Maastricht University

School of Business and Economics

Green Bonds:

Why green bond investors can't eat their cake and have it too.

A master thesis investigating whether investors in the secondary market value the extent to which they can verify the 'green credentials' of a green bond.

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Student Name:	Wouter Reinier Geerlings
Student ID:	I6072855
1st Supervisor:	Prof. dr. Piet Eichholtz
2nd Supervisor:	Prof. Nils Kok

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Abstract

This study provides evidence that investors value the extent to which they can verify the green credentials of a green bond. It does so by isolating the green bond premium through a matching procedure of 95 bonds, issued from the 1st of January 2014 until the 31st of December 2018 and a two-step regression strategy. The first step entails a panel regression with 26,797 daily observations of the yield differential between the matched bonds on their residual liquidity to estimate the green bond premium, followed by a regression of the premium on multiple metrics of verification. The results indicate that green bonds in the secondary market are traded at a premium, meaning with lower yields, of on average -23.2 basis points. Most importantly, the results show that investors are primarily willing to forego yield when they can verify the green credentials of the green bond. Furthermore, the results show that assurance and a second party opinion are to some extent valued as complementary when it comes to green bond verification. The findings imply that there is a mismatch between demand and supply of green bonds with green credentials that can be verified. Taking into consideration the barriers to issue green bonds that are highlighted by bond issuers, policy makers should focus on implementing regulation that incentivises issuers to issue green bonds that enable verification of the green credentials, thereby further unlocking capital for sustainable investments.

Preamble

This thesis is part of a collaborative research project that is conducted with two other master students from Maastricht University, Tom Bour and Martijn Verberne. The foundation of this research project is a research proposal of prof.dr Piet Eichholtz and dr. Nils Kok: Green bonds-solution or hype? The goal of this research project is to investigate whether the market for green bonds is characterized by greenwashing. The collaborative nature of the three theses primarily lies in the construction of the dataset that is at the heart of the three researches: the DISC score dataset. The theses focus on different aspects of the green bond market, while investigating a similar research question: do investor value verification of the green bond credentials? This thesis is similar to the study performed by Tom Bour, as both studies focus on investors' valuation of verification in the secondary green bond market. Martijn Verberne conducts an event study to assess whether verification is valued by investors in the equity market. Hence, the three studies provide an overview of whether verification matters from both a bond investors' perspective as well as a shareholders' perspective.

I would like to thank my supervisors, prof.dr Piet Eichholtz and dr. Nils Kok for providing me with the opportunity to investigate the green bond market. Their feedback proved to be very valuable in better understanding this 'wild west' market. Further gratitude goes out to Nagihan Mimiroglu for giving well-appreciated advice regarding the more technical methodology and analyses of this research. Finally, I would like to thank my colleagues at Finance Ideas for the chance to put this research into a more practical context and supporting me in writing this thesis by providing access to relevant data and facilities.

1. Introduction

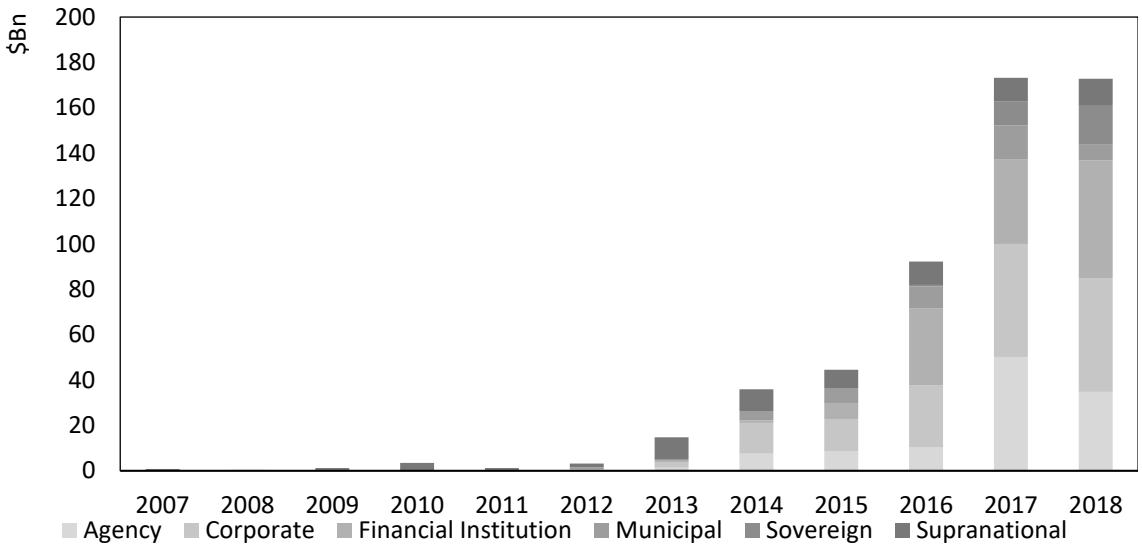
It is evident that the negative externalities that have come with the economic growth of the past century and that will come with future economic growth are one of the crucial challenges of this time. Numerous scientific reports have documented the existence of global warming caused by human activity, with the IPCC report (2018) providing the most recent evidence that global action is now more urgent than ever to circumvent a global environmental catastrophe. On top of this, global pollution is increasingly intensifying health risks, as well destroying ecosystems (OECD, 2017). The stakes are high and concerns are increasing. The OECD (2017) estimates an annual infrastructure investment need of USD 6.9 trillion in the upcoming 15 years to reach the global threshold of 2 degrees Celsius. Similarly, the EU (2018) highlights that an additional EUR 180 billion a year is needed for investments in energy efficiency and renewable energy in order to reach the EU's 2030 climate targets. At the same time, the total global stock of assets under management of institutional investors amounts to USD 160 trillion (Financial Stability Board, 2018). This is a clear indication of the crucial role that investors can play to reach both global climate goals, as well as European climate goals. In this line, Cicero (2016a) argues that it is imperative that private investors will need to support the public sector in addressing the investment needs related to climate change.

Consequently, numerous investments strategies and products that focus on investing more sustainably have become more relevant over the past decade, ranging from excluding 'sin stocks' such as tobacco companies from the investment portfolio to investing in projects with a positive environmental footprint. One notable investment product that has gained attention over the past years is the so-called 'green bond'. A green bond can be defined as "a bond that has been labelled as green by the issuer, with proceeds earmarked for projects beneficial to climate or environment' (European Union, 2016; Flammer, 2018; Ehlers and Packer, 2017). Hence, green bonds provide investors in the bond market with the opportunity to address long-term risks related to climate change while still receiving short-term financial benefits (Climate Bonds Initiative, 2017a). At the same time, issuing a green bond allows for a 'green signal' to the market that the issuer will invest proceeds in sustainable projects.

The green bond market has experienced significant growth over the last years, which is referred to by Morgan Stanley (2017) as the 'green bond boom'. Where the total amount of green bonds issued in 2013 only amounts to around USD 10 billion (Environmental Finance, 2018), the total amount of green bonds that has been issued by the end of 2018 amounts to over USD 500 billion (Climate Bonds Initiative, 2018a). Furthermore, the Climate Bonds Initiative

(2018a) estimates that a total amount of USD 300 billion of green bonds will be issued in 2019. Figure 1 shows the exponential growth of the green bond market over the last years, although the growth of the market surged in 2018 compared to 2017, possibly due to rising interest rates (Moody's, 2018).

Figure 1:
Development of the green bond market



Source: Environmental Finance (2018). Edited by the author.

Academic literature has documented different motivations to invest in such responsible investment products. For example, Jansson and Biel (2010) argue that psychological beliefs can motivate investors to invest responsibly. At the same time, Oikonomou et al. (2014) argue that credit rating agencies imperfectly capture environmental risk into their credit ratings. In this line, recent literature has investigated pricing differences that might occur in the green bond market, focusing on whether the distinctive green label can influence the valuation of green bonds. Overall, this literature documents that investors pay a so-called 'green bond premium' in the primary market (Ehlers and Packer, 2017; Partridge and Medda, 2018; CBI, 2017abcd), and in the secondary market (Zerbib, 2018; Barclays, 2015; Karpf and Mandel, 2018).

However, the saying 'all green bonds are green in the dark' is highly applicable to the green bond market, which is characterized by information asymmetry between investors and issuers (EU, 2016). Consequently, there are reported concerns from investors and regulatory bodies about greenwashing in the green market and what constitutes 'green'. To decrease such concerns, a number of voluntary options are available through which a green bond issuer can confirm the green credentials of the respective bond; one option being more robust than the other. These options range from alignment with green bond standards, to external review via a

second party opinion or an assurance engagement. Furthermore, Baker et al. (2018) and Flammer (2018) argue that external assessment of the green bond credentials through a certificate increases primary market bond pricing and is value enhancing in the stock market.

Arguing that a green bond essentially serves as a signal to the investor that proceeds are invested in green projects, the goal of this research is to assess whether investors actually value such instruments that enhance the credibility of the green bond issuance. The research question of this study is therefore:

Do investors in the secondary market value the extent to which they can verify the 'green credentials' of a green bond?

This thesis defines 'green credentials' as both the labelling of the green bond, as well as the information surrounding the labelling of the green bond. In order to investigate this research question, it is essential to develop a metric that measures the extent to which investors are able to verify the green credentials of a green bond. This thesis does so by developing a so-called *DISC score*, which constitutes out of four integrity principles, created for the goal of this research. These integrity principles are the means by which issuers can enable investors to verify green bond credentials: standards, second party opinion, assurance and certification. Industry practitioners and practitioner articles indicate that an issuer can conform to these integrity principles to enhance the credibility of the green bond issuance (Climate Bonds Initiative, 2018c; International Capital Markets Association, 2018).

To investigate this effect of verification on investors' valuation, this thesis uses an adapted version of the methodology of Zerbib (2018), which consists out of two steps. First, it is necessary to isolate a bond specific green bond premium. In order to do so, this thesis matches 95 green bonds issued in the financial and corporate sector to two comparable conventional bonds. From these two conventional bonds, this thesis creates a synthetic bond. To control for the liquidity premium (Chen et al. 2017), this thesis performs a panel regression with 26,797 daily observations from January 1st 2014 until December 31st 2018 of the yield differential on the residual liquidity between the green bond and the synthetic bond. The green bond premium is the bond specific fixed-effect of this regression. Then, to determine the effect of verification on the green bond premium, this thesis regresses the bond specific premium on the DISC score and the underlying integrity principles, while controlling for a number of other potential determinants of the premium.

The findings are partially in line with expectations. This thesis finds evidence for a highly significant green bond premium that amounts to -23.2 basis points on average. Moreover,

this thesis finds that a one-step increase in the DISC score is related to an increase of the green bond premium by -24 basis points. External verification of the green bond through a second party opinion or through external assurance are significant drivers of the green bond premium, increasing the green bond premium by respectively -112 and -108 basis points. Second party opinion and assurance are to some extent complementary, given that the marginal effect of both means of verification is -21 basis points. On the contrary, this thesis argues that alignment to standards or certification does not increase the green bond premium. Overall, the results indicate that investors are primarily willing to forego yield when they can verify the green credentials of the green bond. A number of robustness tests show that the sample is not subject to sample selection bias, while the results hold for different subsamples.

The results of this thesis have several relevant practical implications. First, the results indicate that investors are willing to forego yield when they are able to verify the green credentials of the green bond. Given that the green bond market is characterized by information asymmetry and concerns for greenwashing, while issuers indicate barriers to issue green bonds, policy makers should implement regulation to reduce information asymmetry and stimulate issuers to issue green bonds that enable investors' verification of their bond. This could in turn mobilize more supply for investments in green bonds and contribute to successfully reaching global climate targets. Then, to the knowledge of the author, this research is the first in investigating the effect of verification in the green bond market in such a detailed way. As such, this thesis is building on past research and can serve as a foundation for future research. First and foremost, future research should focus on researching the types of investors who are active in the green bond market. Moreover, future research can focus on potential heterogeneity in investors valuation of green bond verification, such as valuation differences between investors driven by investment motives and psychological beliefs (Jansson and Biel 2010).

The remainder of this thesis is structured as follows. The second section will provide a comprehensive overview of the green bond market. The third section will summarize the most relevant academic literature that is at the foundation of the research question. The fourth section outlines the hypotheses that support the research question. The fifth section explains the data collection process and the matching procedure. The sixth section outlines the empirical strategy and describes the sample. The seventh section provides the empirical results. The eighth section interprets these results and the thesis concludes in the ninth section.

2. The green bond market

To place the research question in a well-defined context, this chapter will provide a comprehensive description of the green bond market. The first section provides an overview of the green bond market through outlining its development, the issuers and the investors. Then, the second section will highlight challenges in the green bond market and concerns for greenwashing specifically. Building on this, the second section will demonstrate the most important ways in which issuers can enable verification of the green bond credentials and mitigate concerns for greenwashing.

2.1 Green bond market overview

Globally, institutional investors have an estimated value of USD 160 trillion assets under management in 2017 (Financial Stability Board, 2018). Environmental Finance (2018) estimates the total value of outstanding labelled green bonds to be around USD 500 billion. Thus, the green bond market currently accounts for less than 0,5% of global institutional assets under management; a seemingly marginal amount. However, the green bond market is a fast-growing and increasingly relevant market, given the large increase in total debt issued over the past years (Environmental Finance, 2018). Moreover, the United Nations Environmental Programme (2017) cites green bonds as one of the financial innovations that could speed alignment towards the Global Goals for Sustainable Development.

The development of the green bond market starts in 2007, when the European Investment Bank issued the first green bond, given that its proceeds were designated to be invested in energy efficiency and renewable energy. From then on, other large developmental organizations, such as the World Bank (in 2008) and the International Financial Corporation (in 2010) also started issuing green bonds. The turning point from small-scale transactions by the public sector to large- scale market growth occurred in 2013, when EDF, Bank of America and Vasakronan issued the first corporate green bonds (EU, 2016). In 2013, total green bond issuance amounted to USD 10 billion (Environmental Finance, 2018). By the end of 2018, the market grew exponentially, with a total green bond issuance of USD 500 billion green bonds (Environmental Finance, 2018).

A selection of market trends is relevant for this thesis. First, regulators such as the European Union (2016), certifiers such as the Climate Bonds Initiative (2017) and institutions such as the Institution for Climate Economics (2016) cite the standardisation of the green bond definition and its framework as one of the main challenges of the green bond market.

Expectations are that regulators will increasingly launch clearer standards and a framework for green bonds to overcome this challenge. Second, due to the expected increasing development of green bond guidelines worldwide and in Europe, it is anticipated that more investor confidence can be build, in term scaling up investment and injecting more liquidity (Climate Bonds Initiative, 2017a).

2.1.1 Issuers

A green bond issuer can be defined as any entity who labels a green bond with proceeds earmarked for projects beneficial to climate or environment (European Union, 2016; Flammer, 2018; Ehlers and Packer, 2017). For governmental institutions and developmental banks the incentives to issue green bonds are commonly rooted in the institution's mission. For example, the World Bank (2008) views green bonds as an integral part of its 2008 'Strategic Framework for Development and Climate Change'. However, reasons for corporations to issue green bonds appear to be less obvious and less inherent to the mission of the entity. Standard and Poor's (2014) argue that corporate issuers view green bonds as an alternative finance opportunity, as it offers access to a diversified investor base. RBS (2014) argues that, as green bond issuers profit from a large pool of fixed income capital, small projects can benefit from lower funding costs. They also argue that truly social responsible investors can be willing to receive lower coupons for green bonds, thereby creating a financial incentive to issue truly green bonds. In other words, an issuer can issue a green bond at a discount, compared to a similar conventional bond (see chapter 3 for academic foundation).

The Climate Bond Initiative (2017a) distincts between eight categories of green bond issuers: Loans, Sovereigns, Government Backed Entities, Local Governments, Development Banks, (non) Financial Corporates and Asset Backed Securities. There are further significant differences in the geographic location of the issuers and the issue size. Currently, the US has the largest market capitalisation of the green bond market. Next to large corporate issuers, the US market is driven by Asset Backed Securities issuers like Fannie Mae, who is also the largest issuer of green bonds in 2017 (Climate Bonds, 2017a). Not accounting for supranational issuers, the Chinese market is the second-largest market, with banks accounting for the largest share of issuances. In Europe, the bond market is largely dominated by French, Dutch and German issuers. An interesting development in 2017 is the increasing entrance of emerging countries into the green bond market. Countries such as Nigeria, Malaysia and Fiji are entering the market, with the Climate Bonds Initiative (2017a) describing this development as an encouragement for other emerging economies.

2.1.2 Investors

One approach to group investors in the green bond market is by their motivation to invest responsibly. For example, Jansson and Biel (2011) distinct between psychological factors and financial beliefs that influence the investment decision. An investor can be driven by the belief that responsible investing truly promotes sustainability, she or he can be driven by profits or by a combination of both. More specifically, a distinction between three groups can be made.

The first group of 'values driven investors' is described by Derwall et al. (2011, pp 1.) as follows: "the investment approach in which social and personal values instead of financial considerations are the basis for the decision to integrate corporate social responsibility criteria into investment decisions". This is the group of investors that is not driven by financial beliefs, but rather by a belief to promote sustainability. The second group of investors are those investors that are accountable to certain stakeholders who might anticipate the investor to invest sustainably. An example is a public pension fund, whose participants could expect the fund to exclude investment in tobacco companies. Sievänen, Rita and Scholtens (2013) argue that such public pension funds are indeed more likely to engage in responsible investing, as they have a commitment that can extend beyond the financial aspects. The last group of investors refers to the profit seeking investors (Derwall et al., 2011). This group of investors is driven by the more traditional financial goals. Moreover, Jansson and Biel (2011) also outline that risk and return are possible key drivers for investing in responsible investments.

Looking at the three groups above, a distinction can be made between the first two groups and the third group. The first two groups place a more intrinsic value on responsible investing and in term investing in green bonds, be it their own motivation or be it the motivation of their constituency. The third group does not value a responsible investment intrinsically but values the inherent risk and return characteristics of such investments. Although there is no academic research available that has investigated how green bond investors can be grouped, some actors provide brief descriptive statistics. The EU (2016) highlight that pension funds and insurance companies are the largest investors in the green bond market. Both actors can be grouped in the second group of 'accountable investors'.

2.2 The green credentials of green bonds

The EU (2016) has identified a number of bottlenecks that could hamper the growth of the green bond market. Most relevant for this thesis, the EU highlights the following issue: *"One of the biggest hurdles for the development of the global green bond market as well as the growth of regional and national green bond markets is the lack of a common green bonds definition and framework. The issue with the definition mainly concerns the questions what is 'green'* (EU, 2016, pp. 40). In June 2018, the EU set up a Technical Expert Group to tackle the lack of standardization (European Commission, 2018). The TEG will focus on providing standards, an impact benchmark, a taxonomy and disclosure guidelines to assist in developing sustainable finance in the EU.

Likewise, Talbot (2017) emphasises the need for clear transparency and standardization to ensure growth in the green bond market. He argues that greenwashing is one of the major risks facing green bonds, where greenwashing is defined as: "the superficial or insincere display of concern for the environment" (Talbot, 2017, pp. 3). In other words, a major threat is the inability of an investor to distinguish truly green bonds from those green bonds that are labelled as green, but are not actually investing proceeds in green projects. An example is a Chinese green bond issue, which proceeds are used for the funding of clean coal. Talbot argues that the dangerous consequence of greenwashing in the green bond market would be the undermining of its credibility, where he highlights that some experts even argue that this loss of credibility could lead to a collapse of the market. Moreover, if an investor uncovers 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 responsible investor. The posed solution pressed forward by Talbot is similar to the one proposed by the EU: more standardization and more regulation. The sections hereafter shall provide an overview of the options currently available to verify the green credentials of a bond that are further assessed in this research, which this thesis defines as 'integrity principles'.

2.2.1 Integrity principle I

Green Bond Principles

Established in 2014, the Green Bond Principles (GBP) is an initiative of a number of investment banks, from then on hosted by the independent organization 'International Capital Market Association' (ICMA). The most recent version (ICMA, 2018) is used to explain its most important features. The goal of the GBP is to provide guidelines for green bond issuances that issuers can conform to and promote integrity in the green bond market. Commonly, issuers develop and report a green bond framework to signal alignment with the GBP. The GBP are built on four core principles.

First, the GBP have clearly defined use of proceeds that should be categorized by the issuer to show that funds are used for green projects that have clear environmental benefits. Table A.1 in appendix A gives an overview of the possible use of proceeds. Second, the process for project evaluation and selection describes that issuers of green bonds should clearly communicate the following: (1) the environmental sustainability objectives; (2) the process of determining which projects fit into the categories described in table A.1 in the appendix and; (3) the eligibility criteria, exclusion criteria and/or any other processes to map and manage potential social/environmental risks associated with the project. Third, the management of proceeds component requires that issuers clearly track the management of the use of proceeds through, for example, tracking the balance of net proceeds or using a sub-account or portfolio for the net proceeds. Fourth, the reporting pillar states that issuers should ensure the availability of timely information *until* the full allocation of proceeds or give an update when there are any material developments.

Last, the GBP recommends the use of an external review to confirm alignment with the GBP. It is important to note that the GBP are completely voluntary to follow. Hence, engagements with industry practitioners indicate that alignment with the GBP does not provide very strong support for the credibility of the green bond credentials. Nonetheless, the GBP has proven to be a key catalyst in the development of the green bond market (Ehlers and Packer, 2017) and is the basis for other existing green label providers (ICMA, 2014). A summary of the GBP characteristics and a comparison to other the standards mentioned hereafter can be found in table A.2 in appendix.

Climate Bond Standards

The Climate Bonds Standards (CBS) is an initiative of the Climate Bonds Initiative (CBI) to set out clear criteria to facilitate verification of the labelling of a green bond. This thesis uses the latest CBS version to describe the main aspects of the standard (Climate Bonds Initiative, 2018). Building on the more broad integrity principles of the GBP, the CBS claims to have created a more robust and effective certification system. As such, those bonds that are aligned with the CBS are also aligned with the GBP and are eligible to receive a certificate, the 'Climate Bonds Certificate'. To understand how the CBS work, it is relevant to make a distinction between pre-issuance requirements and post- issuance requirements. Pre-issuance, the bond has to conform to four requirements: (1) use of proceeds documentation; (2) a clear process for evaluation and selection of projects and assets; (3) management of proceeds and (4) reporting prior to issuance. The first major extension of the CBS as opposed to the GBP lies in the fourth pre-issuance requirement. Where the GBP *advise* the use of an external review to verify the claims made, the CBS *require* the use of an external assurance party to verify the validity of the reporting. Then, the CBS has four post-issuance requirements that are essentially the same as its pre-issuance requirements, but that are mainly about tracking the claims made pre-issuance. In the case of reporting, the CBS has clearer claims than the GBP as it requires issuers to report annually. Moreover, assurance is mandatory post-issuance. Although the CBS does make some statements about impact reporting, the statements are rather vague and more open to interpretation than other requirements.

Last, the CBS provides sustainability credibility of the green bond credentials as it has more specific, scientific guidelines to determine the eligibility of specific project & assets and whether they are contributing to a more low carbon - and climate resilient economy.

(Supra)national green bond standards

As mentioned before, the EU is currently focusing on standardizing the green bond framework and definition within the EU. In 2018, the High Level Expert Group (HLEG), introduced by the European Commission, published a roadmap for Sustainable Finance in Europe (European Commission HLEG, 2018). One part of the report focuses on the centralization of the green bond framework and definition. The first step of this centralization process is the introduction of the EU Green Bond Standard. Then, the EU plans to introduce a certification system, the EU Green Bond Label. The EU Standard has large similarities to the GBP, as it uses the same four components as outlined before. However, where the GBP sometimes solely makes recommendations, the EU Green Bond Standards requires both an external verifier and impact

reporting. Hence, the EU Green Bond Standards seems to be as extensive as the CBS, further extending the CBS by providing more clarity with regard to the impact reporting requirement.

Furthermore, a number of countries outside - and inside the EU have introduced their own standards. Of these standards, the Chinese standards deserve specific attention, given that China is the second largest issuer of green bonds worldwide (CBI, 2017). Around the beginning of 2016, China's central bank, the People's Bank of China and the National Development and Reform Commission co-initiated national green bond guidelines, the Chinese Green Bond Principles (CGP) (CBI, 2017). Contrary to other countries, China requires that green bonds are aligned with the CGP to be labelled as green. The CGP can best be compared to the GBP, where the CGP have less strict requirements for eligible projects. For example, the CGP also allow cleaner coal investments as an eligible project.

2.2.2 Integrity principle II, III and IV

One of the other major pillars of the GBP and the CBS is the external review of the green bond framework and the reporting process. As stated before, the GBP recommends assurance and external review, whereas the CBS requires assurance by specific verifiers. The following section will provide a brief overview of the possible components of external review: second party opinion and assurance, which are respectively labelled as integrity principle II, III and it will explain certification, which is labelled as integrity principle IV. Notably, the it is the issuer who voluntarily decides to use one of these integrity principles to allow verification of the green bond credentials.

It is important to mention that the two options for external review are often used in similar ways by different parties. Hence, there is no clear definition yet in the market about what constitutes a second party opinion and what constitutes an assurance engagement. Building on the definition by the GBP (2018) which is also used by the EU (2016), this thesis categorizes the these different options for external review in its own way. The *second party opinion* (SPO) assesses the sustainability of the green bond, compliance with the green bond framework to certain standards and gives advice as to how it can be improved. An *Assurance Engagement* (assurance) verifies the claims made by the issuer of green bonds in their pre-issuance and/or post-issuance reporting - and framework and it verifies the robustness of the green bond pipeline. A *certificate* can be given by certain parties to show compliance with the requirements of the certificate. Table A.3 appendix A gives an overview of the different forms of external review and certification and how they relate to each other. The subsections below provide a further explanation of the SPO, assurance and certification.

Integrity Principle I: Second Party Opinion

The first possibility for external review of the green bond, the SPO, can be performed by any institution with environmental expertise. As mentioned above, the assessment focuses primarily on the sustainability of the bond and its alignment with certain standards (mostly the GBP). Cicero defines an SPO in the following way: "SPO's review the bond's potential environmental impact at the time of the issuance, but do not provide any assurance or validation as to the impacts of the projects after the investments are made." (Cicero, 2016, p. 10). The EU (2016) states that the five largest SPO providers (in terms of market share) are Cicero, Vigeo Eiris, Oekom, DNV GL and Sustainalytics. Moreover, the EU (2016) highlights that around 60% of green bonds incorporates an SPO in their green bond issuance.

Zooming deeper into the methodology of the four largest SPO providers, there are two important takeaways. The large majority of SPO's are similar in that they endorse the sustainability framework of the green bond issuer using the GBP as a reference point, while they are different in if - and how they provide an ESG rating of the issuer of the green bond or a rating of the green bond. For example, Sustainalytics (2018) sometimes only provides an endorsement of sustainability alignment of the green bond with the GBP, where Vigeo Eiris (2018) also gives the issuer an ESG rating and Cicero (2016b) gives the bond a specific rating.

Assurance

KPMG (2015) identifies reputational risk as one of the main drawbacks of issuing green bonds. This occurs when investors challenge the labelling of the bond as 'green'. To minimize this risk, an issuer can use an assurance provider to obtain an independent verification of the robustness of the pipeline or green bond framework. Moreover, post-issuance the role of the assurance provider is to ensure the correctness and robustness of the reported numbers. In other words, the assessment of the assurance engager primarily focuses on the correctness of the claims made by the issuer and the robustness of the pipeline to live up to those claims, as opposed to the primarily sustainability focus of the SPO. The level of verification can differ among a number of dimensions when using the Climate Bonds Standards as a reference point (CBI, 2018). First, there is a difference between pre-issuance and post-issuance assurance, referring to whether the issuance is in accordance with pre-issuance and/or post-issuance requirements. Second, the CBI distincts between limited assurance and reasonable assurance, where limited assurance provides less security than reasonable assurance (International Auditing and Assurance Standards Boards, 2008). The Climate Bonds Initiative has set out own criteria for becoming a certified verifier, eligible to perform assurance for a green bond to

comply with the CBS (2018). A complete list of the verifiers can be found on the CBI website (2018).

Although both integrity principles provide an external assessment of the green bond credentials, engagements with industry practitioners indicate that assurance appears to provide more credibility regarding the green bond credentials of a green bond issuance than an SPO. This is due to a number of reasons. First, practitioners indicate that assurance provides a more comprehensive and robust verification of the processes and the pipeline surrounding the green bond issuance. This ensures stronger credibility of the green bond credentials and the intended environmental impact of the green bond issuance. Second, practitioners indicate that assurance is often provided by large audit firms (such as the big four), with accompanying experience. This also makes assurance more costly and higher in intensity than an SPO.

Certification

When an issuer is conforming to the CBS, it is possible to apply for a green bond certificate (Ehlers and Packer, 2017). The certificate that is most prominent in the green bond market (EU, 2016), is the climate bond certificate, issued by the CBI (CBI, 2018c). Next to the pre-issuance and post-issuance requirements and other standards that have been described previously, the climate bond certificate requires third party verification, which is the most rigorous form of assessment in the view of the EU (2016). Moreover, the EU (2016) describes the climate bond certificate as the only certificate designed for verification of green bonds as of 2016. This still appears to hold true as of December 2018, excluding smaller initiatives in Asia.

Industry practitioners indicate that such certification can be seen as ‘the holy grail’ of green bond verification. The strict sustainability requirements of eligible project are comparable to an endorsement of sustainability by an SPO, while the certificate requires assurance. Moreover, the certificate allows for an easy way for investors to filter ‘good’ green bonds from ‘bad’ green bonds.

3. Literature review

There is an extensive amount of literature available regarding the increasing relevance of sustainability for companies and how this affects the pricing of different asset classes. This literature review will give an overview of specific aspects of this literature, relevant for this thesis. The first section will outline the relevant economic theory to develop the economic foundation of this thesis. Then, the second section will give an overview of (non-financial) disclosure literature to show how disclosure can enhance the credibility of corporate reporting. The third section will outline the value of the role of information intermediaries in financial markets. Last, the fourth section will go deeper into the valuation mechanisms of bonds and green bonds specifically. Figure A.1 in appendix C provides an overview of some of the key papers that are mentioned in the literature review, while showing how they relate to each other.

3.1 Economic framework

The concept of legitimacy theory emphasises the importance of corporate legitimacy to ensure the possession of a 'license to operate'. This 'license to operate' enables businesses to access those resources that are necessary to successfully conduct the operation of the business (Deegan et al., 2002). In this line, Hahn and Kuhnen (2013) argue that the existence of the business is rooted in the acceptance of the business by society. The theoretical groundwork for legitimacy theory stems from political economy theory, which views organisations as part of a broader social system, where organisations do not have an inherent right to exist, but are 'granted' by society their legitimacy to exist (Deegan et al., 2002). The author outlines that society, politics and economics are inseparable and, "economic issues cannot meaningfully be investigated in the absence of considerations about the political, social and institutional framework in which the economic activity takes place". (Deegan et al., 2002: 292). As such, stakeholder theory is highly relevant for the legitimacy of the organization (Hahn and Kuhnen, 2013), where stakeholder theory argues "that organizations should be managed in the interest of all their constituents, not only in the interest of shareholders". (Laplume et al., 2008, 1153). Importantly, Freeman (1984) highlights that managers have to incorporate internal and external stakeholders to recognize shifts in the business environment. Marshall et al. (2010) identify the trend to embrace sustainability issues as such a shift, arguing for a paradigm shift that clearly incorporates a sustainability mandate. Moreover, Flammer (2018) argues that green becomes the institutional norm, due to increased external pressure from external stakeholders.

3.1.1 Information asymmetry and signalling

Hahn and Kuhnen (2013) argue that sustainability practices of companies are characterized by information asymmetry; a phenomenon that is well-documented in economic literature, as it can hamper the efficient allocation of resources (Healy and Palepu, 2001). More specifically, the existence of information asymmetry refers to the so called 'lemons problem', which arises from the existence of information asymmetry (Akerlof, 1970). The author argues that the lemons problem causes the incidental overvaluation of bad ideas and undervaluation of good ideas, or, in other words, the inefficient allocation of capital.

Previous sections documented that the green bond market is a market that is characterized by information asymmetry, as numerous actors highlight concerns for greenwashing and lack of standardization (European Commission, 2018; Talbot, 2017). However, the issuing of a green bond can well be seen as a *signal* to the market and investors of the sustainability practices of the company. The existence of such *signals* in markets that are subject to information asymmetry is first introduced by Spence (1973). More specifically, Spence uses the example of job markets to explain the notion of a signal. Spence argues that there is uncertainty regarding the actual capabilities or quality of the individual (person wanting to be hired), as the employer does not have full information about this individual. Some of the information that the employer perceives is fixed, whereas as some information is subject to manipulation by the individual. The information subject to manipulation of the individual is described by Spence as a *signal*. The signal that the individual sends can influence the hiring decision of the employer, since the individual can provide credible information that he or she is more valuable or of higher quality than another individual. Connelly et al. (2011) highlights the importance of the notion of quality in most signalling models, as quality of the unobservable characteristic is what the individual aims to signal. Notably, the unobservable quality of the green bond signal is the truthfulness of the green bond credentials.

3.1.2 Credibility of the signal

Hahn and Kuhnen (2013) emphasize the importance of providing the addressee of the sustainability signal with trustworthy and plausible information to ensure a credible signal regarding sustainability practices.

Healy and Palepu (2001) provide a number of relevant solutions for companies to send such a credible signal. First, they highlight the importance of financial reporting and disclosure. The authors argue that, among others, the existence of information asymmetry is at the root of the demand for (financial) reporting and disclosure. Similarly, Brown and Hillegeist (2007)

argue that disclosure quality reduces information asymmetry through reducing the likelihood of trading on private information. Then, enhancement of the credibility of reporting can be achieved through intermediaries, such as auditors and financial analysts or regulation and specific standards (Healy and Palepu, 2001). This is further substantiated by Farvaque et al. (2012), who argue that the level of disclosure can be enhanced by increasing its quality through hiring, among others, an external auditor. The sections hereafter shall further explore the literature regarding the value enhancing effects of both disclosure a well as (information) intermediaries.

3.2 Corporate disclosure literature

Healy and Palepu (2001) provide an extensive review of the empirical disclosure literature, in which they identify disclosure to be both a relevant means of communication to investors to ensure an efficient capital market, as well as a means to communicate towards stakeholders. The authors identify, among others, financial reports, financial statements, management discussion and analysis and other regulatory filings to be means through with firms can provide disclosure. Furthermore, firms can engage in voluntary communication, where corporate reports, internet sites and press releases are most relevant for this thesis. Notably, in this context, corporate social responsibility (CSR) can be categorized under the umbrella of voluntary corporate reporting. Although a large amount of literature views sustainability, environmental or CSR reporting as voluntarily, increasingly governments have put in place regulation regarding such non-financial reporting. Examples are China, Malaysia, Denmark and South Africa (Ioannou and Serafeim, 2017) and the European Union as of 2018 (European Commission, 2018), who have implemented regulation regrading sustainability reporting.

Therefore, the next sub-sections will categorize the disclosure literature among four categories, namely mandatory or voluntary financial corporate disclosure and mandatory or voluntary corporate sustainability disclosure. Those academic papers that write about regulation fall under the category of mandatory reporting and those papers that write about the quality of reporting generally fall under the category of voluntary reporting.

3.2.1 The value of financial corporate disclosure

First, a number of academic research has investigated the effect of financial corporate disclosure quality on firm performance measures. To assess the effect of the level of corporate disclosure on capital markets, Lambert et al. (2007) look at the effect of the quality of disclosure - and regulation regarding disclosure on the cost of capital. They find that the overall risk premium of the respective market is reduced by an increase in disclosure regulation. Similarly, Akhigbe et al. (2006) find that the implementation of regulation in the form of the Sarbanes Oxley act, aimed at reducing financial opacity, is associated with positive wealth effects. Additionally, Ferrell (2003) finds that implementation of disclosure regulation is associated with lower over the counter stock volatility. Looking at the effect of financial disclosure quality, Lambert et al. (2007) report a reduced cost of capital, caused by a decrease in the relative risk of the specific firm. Similarly, Jiao (2011) argues that a higher disclosure quality is related to better stock returns, a higher Tobin's Q and positively related to a number of accounting metrics. Then, Richardson and Welker (2001) document a negative relation between the quality – and quantity of financial disclosure and firm cost of equity. Moreover, Sengupta (1998) researches the relation between corporate disclosure quality and the cost of debt. He concludes that disclosure quality is negatively associated with the cost of debt, an effect that is stronger in markets with more market uncertainty. Sengupta argues that this effect is caused by lender's calculation of the probability of default, where, notably, lenders incorporate the information at hand into their calculation. Correspondingly, Wang et al. (2008) investigate the effect of voluntary corporate disclosure quality on the cost of capital and firm performance. They find an insignificant relation between voluntary disclosure and cost of capital, but they document a positive relation between voluntary disclosure and firm performance.

3.2.2 The value of sustainability corporate disclosure

Another stream of academic literature has investigated the potential value enhancing effects of non-financial corporate disclosure. Ioannou and Serafeim (2017) investigate the implementation of mandatory CSR reporting on firm valuation. Specifically, they argue that companies can signal good citizenship through their CSR reporting and increase transparency regarding their impact on society, thereby increasing company valuation as proxied by Tobin's Q. On the contrary, Grewal et al. (2018) find an average negative market reaction to the likelihood of the implementation of EU law regarding ESG disclosure. Interestingly, the market reaction is positive for those firms with superior nonfinancial performance. Overall, the authors document that investors incorporate potential costs (benefits) associated with information

regarding lower (better) nonfinancial performance into their perception.

Then, the literature investigating the effects of voluntary non-financial reporting documents similar results as the literature researching the effects of mandatory non-financial reporting. As labelling a green bond does not require any form of non-financial reporting, any reporting surrounding the issuance of a green bond or any subsequent reporting can be seen as voluntary non-financial reporting and communication. Examples of such reporting are all documentation related to alignment with green bond standards. Grewal et al. (2017) find that material voluntary sustainability disclosure increases stock price informativeness; an effect that is stronger for companies that have a further integration of sustainability into their strategy and are more exposed to sustainability issues. Moreover, Dhaliwal et al. (2012) argue that CSR reporting is likely to affect information asymmetry, as indicated by analyst forecast accuracy. Further building on this, Dhaliwal et al. (2014) document that CSR reporting is associated with a lower cost of equity, which is strengthened in countries with more financial opaqueness and a higher stakeholder orientation. Their argument is substantiated by Bachoo et al. (2014) and Ng & Rezaee (2012), who also find a relation between sustainability reporting and cost of equity. Moreover, sustainability reporting is associated with higher expected future performance (Bachoo et al. 2013), higher firm valuation ((Loh et al., 2017), (Berthelot et al., 2012)) and, notably, lower cost of debt (Ng & Rezzaee, 2012).

On the contrary, some researchers have found no value enhancing effect or contradicting effect of higher levels of corporate disclosure. For example, Bushee and Noe (2000) document a positive relation between disclosure quality and stock volatility. Similarly, Verbeeten et al. (2016) do not find any value effects through higher levels of environmental disclosure. Similarly, Cormier and Magnan (2007) find that environmental reporting does not have significant influence on stock valuation in Canada and France. Although this indicates that there is still some ambiguity regarding the effect of the level of disclosure, the majority of literature appears to argue in favour of the value enhancing effects of the level of disclosure and non-financial disclosure specifically. Moreover, non-financial disclosure literature indicates that the value enhancing effects of non-financial disclosure are strongest for those companies operating in a context where there is more information asymmetry, higher stakeholder orientation and sustainability is more relevant.

3.3 Information intermediary literature

According to Healy and Palepu (2001), information intermediaries and auditors play a critical role in overcoming information - and agency problems. These parties ensure the integrity and reliability of the financial or non-financial information disclosed by the firm to external investors or other stakeholders. As set out in section 2.2, there are different types of information intermediaries involved in the green bond market, including assurance providers, second party opinion providers, and certification providers. This section will discuss the empirical evidence regarding the effectiveness of these information intermediaries in capital markets, leveraging literature regarding the role of auditors and the role of certifiers.

3.3.1 Auditors

As argued in section 2.2, the role of independent external verifiers can increase the integrity in the green bond market, as they verify information published by green bond issuers, or verify the alignment of the green bond framework to the GBP or CBS. In this line, the common perception is that auditors enhance the overall credibility of firm reporting and, thereby, support investors in their investment decision (Chen et al., 2014).

Several researchers have investigated this claim and researched the role of auditors. Sami and Zhou (2008) utilized the implementation of new auditing standards in 1996 in China to investigate its effect on the information environment. They document better 'informedness' of investors and an increase in quantity and quality of reporting. Investigating Chinese listed firms, Chen et al. (2014) find a significant decrease in inter-investor divergence of firm value assessment for firms with audited financial statements compared to non-audited firms. Moreover, Zhou (2007) find significantly lower stock bid-ask spreads, proxying for the degree of information asymmetry, following the implementation of stricter auditing standards in the Chinese market. Last, Clinch et al (2012) also find a significant reduction in information asymmetry in the stock market following the appointment of an auditing firm, using pricing differences, volatility differences and differences in short/long ratios as proxies for information asymmetry. Overall, these results suggest that auditors indeed enhance the credibility of reporting and, thereby the signalling of firms.

Linked with the more mature auditing market, a growing stream of literature focuses more specifically on the role of assurance and auditors with regard to sustainability or non-financial disclosure and the enhancement of the credibility of sustainability reporting. Moreover, practitioners such as KPMG (2013) have highlighted that credibility is increasingly

relevant for sustainability reporting. Nugent and Simnett (2007) show the relevance of verification or assurance on carbon disclosure to achieve an adequate level of credibility and an increase in reliability of company sustainability information (Cohen and Simnett, 2015). Notably, sustainability reporting is mostly voluntary, as opposed to financial reporting. In this line, Simnet et al. (2009) show that companies that are concerned with building their corporate reputation are more likely to use an assurance provider to enhance credibility of the reporting. Furthermore, Cuadrado-Ballesteros et al. (2017) examine whether CSR reporting reduces information asymmetry, using financial forecast accuracy to measure information asymmetry. Based on an international sample of listed firms, the authors find evidence that assured sustainability reporting reduces information asymmetry to a larger extent than non-assured reporting. Last, Hodge et al. (2009) argues for the value enhancing effects of assurance, as they find that the provision of assurance improves perceived reliability of ESG information, especially when a reasonable level of assurance is reached. To conclude, these findings show that both financial assurance and audits, as well as sustainability assurance and audits, significantly enhance the credibility of reporting and reduce information asymmetry.

3.3.2 Certification

Green bond issuers can voluntarily apply for certification to confirm the green credentials of the green bond. Several authors investigated investors' response to green labelling or certification, with a specific focus on real estate. Eichholtz et al. (2010) use a sample of U.S. office buildings to estimate the difference in contract rents, effective rents and selling prices between buildings that received a green rating and buildings that did not. The authors find that for such certified buildings the rental rates are roughly 3 percent higher per square foot, the effective rents are more than 7 percent higher, and the selling prices are roughly 16 percent higher. These results can be attributed to both direct energy cost savings and an intangible effect of the label. Morever, Fuerst and McAllister (2011) find supporting evidence of these findings, as they document a rental premium of 4-5 percent for eco-certified buildings in the U.S relative to non-certified counterparts and a corresponding sales price premium of 25-26 percent. Freybote et al. (2015) document a sales price premium of 3.8 percent for LEED-certified buildings, relative to the conventional benchmark. Additionally, Brounen and Kok (2011) document a similar finding, where homeowners are willing to pay a higher price for eco-certified buildings. The authors further argue that certification is an effective way to build transparency in the relative performance of buildings in terms of energy efficiency, which is integrated in the sales price.

Then, Flammer (2018) specifically investigates the role of certification in the green bond market, using an event study of the stock prices following the announcement of a green bond issuance. Notably, the difference in stock market reaction magnitude is economically significant: the positive stock price reaction is about twice as large for CBI-certified green bond compared to non-certified counterparts (Flammer, 2018). Furthermore, the author argues that green bond certification implies larger positive effects in terms of environmental performance and long-term value creation. In particular, the issuance of a CBI-certified green bond is related to a positive effect on firm value as well as profitability and environmental rating. On the contrary, the issuance of a non-certified green bond has no significant effect on these measures. Flammer (2018) concludes that certification in the green bond market represents a more credible signal to investors in the green bond market. Similarly, Baker et al (2018) show that green bonds that have been certified by the CBI are associated with a larger price premium than green bonds that have not been certified as green.

Importantly, the above listed researches show the value enhancing effect of certification, going through two potential channels: the intrinsic or intangible effect of the label, as well as the underlying economic value that the label signals, such as cost savings and higher relative performance in the real estate sector.

3.4 Bond pricing literature

The following section will provide an overview of the literature that has researched the pricing of bonds, with a specific focus on sustainability pricing. First, it will outline conventional bond pricing literature, in turn highlighting the key factors that determine bond prices. Then, it will further explore how sustainability is another factor that can influence bond prices. Last, the section will review the green bond pricing literature. In line with the distinction that is commonly made in the academic literature, the green bond primary market literature (pricing at issuance) and the secondary bond market literature will be explored separately.

3.4.1 Conventional bond pricing

Widely cited among corporate bond researches, Merton (1974) documents three factors that are essential drivers of bond price: the risk free rate, the underlying characteristics of the bond and the probability of default or the probability that a firm is not able to repay its debt obligations. The risk free rate is generally proxied by return of government bonds or the return of very high grade corporate bonds. The underlying characteristics that Merton highlights are the coupon rate, call terms, seniority of the debt, and the provision of a sinking fund. Probability of default

is generally proxied by credit ratings, as this measures the underlying default risk of the firm (Sengupta, 1998), which in term affects the yield of the rated bond (Ziebert & Reiter, 1992).

From then on, numerous authors have researched the effect of these three components on bond pricing and added a number of other determinants. Huang and Huang (2012) show that credit risk or probability of default only accounts for a fraction of yield spread, less than 25%, indicating that a number of other factors explain a significant part of yield spreads. In this line, Petitt et al. (2015) argue that three factors should be included in every model that investigates bond pricing. First, the maturity premium represents the premium that investors want to receive for bond with a longer term structure. Second, the liquidity premium represents the premium that investors want to receive for bonds that are less liquid. Third, the authors again highlight the importance of the credit risk.

The maturity premium is consistent with the liquidity preference hypothesis by Hicks and Kessel (1946) which argues that returns are positively related to maturity and it is confirmed by authors such as Fama and Bliss (1987) and Brown (2006). The effect of liquidity on bond spreads is further substantiated by Chen et al. (2007) and Dick-Nielsen et al. (2012) and can be accounted for through correcting for issue amount and issue date (Bao et al. 2011; Houweling et al. 2005) or the bid-ask spread of the respective bond (Fong et al. 2017). Last, the relevant issuance related characteristics that Merton documented are further documented in adapted forms by Sengupta (1998), who controls for size, maturity, callability, convertibility and subordination and Zerbib (2018), who controls for currency, rating, callability, seniority, collateral coupon type and liquidity.

3.4.2 Sustainability pricing in the bond market

A specific stream of academic literature focuses on the pricing of sustainability in bond markets, although no full academic consensus seems to be reached regarding this pricing relation. First, a number of authors have documented a negative relationship between sustainability performance and yield spreads. Oikonomou et al. (2014) argue that good CSR performance is rewarded in the market, whereas bad CSR performance is subsequently positively related to financial risk. Klock et al. (2005) and Ghouma et al. (2018) research the effect of corporate governance on bond yields in the US and Canada. Both papers show that bond spreads are negatively related to corporate governance quality, arguing that poorly governed firms are associated with more agency problems. Hassan et al. (2017) show that US based firms with more social capital can issue debt at a lower cost, given that they issue bonds at a lower spread. Then, Bauer and Hann (2010) research the effect of environmental performance on a firm's

cost of debt and credit risk. The authors show that better environmental performance is associated with a lower cost of debt and lower credit risk, whereas environmental concerns are associated with a higher cost of debt and higher credit risk.

On the contrary, some authors have documented a negative relationship between sustainability and debt pricing. Although acknowledging that sustainability is often related to better financial performance, Magnanelli and Izzo (2012) document a positive relation between cost of debt and sustainability. The authors argue that their findings are in favour with shareholder theory, where managers should not invest in sustainability, as this is at the expense of shareholder wealth creation. Similarly, Menz (2010) finds that more sustainable firms exhibit a higher risk premium, implying that more sustainable firms are regarded as more risky. The author notes that the effect is marginal, which can signal that sustainability is not yet fully incorporated in bond pricing. Despite the last findings of the last papers, most literature seems to argue in favour of the argument that sustainability positively affects bond valuation and reduces cost of debt, specifically as those firms are perceived as less risky.

3.4.3 Pricing of green bonds in the primary market

The first stream of literature to investigate potential pricing differences of green bonds focuses on the primary market. In this line, Ehlers and Packer (2017) investigate the pricing difference between green bonds and conventional bonds at issuance by comparing green bonds with issuances of conventional bonds by the same issuer. Their results indicate that the yield spread of green bonds is lower than that of their conventional counterparts. The main takeaway is that investor demand for green bonds is significantly high enough to influence the issue price. Furthermore, CBI has released four reports (CBI, 2017c;2017d;2017e;2017f) investigating the pricing of green bonds in the primary market for the four quartiles in 2017. Overall, the reports outline a trend of tightened pricing of USD denominated green bonds in the primary market, relative to initial price talk. On the contrary, evidence for tighter pricing relative to conventional bonds is inconclusive for EU bonds

Although excluded from the sample of this research, it is also interesting to look at the existence of a green premium within the primary municipal bond market, given the small amount of research available about green corporate bonds. Partridge and Medda (2018) investigate the existence of a green premium for US Municipal bonds in both the primary and the secondary market. Using a pricing report by CBI (2018a), the authors outline possible reasons for a green premium. First, the authors argue that the existence of a consistent green premium could be driven by structural tighter pricing in the secondary market. In turn, prices

in primary markets can structurally be higher than those of conventional, comparable bonds. Then, the authors use a matching approach to compare the yield spreads of green bonds and their conventional counterpart. They find a weighted average green bond premium of 4 basis points, which increases year by year. Furthermore, another paper by Partridge and Medda (2018) constructs a US municipal green bond index and researches whether this bond index outperforms the S&P municipal index in terms of returns. They find evidence of outperformance for the period 2014-2017.

Last, Baker et al. (2018) look at the green bond premium of US municipal bonds in the primary markets, but they include another variable that is relevant for the scope of this research; the certification of an external party. Using data from 2010 to 2016, their research focuses on both the yields as well as the ownership concentration in the primary market. The authors find a green premium, as expressed by a lower yield for those bonds that have been labelled as green. The yield difference is economically significant in the view of the authors, as it amounts to an average difference of 6 basis points. Moreover, the result is more economically significant when the green bond has been awarded with a CBI certificate. In this case, the yield difference is on average 14 basis points, showing that efforts from issuers to certify their bonds have a financial benefit.

3.4.4 Pricing of green bonds in the secondary market

The second relevant stream of literature investigates the green bond premium in the secondary market. Zerbib (2018) investigates the yield differential between conventional and green bonds for the period 2013-2016. The author uses a matching approach, thereby matching green bonds to two conventional bonds of the same issuer and extrapolating a so-called 'synthetic conventional bond'. Overall, the author documents a green bond premium in the secondary market, as expressed by a lower yield with a mean of 1.76 basis points. However, significant differences in the green premium are documented within the sample. Depending on the credit rating of the company, the green premium is documented as stronger or weaker, ranging from 0.9 basis points for AAA rated bonds to 12 basis points for BBB rated bonds. Importantly, the author argues that the research controls for risk related to the specific issuer, thereby providing the ability to show that the increased valuation is related to investors exhibiting pro-environmental preferences. Then, Wulanderi et al. (2018) research the effect of liquidity on green bond yield spreads in the secondary market. As part of their research, they also investigate the yield spread between green bonds and a matched sample of conventional bonds. The researchers investigate whether the yield spread can be explained by differences in liquidity

risk. They find that, through relatively higher liquidity of green bonds in the secondary market, the yield spread between green bonds and conventional bonds increases, indicating that higher liquidity increases the premium for green bonds. Moreover, they find that this effect is vanishing over time, indicating that possibly supply for bonds is increasing relative to demand and the market is maturing.

Then, a number of financial institutions have researched the existence of a green premium in secondary markets. Among them are Barclays (2015) and Nationale Nederlanden Investments Partners (2018). All of these studies find that investors pay a premium for green bonds in the secondary market. Barclays (2015) researches the yield of green bonds relative to comparable conventional bonds for the period 2013-2014 and finds that green bonds trade 17 basis points tighter than their conventional counterpart. Using a different approach, Nationale Nederlanden Investment Partners (2018) calculates an interpolated yield curve of the issue, comparing the actual yield of the green bond to the interpolated one. Ranging from December 2014 to November 2017, the researchers find that, on average, the green bonds priced 1.1 basis points below their interpolated curve. Moreover, the research gives two explanations for the existence of premium. First, there can be a mismatch between supply and demand, resulting in higher prices. Interestingly, the premium the research found decreased over time. As the green bond market has grown over time, an increase in supply could explain the decrease in premium. Second, the research argues that it is possible that green bond investors are buy-and-hold investors. In this case, the lower yield would be a consequence of the lower volatility that comes with buy-and-hold investing. Last, CBI (2017cdef) researches the tightening of green bonds in the secondary market as opposed to a basket of equivalents. Although the sample is small, they find that the majority of green bonds tighten more than their counterparts. In other words, over time the green bonds increase more in price than the conventional comparative bonds.

4. Hypothesis development

The literature review provides the necessary academic knowledge to further investigate what determines investors' valuation of sustainability in specifically the green bond market. Recall the research question that is constructed in the introduction:

Do investors in the secondary market value the extent to which they can verify the green credentials of a green bond?

To answer this problem statement, this thesis first investigates the existence of a green bond premium. Given that academic literature argues that sustainability is valued in capital markets and debt markets specifically, while green bonds serve as a signal of sustainability by the issuer, this thesis formulates the following hypothesis:

H1: Investors pay a premium for green bonds in the secondary market

Although the literature regarding green bond pricing documents the existence of a green bond premium, no literature has investigated in detail whether investors actually value the credibility of the sustainability signal that a green bond issuance constitutes. This is relevant, as previous sections document that the green bond market is characterized by information asymmetry and concerns for greenwashing. Figure A.1 in the appendix highlights this gap in the literature. The figure shows that it is academically relevant to research whether secondary market investors value a credible green bond signal, given that academic literature substantiates that green bonds price differently, while a reduction of information asymmetry in the form of reporting, auditor engagements and certification is valued in capital markets.

Then, the integrity principles that are established and substantiated in earlier sections are used to assess how investors can verify the green credentials of green bonds, given that the literature review substantiates their role in reducing information asymmetry and enhancing the credibility of a company's signalling towards capital markets. First, this thesis sees standards as a form of sustainability reporting towards investors, considering that issuers who are aligned with certain standards are expected to provide true information regarding the framework of the green bond issuance. Then, this thesis argues that an SPO, assurance and certification are information intermediaries that drive the credibility of the green bond signal and the credentials of the green bond. More specifically, an SPO focuses on the sustainability of the bond, assurance on the robustness of the bond framework and its pipeline and certification comprises both dimensions of SPO and certification. This thesis bundles the integrity principles under an

overarching score, which is aimed at measuring the extent to which investors can verify the green credentials of green bonds: the *Green Disclosure Score* (*DISC score*). The idea is that alignment with more integrity principles means that investors are better able to verify the green credentials of the bond, increasing the DISC score. Thus, this thesis formulates the following hypothesis:

H2: Investors pay a higher green bond premium when they can verify the green bond credentials of the bond, as measured by the DISC score

Notably, there are differences within the integrity principles. Aligning a green bond with standards (integrity principle I) is a more low-barrier form of enhancing credibility of the green bond signal. There is large heterogeneity within the quality of the frameworks and information associated with the alignment, while the claim to be aligned is often made by the issuer of the bond.. Furthermore, the literature review shows that alignment with standards can be confirmed by some form of external review through an SPO (integrity principle II) or assurance (integrity principle III). The section outlining the green bond market further argues that external review is generally more extensive than alignment with standards and enhances credibility to a larger extent. Similarly, practitioners indicate its added value with regard to confirming the green credentials of the green bond. Thus, this thesis formulates the following hypothesis.

H3a: Investors are willing to pay a higher green bond premium for bonds that received some form of external review than for bonds that are aligned with standards

Still, where the value-enhancing effect of assurance is extensively documented in literature, there is no literature available regarding the value of an SPO, to the knowledge of the author. Furthermore, assurance is more subject to regulation and standards, where the SPO is characterized by large heterogeneity among the approach and the extensiveness of the party performing the SPO. Last, practitioners highlight that assurance is generally more intensive and comprehensive than the SPO. Thus, this research expects that assurance enhances credibility to a larger extent than an SPO.

Hence, this thesis formulates the following hypothesis:

H3b: Investors are willing to pay a higher green bond premium for bonds that have assurance than bonds that have an SPO

Additionally, the section about the green bond market and table A.3 in appendix A indicate the different focus of the SPO and assurance. As such, these components of external review can also be seen as complementary, where having both integrity principles can be seen as value-adding compared to having only one of the two components of external review. Thus, this thesis formulates the following hypothesis:

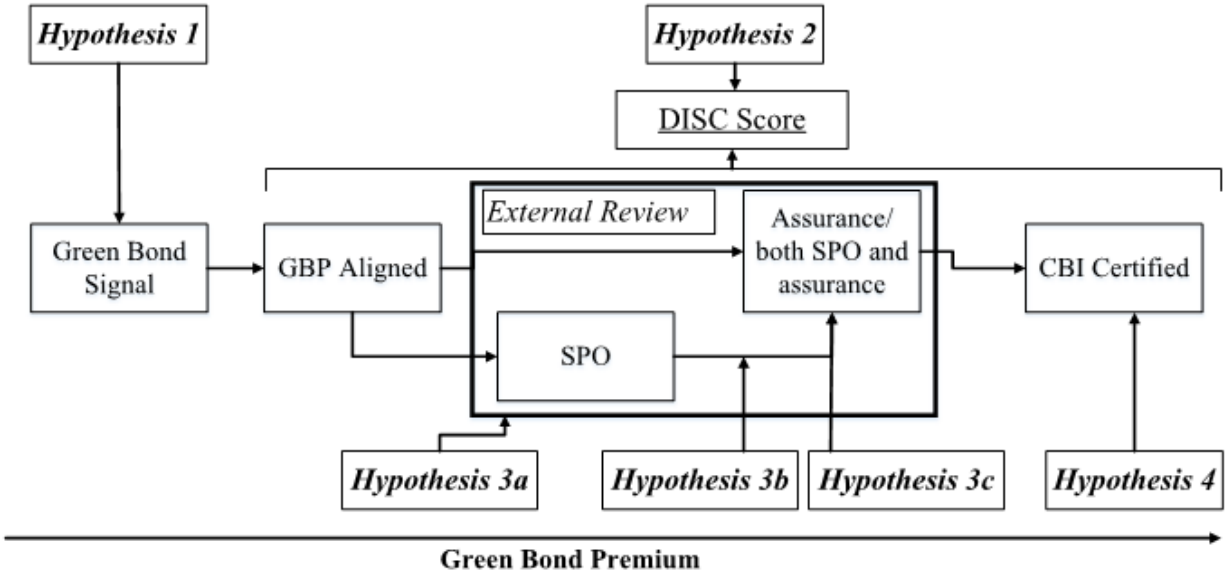
H3c: Investors are willing to pay a higher green bond premium for bonds that have both an SPO and assurance than bonds that have only an SPO or assurance

Last, the literature researching certification highlights that a certificate can be value-enhancing on top of the underlying (economic) value drivers of the certificate; the intrinsic value of the label. Likewise, the green bond literature provides evidence that certified green bonds exhibit a higher green bond premium than non-certified bonds, while a certified green bond is valued more in stock markets than a non-certified green bond. Moreover, a certified green bond provides similar verification as a green bond that has both assurance and an SPO, while practitioners indicate that a certificate is perceived as the most comprehensive and convenient way to verify green bond credentials. Hence, this thesis expects that green bonds that are certified have the largest green bond premium. This leads to the following hypothesis:

H4: Investors pay a higher green bond premium for bonds that are certified than bonds that have both assurance and an SPO

Figure 2 below conceptualizes the relation between the green bond signal, the DISC score and the integrity principles. The figure lists the different steps that a green bond issuer can take to enable verification of the green bond credentials. The figure specifically highlights how the hypotheses set out before relate to these steps in verification. As the hypotheses indicate, each step in verification is expected to increase the green bond premium in the secondary market.

Figure 2:
Conceptualization of the hypotheses



5. Data collection and matching

The upcoming chapter will describe the methodology that this thesis uses to create its sample. As the preamble indicates, this thesis is part of a collaborative research to investigate verification in the green bond market. Hence, the construction of the DISC score and the collection of the dataset that lie at the heart of this collaborative research are a joint effort. In order to research the hypotheses, this data collection method is twofold: on the hand we collect data regarding the financial characteristics of green bond issuances, while on the other hand we collect data regarding the green credentials of green bond issuances. Furthermore, to isolate the effect of the green-labelling of a bond issuance, this thesis uses a matching procedure in a similar way as Zerbib (2018). The first section will describe the collaborative part of the research. As such, it will describe how we collect the data and how we create the DISC score. Then, the second section will explain the matching method that this thesis uses to finalize the dataset and isolate the 'green effect' in the secondary market.

5.1 Green bond dataset

To ensure a dataset that captures the full spectrum of green bond issuances it is crucial to construct a dataset that consists out of all green bond issuances. Ideally, the dataset includes the full spectrum of green bonds, namely 'perfect' green bonds that are certified by an external party to review the bond, as well as 'junk' bonds that have merely been labelled by the issuer as green. One of the main challenges in constructing such a database is the different definition that data providers use of what constitutes a green bond. For example, the Bloomberg Fixed Income Database (2018) requires a green bond to be aligned with the GBP. As this thesis hypothesises that alignment with such standards is a (voluntary) enhancement of the credibility of the green bond signal, it is important to also include those bonds that are not aligned with the GBP. Hence, we construct a dataset that includes a comprehensive number of green bonds, while the dataset still includes the relevant financial information and information to construct the DISC score.

5.1.1 Data retrieval

To fully capture the spectrum of green bond issuances, we use the Environmental Finance Green Bond Database (2018) as a starting point. The Environmental Finance Green Bond Database does not make a judgement regarding the self-labelling of a green bond, thereby including all bonds that have been labelled by the issuer as a green bond. As such, the

Environmental Finance Database provides a complete spectrum of green bond issuances, ranging from the 'junk' green bonds to the 'perfect' green bonds. Furthermore, the Environmental Finance Database reports a number of deal characteristics that are relevant for this thesis. The relevant characteristics will be outlined in detail in the next subsection.

The total database reports 2,419 deals, whereas Bloomberg reports a total of 1,900 green bonds issuances, using the 'green bond' use of proceeds filter. Importantly, Environmental Finance classifies the total number of green bond issuances as *deals*, where a deal can be defined as a green bond issuance on the same date, with the same issuer and lead manager(s). This implies that Environmental Finance can categorize two issuances as one deal, although they may differ in their coupon, currency, rating or other underlying characteristics. Despite this categorization, the total number of deals is still larger than the number of issuances reported by Bloomberg. This provides further evidence that Environmental Finance provides a complete dataset of the green bond market.

We exclude all issuer types other than *Financial Institution* and *Corporate* (supranational institutions, governments, and municipalities). Literature regarding green bond pricing documents that such green bonds price differently, due to specific tax treatments (Baker et al. 2018). Furthermore, to overcome the categorization of multiple different issuances into deals, we split deals that consist out of multiple issuances into individual observations. The resulting dataset after filtering contains 829 issuances, issued from 1st of January 2014 until 31st of December 2018.

Although Environmental finance provides a complete database of the green bond market, the database lacks complete financial information that is needed for this analysis. Furthermore, a large number of observations is missing a security identifier (ISIN or CUSIP). Thus, we manually link each observation that misses such an identifier to an ISIN through filtering each observation by issuer, issue date, maturity, issue amount, coupon, rating and currency in Bloomberg and Factset. We drop any issuance that is missing an identifier and cannot be matched by issue date and maturity within one week, as well as the before-mentioned characteristics. The resulting dataset contains 631 issuances for which information is available about the green credentials via Environmental Finance and financial information is available via Bloomberg.

5.1.2 DISC score

To assess the credibility of the green bond signal, it is key to collect data that about the integrity principles. We first conceptualize the extent to which a green bond issuance complies to the integrity principles in the DISC score. This variable indicates the extent to which investors are able to verify the green credentials of the bond. In other words, it seeks to measure the credibility of the *green signal* by the issuer of the green bond. As such, each underlying integrity principle represents a factor variable, where the factor takes a value of one when the issuance adheres to the respective principle.

The DISC score and the underlying integrity principles are the first of its kind that provide a comprehensive measure of sustainability verification in credit markets, to the knowledge of the author. In order to create a variable that captures the most relevant dimensions of verification of the green bond credentials of green bonds, we perform a large-scale research of the entire universe of opportunities for verification of green bonds. As the green bond market is characterized by segmentation, the biggest challenge is correctly generalizing numerous ways of verifying green bond credentials. Therefore, we group the different options for verification by their focus and their dimension of verification. Hence, the DISC score captures the most relevant dimensions of the green credentials of a green bond issuance. First, standards measure whether the green bond issuance is supported by some of voluntary corporate reporting. Second, an SPO is an indication of the sustainability quality of the projects that are supported through the green bond issuance, given that an SPO implies an endorsement of the sustainability by a firm with environmental expertise. Third, assurance indicates that the pipeline associated with the processes surrounding the green bond issuance is robust. Last, certification is seen by practitioners as the holy grail of green bond verification as it encompasses both dimensions of an SPO and assurance and provides a practical way to verify a green bond. The components of the DISC score and the assigning of the scores are set out in table 1 below.

Table 1:
DISC score integrity principles

DISC Components	Scoring
Standards	The green bond adheres to a set of 'Standards' = 1, otherwise 0
SPO	The green bond received a 'Second Party Opinion' = 1, otherwise 0
Assurance	The green bond received an 'external assurance engagement' = 1, otherwise 0
Certification	The green bond received 'Climate Bonds Certification' = 1, otherwise 0

As mentioned in the previous section, Environmental Finance documents whether an issuance adheres to a number of components that indicate green credentials of the bond. More specifically, Environmental Finance records, where available, the following data: (1) the bond's use of proceeds, following the categorization as set out in the GBP; (2) whether the bond adheres to a set of standards, either the GBP or national standards; (3) the SPO report; (4) the assurance report; (5) the certification documents; and (6) the ICMA review form that provides a summary format for various external verification. By correctly grouping these indicators according to the integrity principles, the Environmental Finance dataset provides reasonably extensive data to construct the DISC score.

Although Environmental Finance provides data regarding the before mentioned indicators, there is a number of crucial limitations that require a manual correction. First, Environmental Finance uses a slightly different definition of assurance and SPO than this thesis. In some cases, Environmental Finance groups an assurance under the SPO, as opposed to the categorization used in this thesis. Second, a robustness check of the Environmental Finance database indicates that a significant amount of assurance engagements has not been identified by Environmental Finance. Thus, it could be the case that an issuance has a lower or different DISC score than it should have, given that the DISC score wrongly assigns a zero to the assurance engagement or a one to the SPO.

To overcome these problems, we manually check compliance of a green bond to the integrity principles, using Environmental Finance as a starting point. We solve definition problems by textually analysing the respective report of the SPO provider or the assurance party. When the report specifically mentions that an assurance engagement has been performed, we mark the DISC score accordingly. We verify completeness of the database by checking the issuers website, as well as sustainability reporting for potential documents regarding the green bond issuance that Environmental Finance has missed. In other words, when the documentation is not readily available, the issuance receives no score for the respective part of the DISC score. Furthermore, given the strictness of the CBS (2018c) to verify the green credentials of the bonds, we make the assumption that a bond with a green bond certificate received an assurance engagement, even when we find no documentation about this engagement. Notably, although the certificate does not require an SPO, there is still sustainability verification of the bond, due to the strict eligibility standards of green bond projects under the certificate. Where necessary, we further complete the Environmental Finance database by using this manual approach. Last, we exclude Africa and Oceania, due to language barriers and other problems related to the data

collection process. The total dataset of 516 issuances is checked according to this method, also indicating that we scored a total of 516 issuances according to the components of the DISC sore.

Table 2 below provides an overview of the total dataset of 516 bonds that we scored according to the DISC score. Overall, the number of bonds that we scored for the integrity principle reduces with the expected intensity of the principle; where the majority of bonds complies to standards and has received an SPO, the minority of bonds has an assurance engagement or a certificate. Overall, this table indicates that there is large segmentation in the market when it comes to levels of verification and intensity of verification. Importantly, this segmentation confirms the concerns for heterogeneity in the quality of the bond behind the green bond signal, while showing support for the differences in intensity related to the integrity principles.

Table 2:
Summary statistics for DISC dataset

		Standards	SPO	Assurance	Certification	N
Total	*Proportion*	0.75	0.62	0.23	0.095	
	N	401	331	124	49	516

Notes:
The table lists the proportion and number of bonds score for the four integrity principles in the DISC dataset. Bonds issued in Oceania and Africa have been excluded.

5.2 Matching methodology

Zerbib (2018) notes that typical empirical methods used in CSR literature to analyse bond spreads leverage a specified OLS regression. Examples are the researches performed by Baker et al. (2018) and Partridge & Medda (2018). Furthermore, Zerbib argues that such a method requires determining the intrinsic financial – and non-financial characteristics that drive the yield of the bond, while at the same time ensuring the robustness of the specification.

Researching the green bond market allows for a different approach (Zerbib, 2018). More specifically, analysing the effect of the self-labelling of the green bond (the green signal) allows for a matching methodology, where the effect of the green signal can be isolated. Such a methodology requires the matching of a green bond to two conventional bonds with exactly the same underlying characteristics except the characteristic of interest: the green bond labelling by the issuer. Hence, a potentially significant yield spread between the green bond and the matched conventional bonds is caused by the isolated green signal.

In line with Zerbib (2018), this thesis matches bonds based on the following criteria,

which are key determinants of the intrinsic value of the bond: currency, rating, presence of a call feature, seniority, collateral and coupon type, while the maximum deviation of the maturity can be two years. Another determinant of the value of the bond is liquidity (Chen et al. 2007; Dick-Nielsen et al. 2012), which can be assessed by the issue amount and the issue date (Bao et al. 2011; Houweling et al. 2005). In this line, the green bond can only be matched to conventional bonds issued two years later - or earlier than the green bond and to conventional bonds with an issue amount that is between one quarter-and four times the issue amount of the green bond. One deviation from the Zerbib method is the matching of bonds by industry type; where Zerbib only matches by *issuer*, this matching method also matches by industry type (BICS Classification Type 2), to ensure a sufficient sample size.

The final determinant of the value of the bond is the time to maturity of the bond: bonds with a longer maturity are typically valued lower (with higher yields) as a longer time horizon implies higher risk. However, accounting for maturity bias by matching bonds with the exact same maturity is difficult and would significantly reduce the dataset. To still account for maturity bias, a synthetic bond is created. The yield of the synthetic bond is linearly extrapolated or interpolated using the relation between the yield and maturity of the two conventional bonds for the maturity of the green bond. When it is only possible to find one exact conventional bond match and the maturity of the conventional bond and the green bond is the same, the green bond is solely matched to the respective conventional bond.

More specifically, the extrapolation (interpolation) is done in the following way. The yield of a synthetic bond $\tilde{y}^{SB}$ is calculated by determining the linear relationship between conventional bond 1 (CB1) and conventional bond 2 (CB2), y^{CB1}, y^{CB2} at the maturity of the green bond ($Maturity_{GB}$). Figure 4 in appendix C visualizes this interpolation or extrapolation methodology. The linear relationship between the conventional bonds is defined as follows:

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

With *a* being the slope and *b* being the intercept of the linear function passing through ($Maturity_{CB1}$, y^{CB1}) and ($Maturity_{CB2}$, y^{CB2}). Finally, the yield spread between the green bond and the synthetic conventional bond is determined by calculating the difference between the yield of the green bond and the synthetic bond. *This green bond spread* per bond i is defined as the difference in ask yield between the green bond and synthetic conventional at time t, where the daily ask yield, taken at the end of the trading day, is exported from the Bloomberg Fixed Income Database. The green bond spread is expressed in the following way:

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

After the matching procedure, the total dataset entails 95 bonds that are matched according to the methodology listed above, with 26,797 daily observations of $\Delta\tilde{y}_{i,t}$.

6. Empirical strategy and descriptive statistics

6.1 Empirical strategy

The empirical strategy used in this thesis is two-fold. First, the green bond premium is calculated by estimating the entity specific fixed-effect after controlling for residual liquidity. Second, the effect of verification, as measured by the DISC score and the integrity principles, on the green bond premium is estimated. This is done by first investigating the overall effect of the DISC score on the green bond premium and then researching the individual effect of the integrity principles. Furthermore, the equations used to assess these effects include a number of control variables that are deemed relevant by the literature regarding the determinants of the green bond premium (Zerbib, 2018).

6.1.1 Green bond premium

The first step of the empirical strategy entails the estimation of the green bond premium, as proposed by Zerbib (2018). Although the matching methodology controls for the majority of green bond pricing determinants, it is still necessary to control for the liquidity difference between the green bond and the synthetic bond. Zerbib (2018) highlights that a fixed effects regression requires a variable that is time variant, other than the issue amount and issue date that are proposed by Bao et al. (2011) and Houweling et al. (2005). Such a fixed effects regression allows for the estimation of the time invariant, individual effect of the difference in liquidity on the yield spread between each matched bond pair, irrespective of the characteristics of the other bonds. Thus, the green bond premium, $greenium_i$ is calculated by using a fixed-effects panel regressing $\Delta\tilde{y}_{i,t}$ on $\Delta Liquidity_{i,t}$. Consequently, $greenium_i$ is the unobserved, fixed effect of this panel regression, given that the matching procedure as well as the panel regression control for all drivers of the value of the respective bond, other than the green signal. The equation used for the panel regression can be defined as follows:

$$\Delta\tilde{y}_{i,t} = greenium_i + \beta\Delta Liquidity_{i,t} + \varepsilon_{i,t}, \text{ where } \varepsilon_{i,t} \text{ is the error term} \quad (1)$$

As such, a significantly negative value of $greenium_i$ would imply the existence of a green bond premium, since investors are then willing to forego yield for the green bond, relative to the synthetic bond. Importantly, a variable is created that measures the difference in liquidity between the green bond and the conventional bonds: $\Delta Liquidity_{i,t}$. This variable can be defined as follows:

$$\Delta Liquidity_{i,t} = Liquidity_{i,t}^{GB} - Liquidity_{i,t}^{CB} \qquad (2)$$

Additionally, Zerbib (2018) highlights two other constraints that arise when controlling for liquidity. First, the data used is low-frequency data, meaning that a low-frequency liquidity proxy should be used. Second, there is no data-available regarding trading volumes, excluding daily trading volumes as a liquidity proxy (Dick-Nielsen et al. 2012). Therefore, the percent quoted bid-ask spread is used to calculate the liquidity, which Fong et al. (2017) argue to be the most suitable low-frequency liquidity proxy.

As a synthetic bond is created from two conventional bonds to be able to correctly estimate the green bond premium, the bid ask spread is also calculated using the same two conventional bonds. More specifically, the bid ask spread is calculated as the distance weight average of the bid-ask spreads of CB1 and CB2. The synthetic bond's bid ask is defined by Zerbib (2018) in the following way:

$$BA_{i,t}^{SB} = \frac{d_2}{d_1+d_2} BA_{i,t}^{CB1} + \frac{d_1}{d_1+d_2} BA_{i,t}^{CB2} \quad (3)$$

In this equation, d_1= Green Bond Maturity – CB1 maturity and d_2= Green Bond Maturity – CB2 maturity. Then, BA is calculated in line with Fong et al. (2017)[1].

Hence, $\Delta \mathrm{BA}_{\mathrm{i,t}} = \mathrm{BA}_{\mathrm{i,t}}^{\mathrm{GB}} - \mathrm{BA}_{\mathrm{i,t}}^{\mathrm{SB}}$, which is consequently the independent variable $\Delta Liquidity_{i,t}$ calculated in equation (2).

A number of tests is performed to ensure robustness of the analysis. First, a Hausman test is performed to assess the robustness of using a fixed-effects model and the analysis is tested for heteroskedasticity. Similarly, the Woolridge test is used to check for serial correlation, given that data is collected repeatedly over time.

6.1.2 Determinants of the green bond premium

After estimating the existence, significance and magnitude of the green bond premium, the goal of this research is to assess whether the credibility of the green signal is a determinant of the green bond premium. The aim of the second step of the methodology is to assess this potential relation, by looking at the main indicators of interest, the DISC score and the integrity principles, as well as other potential determinants that have been highlighted by Zerbib (2018). An overview of these variables and their description can be found in table A.4 in appendix A.

[1] $Percent\ Quoted\ Spread_t\ (BA) = (Ask_t - Bid_{\ t})/(\frac{Ask_t + Bid_t}{2})$

To investigate the effect of these determinants, the methodology of Zerbib (2018) is used, which entails a linear regression, where the dependent variable is the green bond premium $\widehat{greenium}_i$ of bond *i,* that has been isolated in equation (1). The OLS specification is formulated in the following way:

$$\widehat{greenium}_i = \alpha_i + \beta_1 DISC_i + \beta_2 lnamount_i + \beta_3 maturity_i + \gamma_1' Rating_i + \gamma_2' Currency_i + \gamma_3' Sector_i + \varepsilon_i \quad (4)$$

Where the vector $Rating_i$ represents the rating factor variables of the bond, where the factor variable takes the value of one for the respective rating of the bond. The vector $Currency_i$ represents the currency factor variables of the bond, where the factor variables takes the value of one for the currency of the bond. The vector $Sector_i$ represents the sector factor variables of the bond, where the factor variable takes the value of one for the applicable sector of the bond. Finally the coefficient β_1 is the main coefficient of interest, which represents the effect of the DISC score on the bond specific premium green bond premium, $\widehat{greenium}_i$. A detailed description of the control variables can be found in table A.4.

The DISC score of the bond is defined as:

$$DISC_i = Standards_i + SPO_i + Assurance_i + Certification_i \quad (5)$$

As indicated in previous sections, the components of the DISC score are all factor variables, taking on the value of one when the bond issuance complies to the respective integrity principle of the factor variable. Thus, the constructed variable $DISC_i$ can take the value of one to four, where the score is calculated assuming an equal weight of the underlying components.

Then, to research the individual effects of the components of the DISC score, the following equation is formulated, splitting up the DISC score into the integrity principles:

$$\widehat{greenium}_i = \alpha_i + \beta_1 Integrityprinciples_i + \beta_2 lnamount_i + \beta_3 maturity_i + \gamma_1' Rating_i + \gamma_2' Currency_i + \gamma_3' Sector_i + \varepsilon_i \quad (6a)$$

Where the vector variables $Financial_i$, $Rating_i$, $Currency_i$ and $Sector_i$ and their coefficients can be interpreted in the same way as in equation 4. The main coefficient of interest is β_1, which serves as the effect of the vector for $Integrityprinciples_i$ on $\widehat{greenium}_i$. The vector $Integrityprinciples_i$ consists out of factor variables that represent the integrity principles and take on the value of one if a bond confirms to the respective integrity principle. Notably, hypothesis 3a is aimed at investigating the overall effect of external review and its underlying

components. To investigate this overall effect of external review, an alternative equation is formulated, substituting *SPO* and *Assurance* for the variable *External Review.*

This equation is formulated in the following way:

$$\widehat{greenium}_i = \alpha_i + \beta_1 IntegrityprinciplesER_i + \beta_2 lnamount_i + \beta_3 maturity_i + \gamma_1' Rating_i + \gamma_2' Currency_i + \gamma_3' Sector_i + \varepsilon_i \quad (6b)$$

In this equation, $IntegrityprinciplesER_i$ is a slightly adapted version of the vector $Integrity\ Principles_i$, where the underlying factor variables SPO and assurance are replaced by the factor variable External Review. This factor variable takes the value of one if the bond has *either* assurance or an SPO. A number of robustness tests is performed with regard to all the models of both specifications. First, the Breusch-Pagan test is used to identify the potential presence of heteroskedasticity. Furthermore, a VIF test is used to check for potential multicollinearity among the independent variables in equation 6a and 6b (O'Brien, 2007).

6.2 Descriptive statistics

The following section reports the key statistics of the sample of this study, thereby providing some initial indications regarding the hypotheses. Statistics are provided about the green bond sample to review the variety among green bonds in the sample, about the DISC score to review global variety among the DISC score and about the matching procedure to review the effectiveness of the matching procedure.

6.2.1 Green bond sample

Table 3 gives an overview of the key characteristics of the final green bond sample, after matching and creating the DISC score. The bonds are further segmented by currency, credit rating and sector. The characteristics that are used to describe the bonds are the average yield, average maturity and the number of green bonds. All bond characteristics are listed per sub-segment.

First, variation in yield appears to be especially large among the currency in which the bond is issued. Where average yield of bonds denominated in EUR and SEK is relatively small and concentrated around 1 percent to 2 percent, bonds denominated in USD appear to have more varying yields that reach higher levels. Specifically, yields of bonds denominated in USD are fluctuating from 2 percent 5 percent. Interestingly, there does not appear to be a clear relationship between yield and rating or yield and maturity among sectors or currencies.

Second, maturity varies among sector, currency and rating, while generally being below

10 years and concentrated around 5 years. Contrary to the variation in average yield, there appears to be constant variation in the maturity of the bond and the sector, region or rating of the bond. Only investment grade bonds issued in the utilities sector in the Americas and the bond denominated in GBP have a relatively large maturity of around 25 to 30 years.

Third, the number of bonds in the sub-segments varies largely among currency, rating and sector in which the bond is issued. Clearly, a large amount of bonds in the sample is denominated in EUR while issued in the financial sector, with 32 bonds in this sub-segment. Moreover, a significant amount of the bonds in the sample, 22 bonds, is non-rated, indicating that the bonds have not been rated by one of the major credit rating agencies. Similarly, the majority of bonds issued in USD is issued by companies active in the financial sector, while most bonds are investment grade. Then, another large segment of bonds in the sample is issued in the utilities sector and denominated in EUR or USD. The residual sectors display equal variation in the number of bonds, while it is clear that only a relatively small amount of the bonds is issued in these sectors.

In sum, it is evident that the number of bonds included in the sample is relatively concentrated in the financial sector in EUR and USD. At the same time, yields appear to vary mostly among the currency in which the bonds is issued, with less concentrated, and higher yields of USD bonds, while yields of EUR and SEK denominated bonds are more concentrated and relatively low. Last, the majority of green bonds is investment grade, with sixty-nine bonds in the sample being investment grade.

Table 3:
Descriptive statistics of 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								
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
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
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								
A	Avg. yield GB (%)		1.85					4.07
	Avg maturity GB (yrs.)		7.94					29.98
	No. of GB		6					2
AA	Avg. yield GB (%)							3.68
	Avg maturity GB (yrs.)							30.49
	No. of GB							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					

Notes:
Average yield, maturity and number of bonds in the sample are reported by currency, sector and rating.
Ratings are grouped by their letter, regardless of their sign (see table A.4).

6.2.2 DISC score sample

One of the main variables of interest in this research is the DISC score, which seeks to measure the extent to which investors can verify the green credentials of the green bond. Table 4 lists the descriptive statistics of the four components of the DISC score: standards, SPO, assurance and certification. Notably, there is a split between the full dataset and the sample of matched green bonds. This allows for a comparison of the full dataset of green bonds that have been scored for the four components of the DISC score (integrity principles) with the sample used for this thesis. Moreover, the descriptive statistics provide first insights into whether the distribution of the scoring of the integrity principles is in line with the intensity of the of the respective principle.

Comparing the full dataset of bonds that received a score for the integrity principles to the bonds that received scores in the sample, it is evident that the proportion of bonds that have standards, an SPO and certification in the sample is slightly overestimated for all principles. Notably, the scoring for Assurance differs most, with 31% of bonds having assurance in the sample, compared to 23% in the entire dataset. Still, the relative scoring of the integrity principles within the overall sample is distributed in the expected way and similar to the relative scoring within the full dataset. The higher the intensity of the integrity principle, the lower the amount of bonds that have received a score. As such, it appears that the sample used for the empirical research is a seemingly good representation of the full dataset of green bonds that have been scored according to the DISC score in the financial and corporate sector of the Environmental Finance Database.

Table 4
Descriptive statistics integrity principles sample

	Standards		SPO		Assurance		Certified		N	
	Full	Sample	Full	Sample	Full	Sample	Full	Sample	Full	Sample
Proportion	75%	83%	62%	67%	23%	31%	9.5%	12%		
N	401	79	331	64	124	29	49	11	516	95

Notes:
The table lists the proportion and number of bonds for the integrity principles in the sample of 95 bonds. A comparison is made between the full dataset of DISC scores and the sample with matched green bonds

6.2.3 Matched sample

The descriptive statistics in table 5 provide an overview of the main characteristics of the green bonds, the matched conventional bonds and the synthetic bonds. Specifically, the characteristics that are provided allow for a relevant review of the matching procedure, as these characteristics cannot be matched perfectly. Moreover, the GB spread gives a first indication of the spread between the green bond and the synthetic bond and, thereby, the green bond premium.

First, it is relevant to review the yield and maturity of the matched bonds and the yield and maturity of the green bond versus the conventional bonds specifically. Importantly, both the mean yield and the maturity of CB1 are lower than the mean yield and the maturity of CB2 and the green bond. This indicates that the main assumption behind the extrapolation and the interpolation of the synthetics bond, the positive relationship between maturity and yield, holds. At the same time, the maturity and the yield of CB2 is higher than the maturity and yield of the green bond. As such, the maturity of the synthetic bond lies between that of the conventional bonds, indicating that the majority of synthetic bond yields has been interpolated.

Second, the statistics regarding the issue amount and the maturity provide an indication of the correctness of the matching procedure, given that these characteristics are not matched directly, but are matched using broader constraints. The maturity can deviate at most 2 years below or above the maturity of the green bond. As the table indicates, this condition holds for both conventional bonds, among all statistics. Then, the issue amount cannot be lower than 1/4th the issue amount or more than 4 times the issue amount of the green bond. Table 5 shows that this matching criteria is also correctly followed, with the issue amount of both conventional bonds lying closely to the issue amount of the green bond for all of the statistics.

Third, the green bond spread gives a first indication of the possible existence of a green bond premium. Notably, this spread still needs to be corrected for liquidity. As the table indicates, the mean spread is minus 24 basis points, indicating that investors appear to pay a premium on average. Moreover, the highest premium (minimum spread) that is paid corresponds to -233 basis points, whereas the lowest premium (maximum spread) implies a green bond discount;: some investors pay 198 basis points more for the green bond than the synthetic bond. Importantly, this highlights significant variation among the green bond spread.

Table 5:
Descriptive statistics of the matched bonds

	Min	1st. Quart	Median	Mean	3rd Quart.	Max
Nr. of days per bond	1	0.74	172	242.61	330	1292
Ask yield % (y^{GB})	0.12	0.74	1.85	1.89	2.81	5.7
Ask yield SB ($\tilde{y}^{SB}$)	0.10	0.83	1.79	2.13	3.26	7.32
Ask yield CB1 (y^{CB1})	0.03	0.63	1.50	1.74	2.55	5.97
Ask yield CB2 (y^{CB2})	0.18	0.9	2.31	2.26	3.31	6.44
GB spread ($\Delta\tilde{y}_{i,t}$)	-2.33	-0.50	-0.15	-0.24	0.09	1.42
Maturity GB (yrs.)	3.00	5.00	6.00	7.77	8.00	31
Maturity CB1	1.49	4.00	5.00	6.78	7.00	30.11
Maturity CB2	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	6	338	533.	616	802	3000
CB2 issue amount	9	307	600	674	812	3250

Notes:
The table lists relevant statistics to assess the matching procedure; the yield, maturity and issue amount. The GB spread is the difference in yield between the Green Bond and the Synthetic Bond. The number of weeks per bond is the length of the time series per entity in the panel data.

Table 6 shows the descriptive statistics of the bid-ask spread between the green bond and the synthetic bond in the sample. Notably, the bid-ask spread is the independent variable "$\Delta Liquidity_{i,t}$" that is calculated in equation 1 to calculate the entity specific green bond premium in the panel regression. The table provides two relevant insights. First, it shows that the mean bid-ask spread is positively concentrated around zero. This outlines that green bonds are slightly less liquid than the conventional bonds. Second, the small spreads show that the liquidity matching proxies, issue date and issue amount are good proxies for liquidity (Zerbib, 2018).

Table 6:
Descriptive statistics bid-ask spread

	Min	1st Quart	Median	Mean	3rd Quart.	Max	St.Dev
ΔBA	-0.0093%	-.0005%	0.0001%	0.0004%	0.0008%	0.0451%	0.0024%

Notes:
The table lists statistics that indicate the entity-specific variation of the bid-ask spread over the panel period. ΔBA is the difference between the green bonds' bid-ask spread and the conventional bonds' distance-weighted average bid-ask spread, in a specific pair of bonds, during the panel period.

7. Results

The following chapter provides the results of the empirical methodology set out in the previous section to determine the existence and magnitude of the green bond premium and its potential determinants. The first section will take a closer look at the existence of a green bond premium in the sample and for a number of subsamples, to investigate evidence for hypothesis 1. Then, the second section will investigate possible determinants of the green bond premium, focussing on the DISC score to investigate evidence for hypothesis 2 and the integrity principles to investigate evidence for hypothesis 3a, 3b and 3c and hypothesis 4. The third section will outline the results of a number of analyses that serve as robustness checks.

7.1 Green bond premium

The first part of the analysis in this thesis investigates the existence of a green bond premium, through controlling for the residual difference in liquidity between the green bond and the synthetic bond that is indicated in table 6. By controlling for this residual liquidity, the variation in the bond specific fixed-effect $\widehat{greenium_i}$ is estimated, as defined in equation 1. Recall that negative values of $\widehat{greenium_i}$ indicate the existence of an estimated premium for a specific green bond. Before performing the analysis, a number of robustness checks is performed to check for heteroskedasticity and autocorrelation. The Hausman test provides mildly significant evidence in favour of the fixed effects model. Then, a Woolridge-test shows the existence of serial correlation and the Breusch-Pagan test indicates heteroskedasticity. Thus, the model is specified using a fixed effects model with robust estimation of standards errors. Table B.1 in appendix B gives an overview of these robustness tests.

Table 7 lists the results of equation 1. The main variable of interest is the fixed effect, which corresponds to the variable $greenium_i$ in the estimation of the model. As can be derived from the results of specification 1 in table 7, the coefficient $\Delta Liquidity_{i,t}$ is close to zero and not significant. This implies that liquidity has no significant effect on the yield spread between the green bond and the synthetic bond. Moreover, the regression holds a low r-squared, implying a low explanatory power of the specification. Still, $Greenium_i$ is highly significant and negative, while its value indicates an economically significant entity specific fixed-effect of around minus 24 basis points.

This result indicates that investors are willing to a pay a premium for bonds that are labelled as green, given that the matching procedure controls for the underlying characteristics of the matched pairs of bonds while the model controls for the residual liquidity. Ergo, this result provides evidence in support of hypothesis 1.

Table 7:
Estimation results green bond premium

	Dependent variable: $\Delta\tilde{y}_{i,t}$
$\Delta Liquidity_{i,t}$	2.5058
	(0.89)
$Greenium_i$	-0.2394***
	(-192.68)
Observations	26797
R^2	0.012
F	0.7984

Notes:
The table shows the results of equation 1: $\Delta\tilde{y}_{i,t} = greenium_i + \beta\Delta Liquidity_{i,t} + \varepsilon_{i,t}$.

The panel regression is estimated with fixed-effects
t statistics in parentheses
* p<0.10, ** p<0.05, *** p<0.01
Robust Standards Errors

Then, table 8 gives an overview of the distribution of the green bond premium, $\widehat{Greenium}_i$, of the 95 bonds in the sample. The value of $\widehat{Greenium}_i$ ranges from a negative 223.1 basis points to a positive 137.6 basis points, indicating that investors are willing to pay a maximum green bond premium of 223.1 basis points for the green bonds compared to the synthetic bonds. Moreover, the table indicates that investors pay an average green bond premium of around -23.2 basis points for green bonds, while the majority of the bonds is characterized by a green bond premium, as indicated by the median green bond premium of around -14.8 basis points.

Table 8:
Distribution of green bond premium

$\widehat{Greenium}_i$ (%)							
Min	p25	Median	Mean	p75	max	St.Dev	N
-2.231	-0.463	-0.148	-0.232	0.083	1.376	0.597	95

Notes:
The table lists distribution of the entity-specific fixed effect, $\widehat{Greenium}_i$, from equation 1: $\Delta\tilde{y}_{i,t} = greenium_i + \beta\Delta Liquidity_{i,t} + \varepsilon_{i,t}$.

The final part of the analysis of the green bond premium further investigates the distribution of the green bond premium by breaking down the sample into several subsamples. Specifically, the sample is broken down by sector, currency and rating. The average premium and the median

premium is calculated per subsample, while investigating the significance of the premium. Only subsamples that contain at least ten bonds are included in the analysis. As the Shapiro-Wilk normality test rejects the normality assumption, the Wilcoxon signed-rank test is used to assess the significance of the subsamples. Table 9 lists the mean and median premium per subsample, as well as the results of the Wilcoxon signed-rank test by subsample. The table shows that the average green bond premium of -23.2 basis points is highly significant. Furthermore, the only segments that do not document a premium that is at least significant at the 10 percent level are the sample of bond issued in the utilities sector and the sample of NR rated bonds. Breaking down the sample by currency, it is evident that bonds denominated in USD have the largest premium. Breaking down the sample by rating yields further interesting results. The green bond premium is largest for BBB bonds, implying that the premium is the highest for the riskiest bonds in the sample. At the same time, no conclusions can be drawn regarding a relation between riskiness of the bonds and the green bond premium, given that the premium of NR bonds is mildly significant and similar in magnitude compared to the premium of A rated bonds. The most important result of the table is the average green bond premium of -23.2 basis points in the entire sample of green bonds. This result presents further evidence in favour of hypothesis 1, implying that investors in the secondary market pay a premium for green bonds.

Table 9:
Green bond premium broken down by subsample:

		Mean ($\widehat{Greenium_t}$)	Median ($\widehat{Greenium_t}$)	$\widehat{Greenium_t} \neq 0$	No. GB
	Total	-0.232	-0.148	***	95
Sector	Financial Institution	-0.236	-0.149	***	67
	Utilities	-0.198	-0.019		18
Currency	EUR	-0.179	-0.148	***	43
	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

Notes*:*
Only segments with at least 10 observations are included.
Significance of the premia calculated with Wilcoxon signed-rank test.
* p<0.1; ** p<0.05; *** p<0.01.

7.2 Determinants of the green bond premium

The second part of the analysis is aimed at investigating the determinants of the green bond premium. It does so by first investigating whether verification, as measured by the DISC score, matters in the green bond market. Furthermore, heterogeneity in the effect of the constituents of the DISC score, the integrity principles, on the green bond premium is investigated.

7.2.1 The effect of verification on the green bond premium

To research the effect of verification on the green bond premium, the variable $DISC_i$ is calculated in equation 5 and then used in equation 4 to perform a regression of $\widehat{Greenium_i}$ on the DISC score. The Breusch-Pagan test indicates the presence of heteroskedasticity for a number of different models of equation 5, while the VIF test shows no concerns for multicollinearity (see table B.2 in appendix B) Hence, the regression equation is estimated with a robust estimation of standard errors. To ensure that the r-squared of the models is not driven up artificially through the inclusion of multiple dummies, dummies for which there are no more than three observations are dropped. The results of the different specifications of equation 4 are presented in table 10 below. Notably, specification 1 to 4, displayed in respectively column (1), (2), (3) and (4), are different variations of the equation to investigate the explanatory power of different characteristics of the bond that can be potential determinants of the green bond premium. The first model only investigates financial effects and rating effects, adding respectively currency effects and sector effects in specification 2. Specification 3 includes the overall effect of the DISC score on the green bond premium. Then, specification 4 breaks down the effect of the DISC score by the individual score.

Investigating the explanatory power and the significance of the specifications, it appears that specification 1 and specification 2 both have a low r-squared and an insignificant F-statistic, indicating that the models have low explanatory of the variance $\widehat{Greenium_i}$. The full model, including the DISC score, appears to have the most explanatory power with an adjusted r-squared 0.096. Moreover, the model including the DISC score is the only model with a mildly significant F statistic at the 10 percent level.

Note that negative coefficients on $\widehat{Greenium_i}$ indicate an increase in the green bond premium. All specifications of the model show that both financial effects as well as sector effects do not significantly influence $\widehat{Greenium_i}$. At the same time, the specifications show that bonds with rating NR have a premium that increases with -35 basis points compared to bonds with the baseline rating AA. Moreover, specification 2, 3 and 4 show that bonds with

rating A also have a green bond premium that increases with -33 to -38 basis points compared to the baseline. Then, specification 3 and 4 indicate that bonds denominated in USD have a green bond premium that is -25 to -28 basis points higher than bonds denominated in the reference modality EUR. Notably, none of the coefficients is highly significant at the 5 percent level, indicating mild evidence for the effect of the variables.

Specification 3 lists the effect of the main variable of interest, the DISC score. The negative coefficient of 24 basis points indicates that an increase by 1 of the DISC score increases the green bond premium by -24 basis points. Moreover, the effect is significant at the 1 percent level, providing strong evidence for the effect of the coefficient. This result provides sufficient support for hypothesis 2, given that the highly significant -24 basis points increase in $\widehat{Greenium}_i$ for a higher DISC score can be translated into a -24 basis points increase in the green bond premium that investors in the secondary market pay for a higher level of verification of the green bond credentials.

Specification 4 provides a first indication of the effect of the constituents of the DISC score on the green bond premium. As the results show, green bonds with a DISC score of 1 have no significantly higher green bond premium. Then, a DISC score of 2 and a DISC score of 3 increase the green bond premium by respectively -62 basis points and -95 basis points, where the effect of a DISC score of 2 is highly significant, all compared to a DISC score of 0. Interestingly, green bonds that have a DISC score of 4 do not exhibit a higher green bond premium than bonds with a DISC score of 3. Notably, only green bonds that are certified can have a DISC score of 4. This provides a first indication of the heterogeneity within the effect of the constituents of the DISC score. Still, a more credible green bond signal, as measured by the DISC score, does increase the green bond premium for bonds that have a DISC score that is higher than 1.

Table 10:
Estimation results DISC score

	Dependent variable: $\widehat{Greenium_i}$			
	(1)	(2)	(3)	(4)
Financial Effects				
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 Effects (1=yes)				
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)
Currency Effects (1=yes)				
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 Effects (1=yes)				
Financial		0.13	0.24	0.22
		(0.63)	(1.39)	(1.25)
Government		0.23	0.42	0.42
		(0.76)	(1.61)	(1.64)
Consumer Discretionary		0.51	0.53	0.49
		(1.52)	(1.52)	(1.32)
DISC Score (0-4)				
Disc			-0.24***	
			(-2.67)	
Disc Score (1=yes)				
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	-0.29	-0.22	0.15	0.39
	(-0.88)	(-0.44)	(0.32)	(0.79)
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	1.05	0.95	1.78	1.49

Notes*:*
The table lists the results of equation 4: $\widehat{greenium_i} = \alpha_i + \beta_1 DISC_i + \beta_2 lnamount_i + \beta_3 maturity_i + \gamma_1' Rating_i + \gamma_2' Currency_i + \gamma_3' Sector_i + \varepsilon_i$.

Reference modalities: rating is rating AA, currency is EUR, sector is Utilities, DISC is 0.
t statistics in parentheses.
* p<0.10, ** p<0.05, *** p<0.01.
Robust standard errors.

7.2.2 The effect of the integrity principles on the green bond premium

Since the results of equation 4 do not further specify whether there are differences in the effect of the underlying integrity principles of the DISC score, the DISC score is broken down by its components in regression equation 6a and 6b. The specifications of the equations are estimated with robust standard errors, given that the Breusch-Pagan test shows concerns for heteroskedasticity. There are no specific concerns for multicollinearity (see table B.3 in appendix B). Table 11 lists the results of different specifications of equation 6a and the results of specification 6b. To build towards the most efficient specification of the effect of the integrity principles on the green bond premium, the specification are provided in the following way. Column (1), (3) and (4) list different specifications of equation 6a, respectively adding standards, SPO, assurance, certification and an interaction between SPO and assurance to the regression specification. Column (2) shows the result of the overall effect of external review that is included in equation 6b. All specifications account for the same financial, currency and sector effects. The full results of the model are provide in table A.5 in appendix A.

The explanatory power of specification 1 is rather low, given the low adjusted r-squared, while the model reports no significant F-statistic. Adding external review in column (2) yields a significant model with more explanatory power. Moreover, adding assurance and SPO and an interaction between the two variables in column 3 and column 4 yields a highly significant model with good explanatory power compared to Zerbib (2018). Including certification in specification (4) gives no meaningful extra explanatory power to the specification nor a more significant specification, compared to excluding certification in specification 3.

In order to correctly interpret the results, note that negatives values of the dependent variable $\widehat{Greenium_i}$ imply a green bond premium. Investigating the regression coefficients of the integrity principles in the different specifications yields interesting results. First, specification 1 shows that there is no significant relation between alignment with standards and the green bond premium. Then, investigating the variable external review in specification 2 yields a highly significant and negative coefficient. The result highlights that an external review increases the green bond premium by -113 basis points. Comparing the coefficient of external review to the coefficient of standards implies evidence in favour of hypothesis 3a; investors pay a higher green bond premium for bonds with an external review than bonds that are aligned with standards.

To further compare and investigate the individual effect of both SPO and assurance, the variables are both separately included in specification 3. The table indicates that an SPO and

assurance increase the green bond premium by -111 and -113 basis points respectively. Table 11 further shows that the difference between the coefficients is only 2 or 4 basis points and changes in direction depending on whether certification is included in the model. This indicates that there are no meaningful differences in the green bond premium that investors pay for bonds that have assurance compared to bonds that have an SPO. Hence, there is no evidence in favour of hypothesis 3b: stating that investors pay a higher green bond premium for bonds that have assurance than bonds that have an SPO. To investigate hypothesis 3c, which hypothesises the potential complementary effect of having *both* assurance and SPO, an interaction term between SPO and assurance is added in specification 3 and 4. Interestingly, the significantly positive interaction term of 91 basis points or 95 basis points indicates a decreasing marginal premium when bonds have both assurance and SPO. Hence, the effect of a bond also gaining assurance (SPO) on top of having an SPO (assurance) is smaller than a bond gaining assurance (SPO) when the bond has no other form of external review. This result supports hypothesis 3c, highlighting that the green bond premium is higher when a bond has both assurance and an SPO. Still, it is important to note that the complementary effect is not as large as the sum of the individual effects.

Finally, the insignificant coefficient of certification in specification 4 indicates that a certified bond does not have a significantly higher green bond premium, which further implies that bonds that are certified do not exhibit a green bond premium that is higher than bonds that have both assurance and an SPO. This result shows that there is no evidence supporting hypothesis 4; investors do not intrinsically value a green bond certificate on top of having assurance or an SPO. Notably, the constant is positive and becomes significant when including the variable external review or both SPO and assurance in the regression specification. This further indicates that the negative variation in $Greenium_i$, the green bond premium, is significantly accounted for by the variables assurance and SPO.

Table 11:
Estimation results integrity principles

	Dependent variable: $\widehat{greenium}_i$			
	(1)	(2)	(3)	(4)
Integrity Principles (1=yes)				
Standards	-0.17	0.19	0.19	0.21
	(-0.78)	(1.10)	(1.07)	(1.22)
SPO			-1.11***	-1.12***
			(-4.38)	(-4.44)
Assurance			-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)
Controls				
Financial effects	Yes	Yes	Yes	Yes
Rating effects	Yes	Yes	Yes	Yes
Currency effects	Yes	Yes	Yes	Yes
Sector effects	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	0.94	2.87	2.52	2.53

Notes*:*
The table lists the results of equation 6a in column (1), (3) and (4): $\widehat{greenium}_\iota = \alpha_i + \beta_1 Integrityprinciples_i + \beta_2 lnamount_i + \beta_3 maturity_i + \gamma_1' Rating_i + \gamma_2' Currency_i + \gamma_3' Sector_i + \varepsilon_i$.

The table lists the results of equation 6b in column (2): $\widehat{greenium}_\iota = \alpha_i + \beta_1 IntegrityprinciplesER_i + \beta_2 lnamount_i + \beta_3 maturity_i + \gamma_1' Rating_i + \gamma_2' Currency_i + \gamma_3' Sector_i + +\varepsilon_i$.

Reference modalities controls: rating is rating AA, currency is EUR, sector is Utilities.
Full table listed as table A.5 in appendix A
t statistics in parentheses.
* p<0.10, ** p<0.05, *** p<0.01.
Robust Standards Errors.

7.3. Robustness checks

The subsections below present a number of analyses that are performed to assess the robustness of the results in the previous sections. First, a Heckman test is conducted to address potential concerns for sample selection bias. Second, a random effects model is formulated to research whether the results substantially differ from the fixed effects model. Third, a number of sub-sample analyses are performed to judge whether the results hold for underlying segments of the sample

7.3.1 Heckman test

One potential concern of the results estimated with equation 6a is sample selection bias. This problem arises when data is missing regarding the dependent variable of the analysis (Heckman, 1977). Recall that the dataset is created from Environmental Finance, which includes 516 bonds for which data is available regarding the independent variables of interest, the DISC score and its underlying integrity principles. Notably, the dataset shrinks from 516 bonds to 88 bonds due to main two reasons. First and foremost, Bloomberg has limited financial data available regarding the ask yield of the green bonds in the full dataset and the potential conventional bonds that can be matched to these green bonds. Second, it is not possible to find a match for all of the green bonds. As such, the dataset shrinks due to missing data regarding the variable calculated from the ask yields: $\Delta\tilde{y}_{i,t}$. Hence, the number of observations for $\widehat{Greenium}_{\iota}$ is also significantly reduced. It could be the case that bonds for which data is available regarding the ask yield have a DISC score that is significantly different than for all the 516 bonds in the DISC dataset. The question arises whether the results from the sample of 88 bonds can be generalized for the entire dataset of financial and corporate green bond issuances that is created from the Environmental Finance dataset.

To assess whether the results in table 11 are subject to concerns for sample selection bias, the Heckman two step regression is used. The approach of the Heckman is as follows. The first step of the analysis entails a probit regression for the entire dataset of 516 bonds with a DISC score, where all variables in equation 6a are regressed on a dummy variable that is 1 if there is data available for $\widehat{Greenium}_{\iota}$.

From this probit regression the inverse mills ratio is constructed, which measures whether there are concerns for sample selection bias. Table 12 lists the results of the second step of the Heckman model. The inverse mills ratio is denoted as lambda and presented in table 12. The coefficient of lambda is insignificant, indicating that there are not significant

unobservable factors in the full dataset that cause an overestimation or underestimation of the coefficient. Moreover, the signs and magnitude of the coefficient in table 12 are comparable to the results of table 11. This provides evidence that there are no concerns for sample selection bias. The full results of the Heckman analysis are shown in Table B.4 in appendix B

Table 12:
Estimation results Heckman second step

	Dependent variable: $\widehat{Greenium_t}$
Integrity Principles	
Standards	0.02
	(0.05)
SPO	-0.91**
	(-2.15)
Assurance	-0.97***
	(-3.35)
Certified	-0.22
	(-0.76)
*SPO * Assurance*	0.81**
	(2.21)
Lambda	0.95
	(0.53)
Constant	-1.93
	(-0.30)
Controls	
Financial effects	Yes
Rating effects	Yes
Currency effects	Yes
Sector effects	Yes
Observations	87
R^2	0.322
F	2.08

Notes*:*
t statistics in parentheses.
* p<0.10, ** p<0.05, *** p<0.01.
Robust Standards Errors.

7.3.2 Random effects model

The Hausman test provides a mildly significant W statistic, indicating moderate evidence that the fixed effects model is the best model to estimate the green bond premium in the first part of the empirical methodology. To investigate whether using the fixed-effects model provides a different explanatory outcome than the random effect model, the regression equation is re-specified, using a random effects model rather than a fixed effects model. A significant result of the green bond premium of comparable magnitude would further confirm the robustness of the evidence in favour hypothesis 1. To estimate the green bond premium using the random

effects model, a dataset is created that includes the relevant bond characteristics of both the green bonds as well as all matched conventional bonds *CB1*, where a dummy variable indicates whether a bond is labelled is green. Hence, the dependent variable is the yield $y_{i,t}$ rather than the yield spread $\Delta\tilde{y}_{i,t}$. The main variable of interest is the dummy variable $Green_i$, which takes the value of one of the bond is labelled as green. Furthermore, $\Delta Liquidity_{i,t}$ is substituted for $Liquidity_{i,t}$ as the overall effect of liquidity should now be investigated rather than the residual liquidity. Moreover, the regression controls for the same financial characteristics, rating characteristics, currency characteristics and sector characteristics as equation 6a and 6b. Last, as there is no matching procedure that controls for the matching characteristics of the bond, the regression also controls for firm specific effects. The equation if formulated in the following way.

$$y_{i,t} = \alpha_i + \beta_1 Green_i + \beta_2 BA_{i,t} + \beta_3 lnamount_i + \beta_4 maturity_i + \gamma_1' Rating_i + \gamma_2' Currency_i + \gamma_3' Sector_i + \varepsilon_i \quad (7)$$

Where $Green_i$ is a time invariant dummy taking the value of one if the bond is labelled as green. The variable $BA_{i,t}$ is the bid-ask spread of bond *i* on the specific day *t*. The dependent variable is the yield of the respective bond *i* on day *t*. The rest of the variables is defined in the same way as in equation 6a.

Table 13 lists the results of regression equation 7. The main coefficient of interest, the green bond dummy, is significant at the 5 percent level, while the coefficient is minus 28 basis points. This indicates that green bonds exhibit a yield that is 28 basis points lower than non-green bonds. Hence the green bond premium that investors are willing to pay is 28 basis points, confirming evidence in favour of hypothesis 1. Notably, the coefficient of maturity supports the maturity premium, given that a 1 year increase in maturity increases the yield by 16 basis points. Moreover, the coefficient of bid-ask spread implies that differences in liquidity do not significantly influence yield in the full sample. This finding supports the result regarding the effect of residual liquidity in table 7: differences in liquidity do not appear to affect the investors' valuation of bonds in the sample of matched bonds as well as in the full sample of green bonds and CB1 bonds.

Table 13:
Estimation results random effects model

	Dependent variable: $y_{i,t}$
Green Bond (yes =1)	-0.28**
	(-2.47)
BA	-5.95
	(-1.08)
Maturity	0.16***
	(3.37)
Constant	0.19
	(0.40)
Controls	
Financial effects	Yes
Rating effects	Yes
Currency effects	Yes
Sector effects	Yes
Firm effects	Yes
Observations	56257
R^2	
F	

Notes*:*
The table lists the result of the random effects model equation 7: $y_{i,t} = \alpha_i + \beta_1 Green_i + \beta_2 BA_{i,t} + \beta_3 lnamount_i + \beta_4 maturity_i + \gamma_1' Rating_i + \gamma_2' Currency_i + \gamma_3' Sector_i + +\varepsilon_i.$

t statistics in parentheses.
* p<0.10, ** p<0.05, *** p<0.01.
Robust standards errors.
Reference modalities: rating is rating AA, currency is EUR, sector is Utilities.
195 dummies for firm fixed effects.

7.3.3 Sub-sample analyses

The final robustness test entails a subsample analysis to assess whether the results hold for different groups within the full sample. First, the subsample analysis is performed for equation 1 to investigate potential differences among the estimation of the green bond premium. Notably, the analysis of subsamples using the Wilxocon signed-rank test in table 9 did not control for differences in the effect of residual liquidity amount the subsamples. At the same time, CBI (2017cdef) argues that only USD denominated bonds exhibit tighter pricing, while Zerbib (2018) argues that the green bond premium is most pronounced for bonds with a lower credit rating. Furthermore, Chen et al. (2017) notes that the liquidity premium decreases with an increase in credit rating. To investigate such relations in the sample of this thesis while controlling for residual liquidity, the sample of 95 matched bonds is split up by currency and rating. Table 14 presents the results of the subsample analyses. Only subsamples for which a robust analysis can be performed are included. First, the analysis indicates that there are

differences among the magnitude and the sign of the effect of residual liquidity, $\Delta Liquidity_{i,t}$. Recall that an increase in $\Delta Liquidity_{i,t}$ implies an increase in illiquidity. Where EUR denominated bonds exhibit a negative relation between illiquidity and the yield spread, A rated bonds an NR rated bonds exhibit a positive relation between relative illiquidity and yield spread. The liquidity premium is most pronounced for non-investment grade bonds. USD denominated bonds and BBB rated bonds display an insignificant relation between residual liquidity and yield spread. Second, table 14 shows that investors pay a highly significant premium for green bonds in all subsamples. Interestingly, the magnitude of the premium varies largely among the rating of the bonds: the most risky rated bonds in the sample, BBB bonds, have the largest green bond premium compared to the other subsamples. Moreover, the results indicate that the green bond premium is larger for USD denominated bonds than EUR denominated bonds.

Table 14:
Estimation results subsample analysis green bond premium

	Dependent variable: $\Delta\tilde{y}_{i,t}$				
	Currency		*Rating*		
	EUR	USD	A	BBB	NR
$\Delta Liquidity_{i,t}$	-8.0570**	-0.0365	1.1663**	-7.6369	8.6668**
	(-2.21)	(-0.03)	(2.74)	(-1.65)	(2.30)
Constant	-0.1895***	-0.2128***	-0.1108***	-0.4425***	-0.2324***
	(-676.09)	(-312.35)	(-20187.30)	(-131.47)	(-62.65)
Observations	13753	8646	9472	4787	7665
R^2	0.079	0.000	0.023	0.078	0.076
F	4.8769	0.0010	7.4971	2.7135	5.2917

Notes*:*
The table lists the results of equation 1: $\Delta\tilde{y}_{i,t} = greenium_i + \beta\Delta Liquidity_{i,t} + \varepsilon_{i,t}$.

Results broken down by currency and rating.
t statistics in parentheses.
* p<0.10, ** p<0.05, *** p<0.01.
Robust estimation of standard errors.

To assess whether the above documented differences in the effect of $\Delta Liquidity_{i,t}$ and the magnitude of $Greenium_i$ are accompanied by substantial differences in the effect of verification, another subsample analysis is performed using equation 6a for the sample of 88 bonds. The results of the analyses are presented in table 15. The coefficients of SPO, assurance and CBI are all similar in their sign and their significance compared to the results in table 11. Notably, whether the effect of assurance is larger than SPO differs per subsample, while the coefficients of assurance and SPO are all close to each other. The effect of the interaction between assurance and SPO differs per subsample. This is not surprising, given that the amount of observations of the interaction per subsample is very small and even zero for BBB bonds

(the total amount of observation in the sample for the interaction term is 11). Still, where the effect is significant, the coefficient of the interaction term is positive. The subsample analysis further indicates that results do not hold for NR rated bonds. Last, the coefficient of certification is insignificant in all subsamples.

In sum, both the subsample analysis for the estimation of the green bond premium and the analysis for the effect of the integrity principles on the green bond premium yield similar results compared to the full sample analyses, thereby confirming the evidence that has been provided regarding the hypotheses in the results section. Only the subsample analysis of NR rated bonds indicates non-significant results for the effect of the integrity principles on the green bond premium.

Table 15:
Estimation results subsample analysis integrity principles

	Dependent variable: $\widehat{Greenium_i}$				
	Currency		*Rating*		
	EUR	USD	A	BBB	NR
Standards	0.03	0.58**	0.12	0.37	-0.37
	(0.14)	(2.15)	(0.75)	(0.83)	(-0.92)
SPO	-1.02***	-1.30***	-1.29***	-1.60***	0.00
	(-3.08)	(-3.60)	(-4.00)	(-7.61)	(.)
Assurance	-0.97***	-1.20***	-0.95**	-1.50***	-0.29
	(-3.06)	(-3.48)	(-2.57)	(-5.05)	(-0.47)
CBI Certified	0.07	-0.42	-0.01	-0.46	-0.02
	(0.32)	(-0.93)	(-0.06)	(-0.51)	(-0.05)
Assurance*SPO	0.77**	1.39*	0.74*	0.00	0.28
	(2.31)	(2.05)	(1.86)	(.)	(0.72)
Constant	0.06	0.97	-0.92	-5.12	0.37
	(0.07)	(1.18)	(-0.55)	(-1.46)	(0.44)
Controls					
Financial	Yes	Yes	Yes	Yes	Yes
Rating	Yes	Yes	Yes	Yes	Yes
Currency	Yes	Yes	Yes	Yes	Yes
Sector	Yes	Yes	Yes	Yes	Yes
Observations	42	36	31	16	26
R^2	0.376	0.511	0.757	0.776	0.379
Adjusted R^2	0.147	0.223	0.636	0.441	-0.109
F	3.45	4.33	21.23	.	.

Notes*:*
The table lists the results of equation 6a: $\widehat{greenium_i} = \alpha_i + \beta_1 Integrityprinciples_i + \beta_2 lnamount_i + \beta_3 maturity_i + \gamma_1' Rating_i + \gamma_2' Currency_i + \gamma_3' Sector_i + \varepsilon_i$.
Results broken down by currency and rating.
t statistics in parentheses.
* p<0.10, ** p<0.05, *** p<0.01.
Robust estimation of standards errors.

8. Discussion

The previous chapter has provided a detailed overview of the determinants of the green bond premium, while indicating evidence for the existence of such a premium. This chapter aims to provide a comprehensive interpretation of these results. The first section will further discuss the hypotheses, by building on the different results of the specifications in the previous section. The second section will discuss two channels of sustainability valuation in capital markets, thereby further providing insight into to what extent verification of the green credentials can matter for different types of investors. The third section will highlight a number of limitations of this study. The fourth section will discuss the most relevant implications of this study for a number of stakeholders.

8.1 Discussion of hypotheses

8.1.1 The Green bond premium

In line with recent academic literature regarding the pricing of sustainability in debt markets and green bonds specifically, this thesis documents an average green bond premium of -23.2 basis points. This green bond premium indicates the yield that investors are willing to forego in order to invest in sustainable projects. Hence, the results provide evidence in favour of hypothesis 1, substantiating that investors are willing to pay a green bond premium in the secondary market. The premium that is documented is in line with the results of Zerbib (2018), although the premium that is found in this thesis is substantially larger than the premium that is found by Zerbib, which corresponds to -2 basis points. This is not surprising, given that Zerib has isolated the sole effect of environmental preferences on the green bond premium through matching green bonds to conventional bonds of the same issuer. This potentially influences results, taking into consideration the findings of authors such as Oikonomou et al. (2014) and Ge and Liu (2015), who argue that environmental risk is imperfectly captured in credit ratings. This thesis matches by industry type and credit rating, thereby still leaving room for variance in the green bond premium due to differences in firm specific risk that is potentially not captured by credit ratings. The height of the premium that is documented in this research appears to be closest to the green bond premium that is found in a research by Barclays (2015), which finds a premium of -17 basis points.

The robustness tests indicated that the results regarding the existence of the green bond premium hold for different subsamples. Still, it is valuable to shortly elaborate on the effect of

the residual liquidity on the green bond premium in the full sample and in the different subsamples. The liquidity analysis in the full sample presented an insignificant coefficient of the residual liquidity on the yield spread between green bonds and synthetic bonds. This finding is inconsistent with the general consensus in academic literature, which argues that a reduction of liquidity significantly increases yield spreads (Chen et al. 2007). Furthermore, Wulanderi et al. (2018) specifically highlight the positive relation between green bond illiquidity and green bond yields. Hence, it is expected that lower relative liquidity implies an increase in yield spreads between green bonds and conventional bonds. Notably, the results of the subsample analysis in table 14 show that the sign of residual liquidity differs per subsample. This indicates that investors value liquidity differently for green bonds with different characteristics. Such an effect has first been documented by Amihud and Mendelson (1986), who argue that investors have heterogeneous investment horizons, where longer horizons imply a tendency to hold more illiquid stocks. In this line, Huan et al. (2014) argue that the liquidity premium is strongly dependent on the heterogeneous preference for liquidity, while the investment horizon of the investor is indicated as a key preference. The authors conclude that investors with a longer investment horizon exhibit a relatively higher preference for more illiquid bonds. Notably, the EU (2016) states that the green bond market is characterized by buy-and-hold investors with longer investment horizons, while Baker et al. (2018) find higher ownership concentration of green bonds. This could have specific implications for the investor types active in the (EUR denominated) green bond market, where the sign of the effect of liquidity is not in line with general academic consensus.

8.1.2 The effect of the DISC score

This thesis constructed the DISC score to capture the effect of the most relevant and academically supported means by which investors can verify the green credentials of the green bond, the integrity principles. The negative DISC score coefficient of 24 basis points on the green bond premium provides evidence that investors value the extent to which they can verify the green credentials of the green bond. More specifically, a one-step increase of the DISC score, increases the green bond premium by -24 basis points. This is in line with the expectations of hypothesis 2 and the literature that supports the development of the DISC score. Furthermore, the result provides first evidence that the DISC score is an effective tool to measure the extent to which investors can verify the green-labelling of the green bond. However, this result provides no further insight into the effect of the specific integrity principles that constitute the DISC score.

The regression equation that is used to investigate the effect of the DISC score controls for a number of bond characteristics that were first investigated by Zerbib (2018). In line with Zerbib, the premium is more pronounced for bonds with a lower credit rating. The insignificant relation between both issue amount and the green bond premium and maturity and the green bond premium is in line with the findings of Zerbib. The results of the model further document a higher green bond premium for USD denominated bonds. This finding is further substantiated by the CBI (2017cdef), who documents tighter green bond pricing for USD denominated green bonds compared to EUR denominated green bonds. Moreover, academic literature specifically documents the existence of a green bond premium in the American market (Baker et al., 2018; Partridge and Medda, 2017; Karpf and Mendel, 2018).

8.1.3 The effect of the integrity principles

To allow for an in-depth analysis of the effect of verification, the underlying integrity principles of the DISC score have been analysed in detail. The results of this analysis are partially in line with the expectations set out in the hypotheses.

First, alignment with standards has no significant effect on the green bond premium, implying that enhanced credibility of the green bond credentials via standards is not valued by investors in the secondary market. This is not necessarily surprising. The section about the green bond market discussed that alignment to standards is self-proclaimed by the issuer of the bond, while standards are general guidelines and recommendations that allow for a different interpretation or fulfilment. The descriptive statistics of the integrity principles and industry practitioners further indicate that alignment with standards is already relatively wide-spread in the corporate-and financial green bond market, with 75% of bonds aligned to green bond standards. Hence, alignment with green bond standards can be seen as a rather non-obligatory or low-barrier form of verification of the green bond signal, which is consequently valued less by investors.

Second, investigating the effect of external review clearly indicates that investors in the secondary market significantly value the external assessment of the green bond label. Bonds that have some form of external review are accompanied by a highly significant increase in the green bond premium of -113 basis points. This is in line with the expectation of hypothesis 2a, indicating that verification of the green bond via an external party is valued more in the green bond market than alignment with standards. Additionally, industry practitioners and lead managers indicate that an assessment of the green bond through an agency with sustainability expertise (SPO) or an auditor (assurance) is in their experience perceived as a relevant

confirmation of the green bond label for investors. To the knowledge of the author, there is no other research that has investigated whether investors value external review in the green bond market. Hence, it is not yet possible to further compare this result in an academic context.

Third, differentiating between the components of external review demonstrates that there is no evidence that investors pay a different green bond premium for bonds that are verified through an SPO or assurance. Recall that practitioners highlighted that assurance is higher in the intensity of the engagement than an SPO. In addition, assurance is characterized by more regulation and its value is more substantiated in academic literature, such as research by Nugent and Simnett (2007) or Cohen and Simnett (2015). Hence, this finding is not in line with the expectation of hypothesis 2b, which hypothesized that verification via assurance exhibits a higher green bond premium than verification via an SPO. Still, both types of external review are to some extent complementary. Specifically, the mean marginal effect of having assurance (SPO) next to an SPO (assurance) is -21 basis points. This finding supports hypothesis 2c, although the result shows that the effect is lower than the sum of the two individual effects: the extra effect is characterized by a decreasing marginal premium. This indicates that there is partial overlap in investors' valuation of green bonds via these two means of verification.

Fourth, the results show that certification does not significantly increase the green bond premium. It is important to mention that previous sections discussed how certification requires some form of external review. Hence, the insignificant coefficient of certification demonstrates that there is no intrinsic value of the label on top of the underlying drivers through verification via external review. In this line, the insignificant coefficient of certification indicates that the findings of Baker et al. (2018) and Flammer (2018) might measure a different effect than the intrinsic effect of the certificate, given that both authors document a higher valuation of green bonds that are certified. This result is substantiated by practitioners who indicate that certification can be perceived as more redundant in a market where investors are starting to increasingly understand the market and have increased awareness about the possibility of external review. Additionally, certificates are issued by the Climate Bond Initiative (2018c), who charge $1/10^{th}$ basis point of the issue amount for certifying a green bond. The results in this thesis raise question marks regarding the value enhancing effects of paying such a fee for certification.

Last, it is relevant to discuss the variance in the constant of the regression specifications. The regression equations that do not include the integrity principles SPO and assurance exhibit a small and insignificant constant. Notably, when SPO and assurance are included in the

regression, the constant becomes significantly positive. Hence, the negative variance in $\widehat{Greenium_t}$ is primarily explained by these components of external review, not having some form of external review implies a green bond discount, ceterus paribus. The positive constant indicates that investors are primarily willing to give up yield when they can verify the green bond credentials.

8.2 Green Bond Premium Channels

Furthermore, it is important to highlight that this thesis does not provide evidence about what motivates investors to invest in green bonds and forego yield. Recall the types of investors that have been grouped by Derwall et al. (2011) according to their motivation to invest responsibly: values-driven investors and profit-seeking investors. Similarly, Jansson and Biel (2010) differentiate between investment motives and psychological beliefs to invest responsibly. Academic literature investigating the price differential that is paid for sustainable debt has mainly focused on these two channels to explain what causes the difference.

The largest stream of literature has investigated how investment motives influence the pricing differential that characterizes sustainability. Most studies focus on a reduction in risk, as outperformance in terms of return is less relevant in bonds markets than in equity markets, where there is more room for upside potential. For example, Bauer and Hann (2015) show that bonds that are characterized by better environmental performance are associated with lower credit risk, in turn increasing their valuation. As noted before, other authors have documented that this pricing differential is due to credit rating agencies imperfectly capturing environmental risks into their rating models, in turn leading to a pricing difference that is unexplained by credit risk (Oikonomou et al., 2014). Another aspect of investments in green assets is the reduction of stranded asset risk, which can be explained as the risk that an asset has to be written off faster than anticipated or unexpectedly loses its value entirely due to exposure to, for example, environmental risk. Investments in green assets can reduce stranded asset risk, by divesting assets that are more exposed to environmental stranded asset risk and investing in green assets (Buhr, 2016).

Fewer studies have investigated the influence of pro-environmental preferences or pro-social preferences on pricing in capital markets. Recently, Zerbib (2018) showed that investors pay a small premium for green bonds, due to environmental preferences. Similarly, Riedl and Smeets (2017) argue that investors in socially responsible mutual funds are motivated by social preferences to invest responsibly. Given that this thesis does not fully account for risk as strictly as Zerbib (2018); this methodology matches by industry type, rather than on the same issuer,

no conclusions can be drawn regarding the channel through which the green bond premium is driven. Still, the results of this thesis are highly relevant for the literature that investigates both channels. When the premium is driven through the environmental preferences of investors, the results shed light on the extent to which investors are screening the investment that they intrinsically prefer. When the premium is driven through investors' investment preferences, the results show that investors indeed value a reduction in information asymmetry, enabling them to better screen for sustainable bond investments with potentially lower risk characteristics.

8.3 Limitations

The findings in this thesis are subject to a number of limitations that deserve specific attention. First, the most apparent limitation of this study is the limited sample size. Depending on the step in the regression methodology, the sample size is 95 bonds in the panel regression and 88 bonds in the OLS regression. This limited sample size raises concerns about whether the sample is representative for the universe of corporate-and financial green bond issuances. One potential consequence of this limited sample size is sample selection bias, which could imply a systematic overestimation or underestimation of the effect of verification on the green bond premium. To address such concerns, this thesis conducts a Heckman analysis (see section 7.3), which analyses whether bonds in the sample are systematically different from the 516 bonds that received a DISC score (Heckman, 1974). The insignificant value of lambda in the Heckman analysis indicates that there are no concerns for sample selection bias in the sample used for this research. Furthermore, the results of the second step of the Heckman analysis show that correcting for sample selection bias does not indicate a different relation between verification and the green bond premium.

Comparing the sample size of this study to the sample size of other studies in the green bond market further puts the concerns for sample size into perspective. On the one hand, researches in the municipal green bond market have a significantly larger sample size. Baker et al. (2018) use a sample size of 2,083 municipal green bonds, Partridge and Medda (2018) leverage a dataset of 548 bonds and Karpf and Mandel (2018) create a sample of 1880 green bond. On the other hand, researches investigating the corporate or financial green bond market generally use a smaller or comparable sample size. Zerbib (2018) uses a similar methodology as the methodology of this thesis and creates a sample of 92 green bonds. Similarly, Nationale Nederlanden (2018) uses a sample of 133 bonds to investigate the green bond premium in the secondary market, where CBI (2017cdef) uses a sample of 62 bonds to investigate a primary market premium. Hence, the sample size of this thesis is comparable to other researches

investigating the green bond premium of corporate and financial bonds. Although an increased sample size would increase the representativeness of this study, the Heckman analysis and a comparison of literature indicate that statistical evidence shows no concerns for sample selection bias and that sample size lives up to the research standards.

A second limitation of this study is the less stringent matching criterium to match green bonds with conventional bonds than the matching criterium used by Zerbib (2018). Where Zerbib matches bonds by issuer, this thesis matches bonds by industry type to ensure a sufficient sample size. This leaves room for other factors that can influence the green bond premium rather than only the distinct 'green' feature, such as underlying differences in the characteristics of the firm issuing the green bonds.

8.4 Implications for stakeholders

The results of this thesis provide a number of relevant implications for the green bond market as a whole and numerous stakeholders in the green bond market. Most relevant are green bond investors, issuers and policy makers.

First, the green bond premium indicates that there is a mismatch between demand and supply for green bonds, driven by either too little supply or excessive demand, the two not being mutually exclusive (Zerbib, 2018). The author of this thesis would rather argue for a of lack of supply, taking into consideration the large amount of capital needed to reach global climate targets (OECD, 2017). A green bond premium caused by a lack of supply of green bonds is in line with findings of the Institute for Climate Economics (2018), which highlights a number of barriers for issuers to issue green bonds. One of the main challenges in issuing green bonds is the lack of a viable green bond pipeline. Examples of the cause for this concern include different signals from policy makers regarding green bond regulation and financial incentives specifically. A second challenge is the lack of awareness on the issuer side about the benefits of issuing green bonds and the lack of standardization that increases the complexity of the market. A final barrier concerning issuing green bonds are the higher transaction costs associated with labelling a green bond and the processes associated with setting up the green bond pipeline.

Second, from an investors' perspective the findings provide an early indication that investors should expect a trade-off between verification of the green bond credentials and yield. To invest in best-in class green bonds, where the green credentials of the bond are confirmed via some form of external review and ideally both SPO and assurance, investors are willing to forego yield compared to a similar conventional bond. Notably, the valuation of green bonds in

the secondary market is not directly applicable to green bond issuers in the primary bond market from an academic perspective. Still, this thesis provides evidence that verification matters to investors, while showing which instruments for verification matter specifically. This is a first indication for bond issuers that they can raise debt at a lower cost of capital when they provide investors with possibilities to verify the green credentials of the bond, thereby substantiating their sustainability signal.

Finally, the above implications of the results of this thesis are relevant for policy-makers. The need for sustainable investments highlighted by the OECD (2017) indicates the important role that green financial instruments such as green bonds can play in reaching global climate goals. As mentioned previously, the green bond market is characterized by lack of standardization in terminology, while stakeholders interpret important concepts in the market differently. Hence, information asymmetry between investors and issuers is still a relevant concern. As this thesis shows, investors are willing to forego yield when they are able to verify their green bond investments. Moreover, the result indicate that supply of green bonds should increase to match supply and demand, while potential green bond issuers cite a number of challenges that hamper green bond issuance (Institute or Climate Economics, 2018) Hence, policy makers should focus on incentivizing issuers to increase supply of green bonds that enable verification, by providing clearer regulation and further standardizing the green bond market. The initiative to implement regulation surrounding sustainability in capital markets by the European Commission (2018) is certainly a step in the right direction to mobilize more capital for sustainable investments. Still, it us op to issuers to act accordingly to the demand for green bonds and issue green bonds that enable verification of the green credentials.

9. Conclusion

The aim of this thesis is to investigate whether investors in the secondary market value the extent to which they can verify the green credentials of green bonds. Given the concerns for greenwashing in the green bond market in combination with the need for responsible investments, this research question is highly relevant for numerous stakeholder in the capital market. First, the results of this thesis indicate that investors indeed value the green bond signal, as indicated by the average green bond premium of -23.2 basis points. By investigating the overall effect of verification via the DISC score, this thesis shows that investors further value the extent to which they can verify the green credentials of green bonds: a one-step increase in the DISC score increases investors' valuation by -24 basis points. Still, there are differences within the effect of the integrity principles that make up the DISC score: where verification of the green bond signal via an SPO or assurance increases the green bond premium by respectively -112 and -108 basis points, certification and alignment with standards do not significantly affect the green bond premium. Furthermore, the marginal effect of -21 basis points of having both an SPO and assurance shows that these instruments for external review are to some extent complementary. Finally, these results indicate that investors are primarily willing to forego yield when they are able to verify the green credentials of the green bond, otherwise the green bond is likely to rather be characterized by a so-called green bond discount.

Building on the findings of this thesis, there is a number of implications for future research. First, this thesis does not document whether the green bond premium is driven by investment motivations or pro-environmental preferences. It would be valuable to research whether verification matters more to investors that are driven by investment motivations or investors that are driven by pro-environmental preferences. Second, to the knowledge of the author, no research, including this thesis, has investigated which type of investors are active in the secondary bond market. Hence, it would be valuable to research who these investors are, what motivates them to invest and how this relates to the valuation of verification. Third, the findings in this thesis highlight that it is highly relevant that academic research takes into consideration the extent to which investors can verify a green bond, as this significantly affects its yield. As such, it would be valuable if future research regarding green bond pricing takes into account this determinant of pricing to provide more accurate research regarding the pricing determinants of green bonds. Last, it would be interesting to research heterogeneity among the DISC score of the green bonds and the determinants of this heterogeneity.

To conclude, it is worthwhile to elaborate on the combined results of the research

project, focussing on both the equity market as well as the debt market. The results of the thesis investigating shareholders' valuation of verification in the green bond market are similar to the results in this research: investors in the equity market reward companies that issue a green bond where the green bond credentials can be verified. As such, the combined results of the three theses indicate that green bonds that enable verification of the green bond credentials and constitute a more credible green bond signal, are consequently valued higher in both debt markets as well as in equity markets. This provides first evidence that concerns for greenwashing in the green bond market are mitigated by investors in both the equity - and the debt market.

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Appendix

A. Tables

Table A.1
Overview of possible use of proceeds of the GBP

Category	Description
Renewable Energy	Production, transmission, appliances and products
Energy Efficiency	Such as in buildings, energy storage, heating and other.
Pollution Prevention and Control	Such as reduction of emissions and pollution and control of emissions and pollution.
Environmentally Sustainable Management of Living Natural Resources and Land Use	Including environmentally sustainable agriculture; environmentally sustainable animal husbandry; climate smart farm inputs such as biological crop protection or drip-irrigation; environmentally sustainable fishery and aquaculture; environmentally-sustainable forestry, including afforestation or reforestation, and preservation or restoration of natural landscapes
Terrestrial and Aquatic Biodiversity Conservation	Including the protection of coastal, marine and watershed environments
Clean Transportation	Such as electric, hybrid, public, rail, non-motorised, multi-modal transportation, infrastructure for clean energy vehicles and reduction of harmful emissions
Sustainable Water and Wastewater Management	Including sustainable infrastructure for clean and/or drinking water, wastewater treatment, sustainable urban drainage systems and river training and other forms of flooding mitigation
Climate Change Adaption	Including information support systems, such as climate observation and early warning systems
Eco-Efficient and/or Circular Economy Adapted Products, Production Technologies and Processes	Such as development and introduction of environmentally sustainable products, with an eco-label or environmental certification, resource-efficient packaging and distribution
Green buildings	Which meet regional, national or internationally recognised standards or certifications

Source: GBP (2018).

Table A.2:
Comparison of relevant green bond standards.

	Green Bond Principles	Climate Bond Standard	EU Green Bond Standard
Initiator	International Capital Market Association (ICMA); group of over 50 large financial institutions	Climate Bond Initiative (CBI); international investor-focused non-profit organization	EU High-Level Expert Group (HLEG) on Sustainable Finance
Starting Date	2014	2014	Introduced in 2017, expected to be implemented in 2018
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 issuer wants to adopt certificate	No, required if issuer wants to use "EU Green Bond Label"
Project Eligibility	Project must fall under one of the broad green categories	Project must fall under detailed 'Climate Bonds Taxonomy'	Project must fall under detailed 'EU Sustainability Taxonomy'
Sector-specific Criteria	No	Yes	Yes
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 Verifiers	No	Yes	Yes
Sources	ICMA (2018)	CBI (2018)	European Commission (2018)

Table A.3:
Comparison of integrity principles II,III and IV

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

Notes:
Own definition of the author

Table A.4:
Overview of control variables

Control Group	Type	Variables	Note
Rating	Qualitative	Rating AA = AA, AA-, AA+ Rating A = A, A- Rating B = B, B+ Rating BBB = BBB, BBB-, BBB+ Rating NR	The underlying ratings of the variable are included as factor variables. Baseline is rating AA. Scale according to Bloomberg.
Issue Size	Quantitative (MM USD)	Log issue amount	
Maturity	Quantitative (years)	Bond Maturity	
Sector	Qualitative	Financial Utilities Government Consumer Discretionary	The underlying sectors of the variable are included as factor variables. Baseline is utilities. Sector according to Bloomberg BICS Level 1
Currency	Qualitative	EUR USD SEK	The underlying currencies of the variable are included as factor variables. Baseline is EUR.

Table A.5:
Full estimation results integrity principles

	Dependent variable: $\widehat{Greenium}_i$			
	(1)	(2)	(3)	(4)
Financial effects				
ln Amount	-0.02	-0.05	-0.04	-0.04
	(-0.37)	(-1.12)	(-0.83)	(-0.87)
Maturity	0.01	-0.02	-0.02	-0.02
	(1.05)	(-1.24)	(-1.22)	(-1.26)
Rating effects (1=yes)				
Rating A	0.33*	0.31*	0.35*	0.32*
	(1.69)	(1.68)	(1.82)	(1.75)
Rating BBB	0.17	-0.02	0.01	-0.04
	(0.60)	(-0.09)	(0.03)	(-0.17)
Rating NR	0.31*	0.40**	0.43**	0.41**
	(1.72)	(2.14)	(2.16)	(2.16)
Currency effects (1=yes)				
USD	-0.21	-0.40***	-0.44***	-0.42***
	(-1.38)	(-2.94)	(-3.02)	(-2.97)
SEK	-0.15	-0.29	-0.33*	-0.32*
	(-0.91)	(-1.60)	(-1.74)	(-1.75)
Sector effects (1=yes)				
Sector Financial	0.15	0.10	0.15	0.12
	(0.77)	(0.70)	(1.06)	(0.80)
Sector Government	0.27	0.29	0.37	0.28
	(0.88)	(1.07)	(1.43)	(1.04)
Sector Consumer Discretionary	0.51	0.36	0.39	0.37
	(1.50)	(0.93)	(1.01)	(0.96)
Integrity Principles (1=yes)				
Standards	-0.17	0.19	0.21	0.19
	(-0.78)	(1.10)	(1.22)	(1.07)
External Review		-1.13***		
		(-4.54)		
SPO			-1.12***	-1.11***
			(-4.44)	(-4.38)
Assurance			-1.09***	-1.13***
			(-4.23)	(-4.16)
CBI Certified			-0.17	
			(-0.78)	
*SPO * Assurance*			0.95***	0.91***
			(2.97)	(3.00)
Constant	-0.07	1.18**	1.05**	1.12**
	(-0.12)	(2.20)	(2.06)	(2.12)
Observations	88	88	88	88
R^2	0.116	0.332	0.353	0.347
Adjusted R^2	-0.012	0.225	0.218	0.221
F	0.94	2.87	2.53	2.52

Notes*:*
The table lists the results of equation 6a in column (1), (3) and (4): $\widehat{greenium}_i = \alpha_i + \beta_1 Integrityprinciples_i + \beta_2 lnamount_i + \beta_3 maturity_i + \gamma_1' Rating_i + \gamma_2' Currency_i + \gamma_3' Sector_i + \varepsilon_i$.

The table lists the results of equation 6b in column (2): $\widehat{greenium}_i = \alpha_i + \beta_1 IntegrityprinciplesER_i + \beta_2 lnamount_i + \beta_3 maturity_i + \gamma_1' Rating_i + \gamma_2' Currency_i + \gamma_3' Sector_i + +\varepsilon_i$.

t statistics in parentheses.
* p<0.10, ** p<0.05, *** p<0.01.
Robust Standards Errors.

B. Robustness tables

Table B.1:
Robustness tests green bond premium:

	Test	P-value	Conclusion
Fixed vs. Random Effect	Hausman	0.099	Fixed effect
Serial Correlation	Woolridge	0.00	Serial Correlation
Heteroskedasticity	Breusch Pagan	0.000	Heteroskedasticity

Notes*:*
The table reports robustness results for equation 1: $\Delta\tilde{y}_{i,t} = greenium_i + \beta\Delta Liquidity_{i,t} + \varepsilon_{i,t}$.
Hausman assesses fixed versus random effects.
Woolridge assesses serial correlation.

Table B.2:
Robustness tests Disc score.

	Regression equation 4			
Panel A. Heteroskedasticity	(1)	(2)	(3)	(4)
Breusch-Pagan	0.13	0.057	0.23	0.16
Panel B. Multi-collinearity (VIF test)				
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
Financials				
Ln amount	1.211	1.63	1.63	1.73
Maturity	1.032	1.84	1.93	2.24
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 score (1-4)				
DISC			1.52	
DISC score (1=yes)				
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

Notes*:*
The table lists result of robustness tests for regression equation 4: $greenium_i = \alpha_i + \beta_1 DISC_i + \beta_2 lnamount_i + \beta_3 maturity_i + \gamma_1' Rating_i + \gamma_2' Currency_i + \gamma_3' Sector_i + +\varepsilon_i$.

Panel A reports p-values for the Breusch-Pagan test.
Panel B reports values of the variance inflation factor (VIF).

Table B.3:
Robustness tests integrity principles

	Regression equation 6a and 6b			
Panel A. Heteroskedasticity	(1)	(2)	(3)	(4)
Breusch-Pagan	0.066	0.14	0.099	0.12
Panel B. Multi-collinearity (VIF test)				
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
Financials				
Ln amount	1.63	1.65	1.74	1.74
Maturity	1.87	2.45	2.47	2.52
Currency				
USD	1.39	1.54	1.84	1.89
SEK	1.63	1.66	1.69	1.69
Sector				
Financial	2.47	2.48	2.55	2.64
Government	1.60	1.60	1.60	1.74
Consumer	1.60	1.62	1.65	1.65
Integrity Principles				
Standards	1.27	1.56	1.56	1.59
SPO			5.16	5.17
Assurance			4.88	5.12
External Review		2.60		
*SPO*Assurance*			3.52	3.59
Certification				1.68
Mean VIF	1.82	1.98	2.53	2.54

Notes*:*
The table shows results for robustness tests of equation 6a in column (1), (3) and (4): $greenium_i = \alpha_i + \beta_1 Integrityprinciples_i + \beta_2 lnamount_i + \beta_3 maturity_i + \gamma_1' Rating_i + \gamma_2' Currency_i + \gamma_3' Sector_i + \varepsilon_i.$

and equation 6b in column (2): $greenium_i = \alpha_i + \beta_1 IntegrityprinciplesER_i + \beta_2 lnamount_i + \beta_3 maturity_i + \gamma_1' Rating_i + \gamma_2' Currency_i + \gamma_3' Sector_i + +\varepsilon_i.$

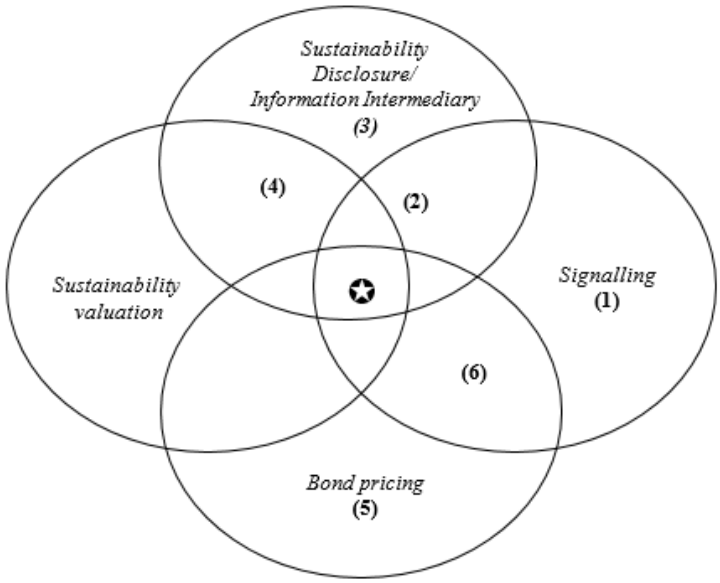
Panel A reports p-values of the Breusch-Pagan test.
Panel B reports the values of the variance inflation factor (VIF).

Table B.4:
Full results Heckman analysis

Dependent variable: $\widehat{greenium_i}$		
Ratinga	0.12	(0.62)
Ratingbbb	-0.05	(-0.20)
Ratingnr	0.25	(0.50)
YRS_TO_MTY_ISSUE	-0.02*	(-1.78)
lnamount	-0.02	(-0.26)
USD	-0.41	(-1.22)
SEK	-0.17	(-0.45)
Financial	0.20	(0.18)
Government	0.27	(0.70)
ConsumerD	0.36	(0.56)
Standards	0.14	(0.42)
External Review (SPO)	-1.07***	(-3.12)
Assurance	-1.04***	(-4.48)
Certification	-0.12	(-0.59)
Credible	0.91***	(2.94)
Constant	1.18	(0.53)
Dependent variable: insample		
Ratingaa	7.30***	(18.44)
Ratinga	7.46***	(23.29)
Ratingbbb	7.50	(.)
Ratingbb	0.36	(.)
Ratingb	0.22	(.)
Ratingnr	6.76***	(20.27)
ConsumerD	6.55***	(10.45)
ConsumerS	0.05	(.)
Energy	0.62	(.)
Financial	7.11***	(15.15)
Government	6.17	(.)
Materials	-0.16	(.)
Technology	0.47	(.)
Utilities	5.95***	(11.50)
CNY	-15.24	(.)
GBP	-13.87	(.)
HKD	-14.20	(.)
IDR	6.61	(.)
INR	0.32	(.)
JPY	-14.80	(.)
EUR	6.36	(0.00)
MYR	7.15	(.)
NOK	7.12	(.)
SEK	6.78	(0.00)
TWD	6.93	(.)
USD	6.76	(0.00)
Standards	-0.36	(-1.01)
External Review (SPO)	0.35	(0.86)
Assurance	0.10	(0.24)
Certification	-0.06	(-0.14)
Credible	-0.22	(-0.39)
Constant	-20.30	(-0.01)
mills		
lambda	0.18	(0.12)
Observations	487	
N_cens	400.00	
lambda	0.18	
chi2	37.55	
p	0.00	

C. Figures

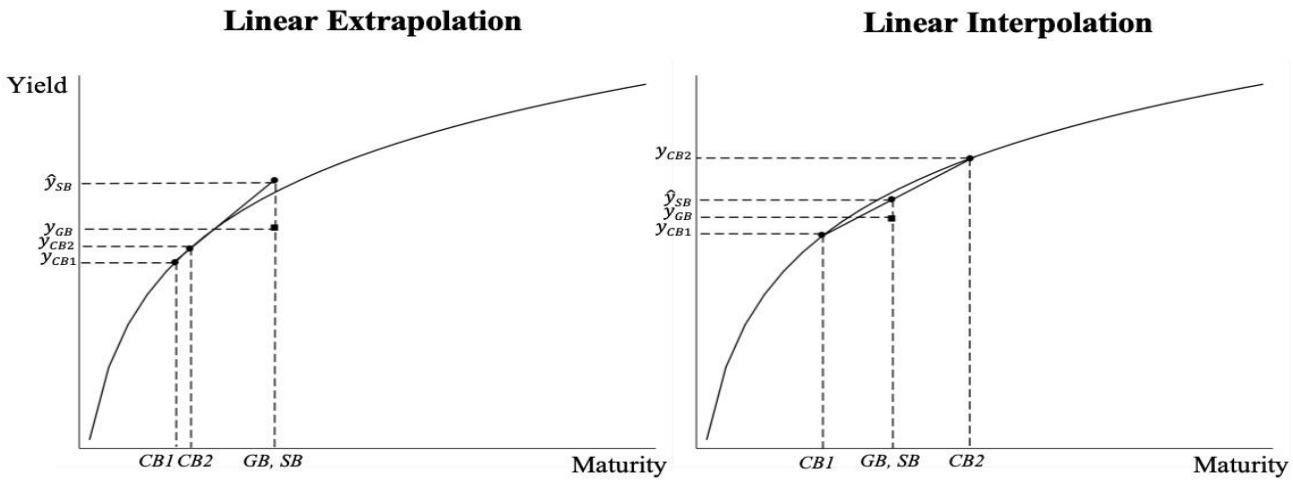
Figure 3:
Overlap between relevant streams of literature and their key papers.



Legend	*Selection of Key Authors (in order of Literature Review)*
(1)	Spence (2013) and Connelly et al. (2011)
(2)	Hahn & Kuhnen (2013) and Healy & Palepu (2001)
(3)	Lambert et al. (2007), Sengupta (1998)
(4)	Grewal et al. (2016), Dhaliwal et al. (2012, 2014), Chen et al. (2014)
(5)	Merton (1974), Chen et al. (2007), Brown (2006), Sengupta (1998)
(6)	Baker et al. (2018), Zerbib (2018), Flammer (2018)

Notes: The central star lists the gap in literature that this thesis aims to fill.

Figure 4:
Extrapolation and interpolation methodology



Notes*:* This figure visualizes how the synthetic bond has been extrapolated or interpolated.