The Role of Greenness Indicators in Green Bond Market Development: An Empirical Analysis

Introduction

The green bond market has grown rapidly since the first Climate Awareness Bond was issued by the European Investment Bank in 2007. According to the Climate Bonds Initiative (CBI), total global green bond issuance reached USD155.5 billion in 2017. A key catalyst of green bond market development was the introduction in January 2014 of the Green Bond Principles (GBP), which helped define whether a bond is green or not, by the International Capital Market Association (ICMA).

Although the green bond market has expanded substantially, Ehlers and Packer (2017) show that the market for green bonds is nevertheless still very small compared to the wider global bond market, representing less than 1.6% of global debt issuance in 2016. One major cause of underdevelopment is the lack of a universally accepted definition for green bonds, as well as commonly recognized standards and regulations, which hampers the expansion of the nascent market. According to Ehlers and Packer (2017), although the GBP and the CBI's Climate Bonds Standard serve as general guidelines to distinguish between green bonds and conventional bonds, the green bond market lacks enforcement mechanisms and widely acknowledged consistent standards across markets to regulate green bonds. This leads to heterogeneity among green bonds and also causes doubts about the greenness of some green bonds in the market.

The lack of commonly recognized standards in the green bond market has limited the universe of institutional investors who are ethically mandated to invest in green bonds. According to a *Wall Street Journal* interview of green bond market practitioners, many investors face a relatively limited asset universe even though the green bond market is growing fast.[11] Some investors will just target labeled green bonds or the leading issuers of green bonds. Such a phenomenon underlines a vital missing component in the development of the green bond market: a commonly acknowledged greenness standard. Ethically mandated investors could more easily associate green bonds with bonds that finance investments with a positive effect on the environment. If the green bond market functions smoothly enough for investors to assess the greenness of a bond, demand from ethical investors would be more efficiently allocated to green projects and contribute to environmental benefits. If the market is efficient, more demand would be directed to greener projects, lowering financing costs for these issuers, which in turn would encourage more environmentally friendly investments.

The green premium is defined as the yield difference between a green bond and an equivalent conventional bond from the same issuer. The empirical evidence on the existence of a green premium is mixed. While Zerbib (2017), Barclays (2015), and Ehlers and Packer (2017) found a yield discount on green bonds, Östlund (2015) did not find any significant difference between green bonds and conventional bonds. Such mixed results partly reflect heterogeneity among green bonds due to the lack of a universally accepted greenness standard in the market. If the negative green premium is mainly driven by excess demand from investors herding into a small subgroup of green bonds, it may indicate that the green bond market still needs to further improve so as to efficiently direct and diversify green bond demand to a broader base of qualified green projects and foster more environmentally friendly economic activities.

Against this backdrop, this paper is the first empirical study that incorporates the greenness information of green bonds in the analysis of green bond pricing mechanisms. This study thereby contributes to the existing literature by extending our understanding of whether greenness is priced in the green bond market,

[11] G. Cowan. 2017. Investors Warm to 'Green Bonds'. *Wall Street Journal*. 9 April. https://www.wsj.com/articles/investors-warm-to-green-bonds-1491790201.

and if so, how greenness affects the pricing of green bonds. This paper also sheds lights on important policy dimensions such as how market arrangements, including external reviewers and green bond standards (labels or certificates), could foster investments in qualified green bonds and thus lower issuer financing costs.

This study employs a sample of 60 investment grade GBP-labeled green bonds and follows the matching procedure in Zerbib (2017) by pairing each green bond with a conventional bond. Each pair has identical characteristics—such as issuer, currency, credit rating, bond structure, and maturity—to control for common factors that affect bond yield. In the entire sample, we documented, on average, there is no significant premium on green bonds over the conventional bonds. Controlling for other pricing factors, we document that having an independent reviewer leads to a green discount of about 7 basis points (bps). In addition, a green premium of −9 bps was documented for the small group of bonds that obtain CBI certification.

Our results have several implications. First, adjusting for various pricing factors, green bonds, on average, are not traded at a premium compared with conventional bonds. This suggests that despite the market's relatively small size and low liquidity, the green bond market has had some success in drawing ethical investors, who are less yield-driven, to green issues. Second, since investors face information asymmetry in assessing the greenness of green bonds, a proper market mechanism such as an independent external reviewer or a commonly recognized green bond standard could mitigate their information costs and direct demand to environmentally friendly projects. Such a mechanism would help the green bond market function better. Third, and related to the second implication, continued development of the green bond market requires widely accepted green bond standards; a well-functioning external reviewer practice would also benefit the market. For example, the recent release of the Association of Southeast Asian Nations' Green Bond Standards in November 2017 highlighted efforts to foster development in the region's green bond market.[12]

This study is organized as follows. Section II is devoted to understanding the building blocks of the green bond market and outlines the market's underlying operational logic. Section III reviews current literature on the green bond premium. Section IV first describes the research method and sample construction. It then presents the empirical evidence that uncovers differences between green bonds and conventional bonds, and explores the possible determinants of the green bond premium. Section V discusses possible policy implications that relate to green bond market development.

Attributes of the Green Bond Market

Green bonds are fixed income securities that exclusively fund green projects with environmental or climate-related benefits. They combine both financial and environmental risk into a financial product. Green bonds have been gaining more attention as an innovative financial instrument to mitigate the negative impacts of human economic activity on climate change. Specific criteria and requirements that underpin the concept of green bonds are best described in the GBP issued by the ICMA (ICMA 2017). The GBP are voluntary process guidelines that outline general criteria that most certification schemes follow. They were put together by major private financial institutions under the aegis of the ICMA. The GBP provide prospective issuers with guidance on the four key elements of green bond issuance: (i) use of proceeds, (ii) process for project evaluation and selection, (iii) management of proceeds, and (iv) reporting. Though external review is not a part of the four key elements of the GBP, it was recommended in the 2015 edition of the GBP that green bond issuers "use external assurance to confirm alignment with the key features of green bonds."[13]

Once green bonds are issued in accordance with the GBP, they are subject to reporting. If the proceeds from green bonds are not utilized in the green projects that are suggested in the pre-issuance reports within 24 months of issuance, then the bonds lose their green status (Petrova 2016). Since investors often do not have reliable data and analysis on the environmental impacts of green bonds, they may use their own criteria to ensure the greenness of their investment portfolios by referencing green bond labels or indexes. The green bond market

[12] Association of Southeast Asian Nations (ASEAN) Capital Markets Forum. 2017. *ASEAN Green Bond Standards*. http://www.theacmf.org/ACMF/upload/ASEAN_Green_Bond_Standards.

[13] This includes second opinions and verifications. From 2016, the GBP referred to "external reviews" rather than "external assurance," while the list of recommended external reviews was expanded to include those provided by rating agencies (ICMA 2017).

aims to channel a significant amount of funds into environmentally friendly projects. This section briefly reviews the attributes of the key building blocks of the green bond market.

Issuers

Green bonds are broadly similar to conventional bonds, except for the fact that their proceeds are earmarked exclusively for investment in green projects with environmental benefits. One notable difference, however, is that green bonds are generally less liquid than conventional bonds. This is because most green bond investors are long-term ethical institutional investors with environmental and social mandates, and they are seeking incentives to protect themselves against inflation risk, default risk, and market volatility. Therefore, many green bonds offer various documents certifying greenness as well as tax privileges, guarantees, and letters of comfort in order to attract more investors (Veys 2010).

Green bond issuers also incur substantial costs to remain green. Specifically, issuers need to bear the cost of providing scheduled reports and recurring R&D expenditure to go green, which can be especially burdensome to small-sized green bond issuers. Due to growing concerns about environmental risks associated with corporate operations, reporting on greenhouse gas emissions is becoming a requirement rather than an option.[14]

When a green bond and a conventional bond are both issued by the same issuer, the risk profiles of a green bond are essentially identical to those of a conventional bond. While the proceeds from the issuance of a green bond are earmarked for environmentally friendly projects, green bonds can be serviced with cash flows generated from the entire operations of the issuer—not just the green project.

Investors

Recent years have witnessed steadily growing demand for green assets. Green bonds are an important asset class for ethical investors whose portfolio objectives include environmental targets. For green bonds, ethical investors are usually institutional investors such as mutual funds, exchange-traded funds, insurance companies, pension funds, investment banks, international organizations, and governments. Many ethical investors have clear environment-related investment mandates and are less return-sensitive. These investors need to review the green reports provided by issuers to make appropriate green bond investment decisions.

Many investors in the green bond market tend to be long-term investors. It is costly for investors to identify suitable investment targets. This is because the limited universe of green bonds leaves fewer investment choices. There are not enough green bonds offered to meet the increasing demand for green bonds. The imbalance between supply and demand is evident in the widely observed oversubscriptions for green bonds. Due to robust and growing demand, green bonds are priced more tightly than conventional bonds (CBI and International Finance Corporation 2017). This stable and diversified investor base in the green bond market helps motivate corporate issuers to go green, despite the expenses associated with green bond issuance.

Although the empirical evidence on the existence of a green bond premium is mixed, it is intuitively plausible that ethical investors hold green bonds out of preference for the social or environmental benefits underlying green bonds. Given identical risk levels as conventional bonds, such a preference would lead to lower yields, which is a cost that ethical investors will bear in exchange for social or environmental value. Thus, the green bond market works by rewarding green issuers by lowering financial costs based on demand from ethical investors. Such a mechanism offers a channel by which financial markets can help monetize the social benefits of green projects and efficiently allocate resources.

However, due to the lack of a widely recognized standard on the quality of green projects, deadweight cost in the form of information asymmetry directs green bond investors to a limited group of leading green bonds or green bonds meeting certain standards. Such excess demand for a small group of bonds may not only substantially lower the yields and dent the return and portfolio diversification of ethical investors, but may also exclude many green projects with environmental benefits from the investment universe. Similar to accounting

[14] Standard & Poor's (2016) introduced the Carbon Disclosure Project (optional) on behalf of 827 institutional investors managing USD100 trillion in assets. In 2013, the Government of the United Kingdom required that all United Kingdom-listed companies report on their greenhouse gas emissions.

standards or credit ratings, a widely recognized standard and evaluation on greenness is essential for the development of the green bond market.

Other Participants

For green bond issuance, there are four other institutions involved in addition to issuers and investors. They are the underwriters, external reviewers, index (label) providers, and market intermediaries. The underwriters are the financial institutions that deal with the public and private issuance and distribution of the bond. The terms, definitions, and obligations of the bond shall be specified by the underwriters. The role of the external reviewers is to verify the greenness of the underlying projects. The index (label) providers are not directly involved in the issuance and distribution of the bond. However, they create green bond indexes (or labels) according to certain standards. In practice, the inclusion of a green bond in a widely recognized index (or label) adds an extra layer of credibility for investors. Lastly, other market intermediaries help to facilitate trading since most green bonds are traded over the counter (Östlund 2015).

In the following section, a green bond premium relative to conventional bonds will be analyzed empirically. Characteristics of a green bond that may influence a green bond premium have implications for the pricing of green bonds and their attractiveness for investors. For instance, a yield discount at issuance over comparable bonds with a green label would indicate that a significant number of investors value the green label, which provides issuers with extra incentives to issue green bonds.

Current Knowledge about a Green Bond Premium

Apart from the fact that green bonds need to comply with the GBP and meet the requirements suggested by the CBI, VanEck (2017) and Östlund (2015) argue that they are not much different from conventional bonds. This is especially true in primary markets where brokers have to sell green bonds to a large pool of investors buying both green bonds and conventional bonds. Standard & Poor's (2016) shows that the trading yields for conventional bonds and green bonds are similar. In secondary markets, the only way for investors to be assured that the bonds they are buying are truly green is to check the binding guidelines by which green bonds are issued and maintained. The green bond label is considered by investors as a key criterion for reducing information costs and selecting bonds. However, the existing empirical evidence on whether a green bond premium exists or not has been mixed.[15]

The Green Bond Premium Exists

In order to investigate the existence of a green bond premium, Zerbib (2017) used a matching method, comparing each eligible green bond with two similar conventional bonds with identical conditions such as currency, rating, bond structure, seniority, collateral, and coupon type. He started out with 681 green bonds in compliance with the GBP on 30 December 2016. After removing outliers and incomplete data, only 135 investment-grade, senior, bullet, fixed-coupon bonds were selected for the analysis. Zerbib (2017) further identified the determinants of the green bond premium, finding that the average green bond premium was –8 bps against conventional bonds within the whole sample of investment-grade bonds, –5 bps among USD-denominated bonds, and –2 bps among EUR-denominated bonds. He attributed the negative green bond premium to the presence of excess demand for green bonds in the market.

Ehlers and Packer (2017) compare the credit premium at issuance of a cross-section of 21 green bonds issued during 2014–2017 to conventional bonds with the same issuers at the closest possible issuance date. They show that green bond issuers on average have borrowed at lower costs than they have through conventional bonds. Barclays (2015) conducted a cross-sectional analysis as of mid-2015 and found a green bond premium of –17 bps. His findings thus confirm the existence of a green discount (i.e., negative premium), as do the findings of Zerbib (2017) and Ehlers and Packer (2017).

The Green Bond Premium Does Not Exist

Östlund (2015) used a data set of 28 matching pairs of bonds from Bloomberg on 17 March 2015 and investigated the existence of a green bond premium

[15] VanEck (2017) simply summarizes the discussion by saying that the existence of a green bond premium is not a black-or-white issue.

defined as the spread differentials between green bonds and conventional bonds by the same issuer. In testing the null hypothesis that there are no differences between green bonds and conventional bonds, he did not reject the null hypothesis and finds no evidence of either a positive or negative green bond premium.

Petrova (2016) conducted both panel-regression analysis and time-series analysis to evaluate and compare the performance of green bonds and conventional bonds during a sample period covering 2008–2016. After controlling for various possible factors such as default risk and term premium, and different time-series parameters, no statistically significant difference between green bond and conventional bond yields was documented.

Empirical Analysis

In this section, we describe the data and methodology for our empirical analysis and the main empirical findings.

Sample Construction

This study collected data on all green bonds issued from 2010 to 2017 from Bloomberg on 31 December 2017. Using the green bond function in Bloomberg ensures that all green bonds comply with the GBP. Bond pricing data such as bid and ask yields; bond basic information such as issuer, credit rating, issue amount, maturity time, issue date, denominated currency, and coupon type; and bond structure attributes such as seniority, option clause, and collateral were collected from Bloomberg.

In the first step, green bonds with a noninvestment grade, a zero coupon, a floating coupon, or option clauses were excluded. Then a matching process similar to Zerbib (2017) was adopted to identify the equivalent (or synthetic) conventional bond for the remaining green bonds. For each green bond, all conventional bonds issued by the same issuer were identified. They were then screened for the same currency, credit rating, and maturity as well as bond structures (e.g., coupon type, seniority rank, and collateral terms) as the green bond. Since issue date cannot be controlled, this study chose the screened conventional bond with the closest issue date as the green bond but limited the issue date difference between green bonds and screened conventional bonds to within a 6-year interval, following Zerbib (2017). Such a screening leaves a sample of 60 investment-grade, senior, bullet, fixed-coupon, green and conventional bond pairs that share roughly equivalent conditions. The sample thus consists of monthly bond yields and these 60 pairs of bonds, total of 1,365 bond-month observations.

Such a matching procedure serves as a useful model-free technique to analyze the specificity of a financial instrument by pairing a benchmark instrument with other controlling characteristics to highlight the effect of the variable of interest. In line with Zerbib (2017), the sample is constructed to evaluate the yield spread between a green bond and its equivalent conventional bond. For each pair, the green bond and its synthetic conventional bond share identical characteristics except for greenness and liquidity features.

Table 1 compares the prices and issuance amounts of the 60 paired green bonds and conventional bonds in the sample. While the bid and ask yields do not show statistically significant differences between green bonds and their synthetic conventional bonds, green bonds have significantly lower coupon rates and smaller issuance amounts.

Table 2 lists the average issuance amount, converted to United States (US) dollars, of green bonds and conventional bonds issued in various denominating currencies. It shows that the average issuance amounts of green bonds and conventional bonds vary across currency, which suggests that green bond market depth also varies across currencies. For example, while the average issuance amount for green bonds in US dollars is USD1.0 billion, that of conventional bonds is USD1.3 billion. As for pound sterling, while the average issuance amount for green bonds is USD2.0 billion, that of conventional bonds is USD5.5 billion. Therefore, when empirical models are specified to identify the determinants of a green bond premium, a bond's denominating currency should be considered.

Table 3 shows the average ask yield of green and conventional bonds across credit ratings and currency denominations. While there is significant variation in yield levels across currencies, credit ratings are not necessarily monotonically related to bond yields. This may reflect different demand levels for various credit ratings.

Table 1: Descriptive Statistics

Variable	N	Mean	Median	Standard Deviation	Minimum	Maximum	Mean Difference (p-value)
AskYLD (%)	1,365	1.68	1.47	1.92	−0.67	12.98	0.5559
AskYLD_M (%)	1,365	1.64	1.41	1.88	−0.66	12.40	
BidYLD (%)	1,365	1.76	1.56	1.95	−0.49	13.60	0.5702
BidYLD_M (%)	1,365	1.71	1.45	1.92	−0.52	13.12	
CPN (%)	1,365	2.26	1.88	1.73	0.13	8.50	<.0001
CPN_M (%)	1,365	3.43	3.13	1.74	0.63	10.50	
AmtIssued (USD billion)	1,365	1.10	0.60	1.12	0.07	6.00	<.0001
AmtIssued_M (USD billion)	1,365	1.67	1.20	1.72	0.02	7.53	

USD = United States dollar.
Source: Authors' calculations.

Table 2: Average Issue Amount by Currency

Currency	Average Issued Amounts in USD	
	Green Bond	Conventional Bond
AUD	1,054,764,930	831,081,074
CAD	1,233,025,000	3,977,500,000
CHF	359,240,000	282,260,000
EUR	1,296,091,215	1,987,603,898
GBP	1,999,924,000	5,547,086,500
INR	243,350,000	233,930,000
MXN	106,890,000	269,770,000
TRY	72,407,500	22,380,500
USD	1,000,441,501	1,275,529,801
Mean	818,459,350	1,603,015,753
Median	1,000,441,501	831,081,074

AUD = Australian dollar, CAD = Canadian dollar, CHF = Swiss franc. EUR = euro, GBP = Pound sterling, INR = Indian rupee, MXN = Mexican peso, TRY = Turkish Lira, USD = United States dollar.
Source: Authors' calculations.

Research Method

This study measures the green premium in line with Zerbib (2017). The first step is to obtain the yield spread between a green bond and its synthetic conventional bond. Since this study focuses on the investors' demand and the issuers' supply of green bonds, the yield spread is the difference between the ask yields of each bond for a particular pair. As implied in the above matching procedure, common risk factors such as default risk and term premium have been controlled, except for the fact that the conventional bond market is much larger and more liquid than the green bond market. Such a difference in liquidity between the two bond markets might produce a liquidity bias in the above yield spread. A substantial difference in liquidity can

Table 3: Average Ask Yield by Currency and Rating

Variable	Average Ask Yield (%)							
	Green Bond Rating				Conventional Bond Rating			
	AAA	AA	A	BBB	AAA	AA	A	BBB
AUD	2.39	3.10			2.54	2.97		
CAD			1.90				1.75	
CHF	0.01				0.02			
EUR	0.20	0.61	0.40	0.76	0.21	0.48	0.42	0.51
GBP	0.99				0.82			
INR	5.73			6.76	5.57			6.79
MXN	5.20				4.73			
TRY	10.29				10.04			
USD	1.76	1.95	2.45	1.78	1.70	1.92	2.34	2.13

AUD = Australian dollar, CAD = Canadian dollar, CHF = Swiss franc. EUR = euro, GBP = Pound sterling, INR = Indian rupee, MXN = Mexican peso, TRY = Turkish Lira, USD = United States dollar.
Source: Authors' calculations.

have a considerable effect on the yield level and must therefore be controlled.

Thus, in the next step, this liquidity bias is eliminated from the yield spread. In doing so, the yield spread is regressed on the bid–ask spread, a proxy of liquidity. Following Zerbib (2017), the green bond premium is defined as the residual from this regression. This residual is a part of the yield spread that cannot be explained by different liquidity situations between green bonds and conventional bonds. After controlling for the liquidity difference between the conventional and green bond markets, the liquidity-adjusted green bond premium captures how the market prices greenness, which is now the difference between the two paired assets.

Following Zerbib (2017), **Table 4** shows that estimated results from both ordinary least squares and fixed-effects generalized least squares estimations. The bid–ask spread proxy, which is used to control for differences in market liquidity, is positive and statistically significant, which suggests that lower liquidity (higher bid–ask spread) is compensated in the market with a liquidity premium.

Figure 15 shows the distribution of the green bond premium. It is seen that after controlling for liquidity, the green bond premium is concentrated around zero ranging from –0.91% to 0.87% using the ordinary least squares (OLS) estimation method and from–0.92% to 0.85% using the fixed-effects generalized least squares (FEGLS) estimation methods.[16] The mean of the liquidity-adjusted green bond premium is close to zero and its median is –0.4 bps. Thus, on average, there is no economically significant green discount documented among the sample bonds.

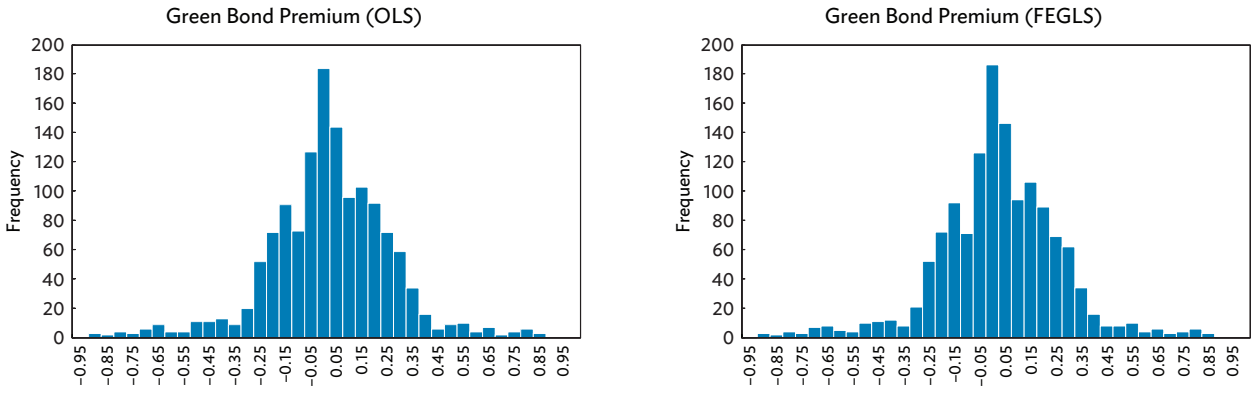
This study aims to empirically identify various factors that influence the estimated green bond premium. In particular, we are interested in whether greenness may contribute to a lower premium because it can enhance investor confidence and substantially lower the information costs of investors regarding the quality of green bonds. While there is no commonly acknowledged indicator of greenness, this analysis extends the existing literature by incorporating into the analysis two variables

Table 4: Step 1 Regression—Obtaining the Green Bond Premium

Dependent Variable: Ask Yield Spread		
	OLS	FEGLS
	(1)	(2)
Liquidity	1.530***	1.380***
	(14.537)	(19.562)
Intercept	0.04***	0.04***
	(6.363)	(23.203)
Observations	1,365	1,365
R-squared	0.134	
Adjusted R-squared	0.134	
Wald χ^2		382.70

FEGLS = fixed-effects generalized least squares, OLS = ordinary least squares.
Notes:
1. *** denotes significance at 1% level.
2. Robust t statistics in parenthesis.
Source: Authors' calculations.

Figure 15: Distribution of Green Bond Premium



FEGLS = fixed effects generalized least squares, OLS = ordinary least squares.
Source: Authors' calculations.

[16] The estimates generated by both OLS and FEGLS are very similar and highly correlated, with a correlation coefficient of 0.99.

that may contain information about the greenness of a bond.

The first greenness indicator is whether a green bond has an independent reviewer. Since all the sample green bonds are labeled as a green bond by Bloomberg, these bonds would have undergone review and research by Bloomberg New Energy Finance. Also, the issuer has provided the required term sheet or prospectus containing a "use of proceeds" disclosure that aligns with the market accepted categories set by Bloomberg New Energy Finance. While the GBP recommend that issuers seek an external (independent) reviewer to confirm alignment with green bond standards, not all issuers have had an independent reviewer for their bonds. Thus, those bonds with an independent reviewer would give more confidence to potential investors. Information on independent reviewers is collected from the CBI and a dummy variable (INDREV) is set to 1 if a green bond has had an independent review, or zero otherwise.

Our second greenness indicator is whether a green bond obtains a certification issued by the CBI. The CBI manages the Climate Bonds Standard and Certification, an international certification scheme for green bonds. The scheme includes robust frameworks for monitoring, reporting, and ensuring conformance with the Climate Bonds Standard. Its key features include full alignment with the GBP and certification by an independent Climate Bonds Standard Board, among others. The Climate Bonds Standard Board provides oversight to the development of the standard. The Climate Bonds Standard has pre-issuance and post-issuance requirements that need to be met by issuers seeking certification. In both stages, issuers are required to obtain independently approved Climate Bond Verifiers, who will assess whether a bond complies with the requirements of the Climate Bonds Standard. Empirically, a dummy variable (CBICTF) is constructed to indicate whether a green bond has obtained certification from the CBI. CBICTF is equal to 1 if a green bond has CBI certification, or zero otherwise. Since it is costly to obtain an independent reviewer and CBI certification, in a well-functioning green bond market it is intuitive to expect that these green bonds can be compensated with a lower financing cost, or a yield discount, for going green because these additional steps substantially lower ethical investors information costs and attract more demand.

To investigate whether green quality indicators such as an independent reviewer or CBI certification affect a green bond premium, this study controls for other risk factors that may affect the level of the premium. Specifically, control variables include issuance size, maturity, issuance currency, credit rating, and sector. The issuance amount is expressed in billions of US dollars as of 31 December 2017, and bond maturity is expressed in years. To reflect the possible nonlinear effects of issuance size and maturity, this study follows Zerbib (2017) by including a squared term of both issuance amount and maturity. To capture the effects of credit rating and issuance currency, as well as sector effects, a list of dummy variables are constructed, including four credit rating dummies for AAA, AA, A, and BBB ratings; three currency dummies for US dollars, euros, and non-US dollar and non-euro currencies; and three sector dummies for financial, utility, and other sectors.[17] Finally, since the green bond premium is a part of the ask yield, the ask yield is included to control for the yield level. **Table 5** lists the summary statistics of the key variables in the analysis. The model specification for empirical tests is listed below and estimated using a panel fixed effects regression:

$$GreenPrem_i = \alpha_0 + \alpha_1 Greenness_i + \alpha_2 Control_i + \eta_i \qquad (1)$$

Empirical Results

The empirical results are reported in **Table 6** and **Table 7**. Most significantly, an independent review and CBI certification can significantly lower the green bond premium by 6.6 bps and 8.6 bps, respectively, for the OLS-estimated green premium, and by 6.7 bps and 8.7 bps, respectively, for the FEGLS-estimated green premium. This evidence indicates that a greenness indicator that enhances investor confidence and information quality can lower the issuer's financing costs. Given other conditions, investors will tolerate a relatively lower yield for greener projects.

The results for control variables are also interesting. There is consistent evidence that larger issues tend to have a lower green bond premium for better liquidity for a particular bond. The green bond spread is positively related to maturity, implying a positive term premium in the green bond market. However, this term premium grows more slowly as the maturity gets longer as the

[17] Level 1 Bloomberg classification (BICS level 1) is used for sector groups.

Table 5: Summary Statistics of Key Variables

Variable	N	Minimum	Mean	Median	Maximum	Standard Deviation
Prem_ols (%)	1365	−0.91	0.00	0.00	0.87	0.24
Prem_gls (%)	1365	−0.92	0.00	0.00	0.85	0.24
INDREV	1365	0.00	0.68	1.00	1.00	0.46
CBICTF	1365	0.00	0.06	0.00	1.00	0.24
Maturity	1365	2.04	6.49	5.50	15.53	2.76
Maturity_SQ	1365	4.17	49.76	30.27	241.06	44.52
ASKYLD (%)	1365	−0.67	1.68	1.47	12.98	1.92
EUR	1365	0.00	0.39	0.00	1.00	0.49
USD	1365	0.00	0.33	0.00	1.00	0.47
Financial	1365	0.00	0.25	0.00	1.00	0.44
Utilities	1365	0.00	0.14	0.00	1.00	0.35
ISSAMT	1365	0.07	1.10	0.60	6.00	1.12
ISSAMT_SQ	1365	0.01	2.46	0.36	36.00	5.92
RATING_AA	1365	0.00	0.21	0.00	1.00	0.41
RATING_A	1365	0.00	0.22	0.00	1.00	0.42
RATING_BBB	1365	0.00	0.14	0.00	1.00	0.35

Note: Nonlinearities such as $Maturity_i^2$ (Maturity_SQ) and $Issued\ Amount_i^2$ (ISSAMT_SQ) are incorporated in the specification based on Zerbib (2017).
Source: Authors' calculations.

negative sign on maturity squared indicates, which justifies the nonlinearity of a term premium. As a part of asking yield, a higher asking yield is intuitively positively related to a green bond premium. In terms of currency, EUR-denominated green bonds tend to have a significantly lower green bond premium compared to green bonds in other currencies. There are differences across sectors as well. In particular, the utilities group shows a significant 10–15 bps green premium. In line with Table 3, credit rating is not monotonically related to the green premium. This may reflect the demand of investors toward certain green bond ratings.

Overall, there is no evidence of a significant green premium in our matched sample, the negative role of green proxy on green bond premium highlights the fact that demand pressures relative to the supply capacity are greater for certified green bonds than noncertified green bonds. These market phenomena result from excess demand in the market for certified green bonds due to lower information costs, greater investor confidence, and an insufficient volume of certified green bond supplies. In fact, the lower green bond premium for certified green bonds reveals benign financing conditions for these green bond issuers, relative to noncertified green bond issuers, due to improved information asymmetry.

Nevertheless, more work remains to be done to further develop the green bond market. First, the significant negative impact of a greenness indicator on a green premium reveals the insufficient supply of green projects and green bonds that are certified based on widely accepted standards or quality. Thus, only some green bonds are able to enjoy lower financing costs for going green. Second, herding into a relatively small group of qualified green targets may lead to a lower return on investing in green bonds, which might subdue the appetite of some investors. This may be the case for some traditional pension funds and insurance companies for which the investment committee has not set up a binding guideline for green assets in the strategic asset allocation.

Summary and Discussion

Green bonds can make significant contributions to financing green investments that help tackle climate change and promote a cleaner environment. While the green bond market has grown substantially over the past decade, it remains very small compared to the conventional bond market. In this paper, the green bond premium is calculated as the difference in the ask yields between a green bond and an equivalent conventional bond after controlling for differences in liquidity between

Table 6: Determinants of the Green Bond Premium I

Prem_OLS	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
CBICTF									−0.086***
									(−6.12)
INDREV								−0.066***	
								(−8.54)	
Maturity						0.131***	0.128***	0.132***	0.132***
						(10.04)	(13.11)	(13.56)	(13.02)
Maturity_SQ						−0.007***	−0.007***	−0.00686***	−0.00676***
						(−9.87)	(−12.79)	(−13.64)	(−12.80)
ASKYLD					0.017***		0.011**	0.009**	0.012***
					(4.68)		(2.62)	(2.20)	(2.73)
EUR				−0.060***			−0.025***	−0.017**	−0.041***
				(−4.91)			(−3.24)	(−2.21)	(−5.82)
USD				−0.117***			0.008	−0.002	−0.008
				(−4.93)			(0.60)	(−0.12)	(−0.56)
Financial			−0.115***				−0.033**	−0.032**	−0.001
			(−5.85)				(−2.18)	(−2.09)	(−0.05)
Utilities			0.020				0.123***	0.106***	0.151***
			(1.34)				(8.52)	(7.76)	(11.06)
ISSAMT		0.003					−0.068***	−0.076***	−0.067***
		(0.30)					(−5.79)	(−6.46)	(−5.95)
ISSAMT_SQ		−0.016***					0.002	0.002	0.002
		(−9.71)					(0.87)	(0.60)	(0.84)
RATING_AA	0.025*						0.010	0.032**	0.026**
	(1.71)						(0.81)	(2.39)	(2.13)
RATING_A	−0.039***						−0.063***	−0.062***	−0.084***
	(−3.17)						(−5.77)	(−5.82)	(−6.44)
RATING_BBB	−0.139***						−0.088***	−0.073***	−0.104***
	(−4.41)						(−5.56)	(−4.64)	(−5.72)
Constant	0.022**	0.035***	0.026***	0.062***	−0.029***	−0.527***	−0.437***	−0.386***	−0.443***
	(2.40)	(6.15)	(3.80)	(5.03)	(−4.80)	(−10.14)	(−14.14)	(−11.45)	(−13.75)
Time Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	1,365	1,365	1,365	1,365	1,365	1,365	1,365	1,365	1,365
Adj R-squared	0.043	0.140	0.043	0.033	0.017	0.171	0.308	0.318	0.310
F	37.48	301.30	61.91	12.97	21.91	52.35	152.40	152.70	140.30

Notes:
1. ***, **, * denote significance at 1%, 5%, and 10% levels, respectively.
2. Robust t statistics in parenthesis.
Source: Authors' calculations.

the two types of bonds. The main objective of the paper is to calculate the green bond premium and to identify the major determinants of this premium.

We find that, on average, there is no significant premium for green bonds relative to conventional bonds. However, the green premium can be significantly reduced if a green bond has an independent reviewer or CBI certification. This implies the importance of a widely recognized and accepted standard in the green bond market in lowering the information costs of investors.

In addition, the evidence indicates that green indicators such as an external reviewer and green bond certification can boost investor confidence. Unlike conventional bonds, green bonds are not standardized instruments. Therefore, certain factors like greenness operate in the pricing dynamics and match the needs of issuers and investors. The issued amount is negatively related to the green bond premium, while a longer maturity leads to a positive term spread. In addition, EUR-denominated bonds show a lower premium compared with other currencies.

Table 7: Determinants of the Green Bond Premium II

Prem_GLS	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
CBICTF									−0.087***
									(−6.26)
INDREV								−0.067***	
								(−8.56)	
Maturity						0.131***	0.129***	0.132***	0.133***
						(10.10)	(13.12)	(13.58)	(13.04)
Maturity_SQ						−0.007***	−0.007***	−0.007***	−0.007***
						(−9.94)	(−12.84)	(−13.69)	(−12.86)
ASKYLD					0.017***		0.012***	0.010**	0.012***
					(4.92)		(2.86)	(2.43)	(2.98)
EUR				−0.061***			−0.023***	−0.016*	−0.039***
				(−5.00)			(−3.04)	(−2.00)	(−5.61)
USD				−0.118***			0.007	−0.002	−0.008
				(−5.02)			(0.57)	(−0.16)	(−0.61)
Financial			−0.116***				−0.033**	−0.033**	−0.001
			(−5.89)				(−2.22)	(−2.13)	(−0.05)
Utilities			0.019				0.121***	0.105***	0.150***
			(1.33)				(8.53)	(7.75)	(11.08)
ISSAMT		0.002					−0.067***	−0.076***	−0.067***
		(0.30)					(−5.72)	(−6.39)	(−5.87)
ISSAMT_SQ		−0.016***					0.002	0.001	0.002
		(−9.81)					(0.81)	(0.54)	(0.78)
RATING_AA	0.025*						0.011	0.033**	0.026**
	(1.71)						(0.84)	(2.44)	(2.17)
RATING_A	−0.039***						−0.063***	−0.061***	−0.084***
	(−3.20)						(−5.72)	(−5.76)	(−6.41)
RATING_BBB	−0.140***						−0.088***	−0.073***	−0.104***
	(−4.46)						(−5.55)	(−4.62)	(−5.73)
Constant	0.023**	0.036***	0.026***	0.063***	−0.030***	−0.529***	−0.440***	−0.388***	−0.446***
	(2.47)	(6.32)	(3.89)	(5.15)	(−4.98)	(−10.18)	(−14.27)	(−11.54)	(−13.87)
Time Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	1,365	1,365	1,365	1,365	1,365	1,365	1,365	1,365	1,365
Adj R-squared	0.043	0.141	0.043	0.034	0.018	0.172	0.31	0.321	0.312
F	37.78	307.20	61.54	13.47	24.16	52.54	154.00	153.60	141.90

Notes:
1. ***, **, * denote significance at 1%, 5%, and 10% levels, respectively.
2. Robust t statistics in parenthesis.
Source: Authors' calculations.

Sufficiently large, committed demand from institutional investors would lower the cost of capital for green projects. There is a good opportunity for issuers to expand their funding capacity for green projects thanks to ethical investors who are willing to sacrifice some yield to participate in environmentally friendly projects. The urgent need to finance a low-carbon and environmentally sustainable economy makes green bonds attractive and compelling. More green bonds would help economies meet the huge green investment needs required to cope with climate change and mitigation.

However, going green does not necessarily mean sacrificing yield, and institutional investors may not necessarily suffer a green discount forever. The current negative premium has been partly driven by excess demand. To make green bonds more attractive to investors, externalities like the environmental benefits generated from green projects should be monetized.

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