(.)
NOK	3.03	(.)
SEK	7.03	(0.00)
TWD	6.83	(.)
USD	7.15	(0.00)
Sector		
Consumer Discretionary	6.92	(0.00)
Consumer Staples	0.74	(.)
Energy	-3.16	(.)
Financial	7.60	(0.00)
Government	6.63	(0.00)
Materials	-3.97	(.)
Technology	1.22	(.)
Utilities	6.31	(0.00)
Disclosure		
GBP Aligned	-0.29	(-0.82)
SPO Given	0.36	(0.87)
Assurance Provided	0.15	(0.36)
CBI Certified	-0.19	(-0.43)
SPO * Assurance	-0.23	(-0.40)
	Mills	
Lambda	0.95	(0.43)
Observations	483	
N_cens	396.00	
chi2	12.79	

Note: Table shows the results of a two-step regression determining the green bond premium, including a correction for sample selection bias (λ). *t* Statistics in parentheses, * p<0.10, ** p<0.05, *** p<0.01