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ORIGINAL ARTICLE

Green bonds: shades of green and brown

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Abstract
We analyse the existence of a green bond premium and find a negative premium of 8 to 14 basis points. We are further interested in the influence of ESG ratings on green bonds to determine if investors differentiate between the shade of green. Examining a unique dataset of green bonds, we find a statistically significant influence of ESG ratings on bond spreads. A one-point increase in the weighted average ESG score leads to a decrease in the spread of 6 to 13 basis points. Interestingly, the results are not driven by the environmental friendliness of the green bond issuer, but through the company's governance.

Keywords Green bonds · ESG ratings · Green bond premium · Governance

JEL Classification G12 · M14 · Q50

Introduction

A few years ago, green bonds were mainly issued by government-related or supranational development banks. Green bonds are securities, whose proceeds are used to support climate-related or environmental projects. During the last years, more and more corporates have started to issue green bonds, as well, followed by governments who discovered this asset class. While there have been many constructive developments in this segment, not all have been perceived positively. The accusation of greenwashing is omnipresent, and the "true greenness" of green bonds is regularly discussed (see, e.g., Laufer 2003; Wu et al. 2020). One reason for this uncertainty is that green bonds are usually issued with a credit rating but provide additionally environmental, social and governance (ESG) ratings only on a voluntary basis. We focus on this ESG rating information and examine the influence of ESG aspects on the pricing of green bonds, specifically the bond spread.

The potential existence of a (negative) green bond premium has been analysed by manifold studies in the past (e.g., Hachenberg and Schiereck 2018; Zerbib 2019), but the results are mixed. The green bond premium is defined as the incremental yield investors receive for holding a green bond over its equivalent non-green counterpart. The non-green counterpart is often referred to as a conventional or brown bond and implies no specific use of proceeds. Hence, the bonds we analyse are exclusively green or brown. Therefore, we define the bonds we analyse as either green or brown. In a first step, we test if a green bond premium can be found using a similar approach as Preclaw and Bakshi (2015). In a second step, we analyse the influence of ESG ratings on green bond pricing. We define the directional effect as dependence of the green bond premium on the existence of the ESG rating. ESG ratings are based on issuer level and graded on a scale. If the company's shade of green matters for the pricing of green bonds, the (negative) premium is expected to be larger for higher ESG ratings. We define this as the magnitude effect. As shades of green (or brown) are hardly the subject of investigations in green bond studies, we contribute to the existing literature on green bonds and fill a niche examining the greenness of the bond. Finally, as ESG ratings are a composition of E, S and G criteria, it is obvious to test which of these criteria are the main drivers of the green bond premium. We define this as the composition effect.

The rest of the paper is structured as follows. The next section provides a literature review and develops our hypotheses. "Data and methodology" section presents the data and

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methodology used. "Empirical results" section documents the empirical results, and "Conclusion" section concludes the paper and outlines possible areas of future research.

Sample literature review and hypothesis development

ESG has been the subject of research for many years now, however, not necessarily using the term ESG. Research on topics such as corporate social responsibility (CSR) or corporate environmental responsibility (CER) goes back more than 60 years.

Many studies were published since the 1990s, most of them focussing on empirical relationships between corporate social/environmental responsibility and corporate financial performance (CFP), which might be due to improved data availability (Capelle-Blancard and Monjon 2012). The majority of papers find a positive relationship between ESG and CFP. The relationship is measured, among others, through market-stock prices or accounting measures, e.g., return on assets (Schiereck et al. 2019).

Since the pricing of bonds is more complicated and technical due to the huge variety of bonds (different coupon type, maturity, payment rank, callability, etc., see, e.g., Maul and Schiereck 2017), we specifically review the literature regarding the pricing of bonds. By analysing 4260 bonds issued between 1992 and 2009, Ge and Liu (2015) find that CSR performance is associated with better credit ratings and lower yield spreads in new corporate bond issues.

The majority of empirical studies investigating green bonds focus on the (negative) green bond premium. Panel A of Table 1 summarizes the most relevant literature analysing the green bond premium. Zerbib (2019) compares 110 senior fixed-rate green bonds with their equivalent synthetic conventional bonds. He finds a significant negative green bond premium of approximately 2 bps. The effect is especially visible for financials as well as for lower rated bonds. For government-related issuers, the effect is not visible on a AAA-rating base, but a small negative premium can be found for AA-rated issuers.

Hachenberg and Schiereck (2018) also use a matching approach in order to avoid heterogeneity among bonds. They find that A-rated bonds show a significant negative premium of 3.88 bps. Green bonds with different ratings also trade tighter than their corresponding brown bonds but without statistical significance. The study shows that the only significant factors for the "Greenium" are industries and the existence of an issuer's ESG rating. Contrary to Zerbib (2019), they find that green bonds from government-related companies trade wider than comparable brown bonds.

Bachelet et al. (2019) show that green bonds have higher yields coupled with higher liquidity and are also less volatile than their brown correspondents. By investigating the issuer breakdown further, the authors determine a difference between institutional and private issuers. Green bonds from institutions have a negative yield premium and are far more liquid than the matching brown bonds. Green bonds from private issuers on the other hand have a positive premium and do not differ too much in liquidity compared to brown ones. Moreover, if the private issuer has no third-party verification, the premium is significantly higher. Bachelet et al. (2019) conclude that institutional investors are able to attract large institutional investors as these issuers have transparency and information rules that lower information asymmetries. Private issuers can get a similar reputational effect when they obtain a green verification from a third party.

Partridge and Medda (2018) run a yield curve analysis on a selection of US green-labelled municipal bonds, issued at the same time as brown bonds and by the same issuers. Additionally, they use a pair-wise analysis to identify potential yield differentials between bonds that are identical except for the green label (same issuer, maturity, etc.). For both analyses, they find a (negative) green premium in the primary as well as in the secondary market. Contrary, Karpf and Antoine (2017) find that the green characteristic of a green-labelled municipal bond gets penalized through the market, as green bonds trade at higher yields than expected by their credit profiles.

Preclaw and Bakshi (2015) investigate that a premium is being paid by investors in order to acquire green bonds. They calculate a spread difference of approximately 20 bps between green bonds and ordinary (brown) bonds. They quantify this green bond premium using a regression that decomposes the OAS-spread into common risk factors like credit rating or spread duration and a dummy variable for green bonds. Preclaw and Bakshi (2015) use a global credit index including corporates as well as government-related issuers, which provides the best overlap of constituents with the global green bond index.

Using a propensity score matching approach, Gianfrate and Peri (2019) find that green bonds are cheaper to issue than ordinary bonds. This effect holds even after accounting for green certification costs and is larger for corporates. This finding is contrary to Kapraun and Scheins (2019) who find that green bonds are generally traded at a higher bond premium except for green bonds issued by governments and supranational institutions.

Summarizing the discussed literature, there is no clear consensus about a (negative) green bond premium. Therefore, the first question we aim to answer is whether a green bond premium really exists.

Should this green bond premium exist and confirmed to be negative, we must address the concern posed by a potential greenwashing effect, i.e., that green bond issuers may be attempting to present a misleading impression of

Table 1 Empirical findings related to this study

Study	Green bonds (GBP)	Scope	Primary/Secondary market	Number of bonds	Time period	Method	Yield premium	Main findings
Panel A: Empirical studies related to green bonds								
Zerbib (2019)	Yes	Global	Secondary	110 green bonds/110 synthetic bonds	July 2013–December 2017	Matching + 2 step regression procedure	− 2 bps	The negative premium is more pronounced for financial and low-rated bonds. The results emphasize the low impact of investors' pro-environmental preferences on bond prices.
Hachenberg and Schiereck (2018)	Yes	Global	Secondary	63 green bonds/126 brown bonds	October 2015–March. 2016	Matching + panel regression	− 1 bp	Significant are neither maturity, nor volume or currency, but rather industries, namely government-related and financial issuers, as well as the existence of an ESG issuer rating
Bachelet et al. (2019)	Yes	Global	Secondary	89 green bonds + 89 brown bonds	January 2013–Dez. 2017	Matching	2.06–5.9 bps	Green bonds have higher yields. Premium for non-certified green bonds are higher than for those certified. Institutional green bonds have a negative premium.
Partridge and Medda (2018)	N.A.	US green-labelled muni bonds	Primary and secondary	1215 (548 green and 667 brown)	June 2013–January 2018	Yield curve analysis + matching	− 5 bps in the secondary market	They find that there is a growing trend towards green premium in both the primary and secondary markets in both the series trend analysis and in the pair-wise analysis

Table 1 (continued)

Study	Green bonds (GBP)	Scope	Primary/Secondary market	Number of bonds	Time period	Method	Yield premium	Main findings
Karpf and Antoine (2017)	N.A.	US green-labelled muni bonds	Secondary	1,880 green bonds	N.A.	Yield curve analysis	Positive premium	The market valuates green bonds in a less favourable manner than their brown counterparts. If green bonds had the same coefficients as brown bonds or the pooled sample, their expected mean return would be lower -> the market penalizes green bonds to a higher degree than brown bonds
Preclaw and Bakshi (2015)	Yes	Euro and US	Secondary	N.A.	March 2014–August 2015	OLS regression	− 17 bps	Negative premium
Gianfrate and Peri (2019)	N.A.	Europe	Primary and secondary	121 green bonds	2013–2017	Propensity score matching	Negative premium	Magnitude depending on secondary or primary market and on corporate and non-corporate issuers.
Kapraun and Scheins (2019)	Yes	Global	Primary and secondary	1,500 green bonds	N.A.	OLS regression	− 18 bps	Especially for corporate green bonds, a green label, a third-party verification or a listing on a dedicated green bond exchange is decisive in order to be seen as a green bond and to generate the premium.

their activities and the lack of consistency in audit standards. We have a number of tools at our disposal including the existence of an ESG rating or an external certification and we focus our efforts on the former. Testing the dependence of a green bond premium on the existence of an ESG rating, called the directional effect, is the subject of studies from, among others, Polbennikov et al. (2016), Menz (2010) and Stellner, Klein and Zwergel (2015). Polbennikov et al. (2016) measure slightly lower spreads for corporates with higher ESG ratings. This strand of literature is summarized in Panel B of Table 1. Menz (2010) cannot confirm that CSP/CEP/ESG is related to lower financing costs. His study shows that firms that are labelled socially responsible have a higher risk premium than non-socially responsible companies.

Stellner et al. (2015) empirically observe the influence of CSR on the credit rating and the z-spread. They find only weak evidence of unconditional benefits from CSR investments on the z-spread. But by examining more closely the influence of the issuer's country, they observe that in countries with above average ESG ratings better CSP performance is rewarded with a better rating and a lower spread. Additionally, they find that it is beneficial for companies to have the same relative ESG rating as the country (above average or below average).

Gatti and Florio (2018) investigate the role of the Green Bond Principles and a second party review on green bond spreads. Using a sample of green bonds issued between 2007 and 2015, they find that with the introduction of the Green Bond Principles in 2014 issues with low credit ratings were also able to enter the market.

The certification of green bonds is a field of analysis of Bachelet et al. (2019), as well. They extend their study and divide their sample of private issuers in certified and non-certified green bonds. For non-certified issues, they detect a positive premium. They conclude that green bonds can have a negative premium (lower financing costs) under the premise of trust which is either generated through being an institution or through green verification. Missing reputation or certification will lead to higher financing costs due to the investors' concerns about greenwashing.

Kapraun and Scheins (2019) show similar results analysing the pricing in both primary and secondary markets of a sample of more than 1,500 green bonds. For both markets, only certain green bonds show lower yields (i.e., negative green premium) in comparison with their brown counterparts. This applies in particular to issues of government and supranational entities, butalso corporate issues when they issue at large size. The latter is in contrast to Zerbib (2019). Especially for corporate green bonds, a green label, a third-party verification or a listing on a dedicated green bond exchange is decisive in order to be seen as a green bond and to generate the negative premium.

Table 1 (continued)

Study	Purpose of investigation	Main findings
Panel B: Studies analysing the impact of ESG ratings		
Polbennikov et al. (2016)	ESG rating influence on corporate bond spreads	Bonds with high composite ESG ratings have slightly lower spreads, all else being equal. They also find that bonds with high ESG ratings have modestly outperformed their lower rated peers when controlling for various risk exposures
Menz (2010)	CSR-influence on corporate bond spreads	CSR has apparently not yet been incorporated into the pricing of corporate bonds
Stellner et al. (2015)	CSR-influence on credit rating and z-spread	Only weak evidence of unconditional benefits from CSR investments on the z-spread. But in countries with above average ESG rating better CSP performance is rewarded with a better rating and a lower spread
Gatti and Florio (2018)	Influence of Green Bond Principles and second party review on green bond spreads	Green bond issues with a second party opinion have a lower spread than those without
Barnett and Salomon (2012)	Relationship between CSR and CFP	Low social responsibility comes with a higher CFP than moderate social responsibility but with a lower CFP than high social responsibility
Trumpp and Guenther (2017)	Relationship between CEP and CFP	Companies with low CEP have a negative relationship to CFP, while companies with a very high CEP are positively related.
Nollet, Filis and Mitrokostas (2016)	Relationship between CSR and CFP in the S&P 500	Applying a linear model leads to a negative relationship between CSR and CFP. But applying a nonlinear model they find a u-shaped relationship which implies that there is a threshold amount of investments going into CSR after which the engagement will show positive effects with regards to the financial performance

Hachenberg and Schiereck (2018) find that having an ESG rating reduces the negative premium (green bonds are priced less tight than brown bonds). This might seem surprising at first thought, but they argue that this might be due to the fact that ESG-dedicated investors do not necessarily need to pick a green bond where the issuer has an ESG rating in order to conform with their ESG investment policy. The ESG rating might allow the investor to simply purchase the ordinary bond. By extending this research, we analyse further determinants of green bond pricing. Hachenberg and Schiereck (2018) compare green bonds with ordinary (brown) bonds. We, on the other hand, compare green bonds from various issuers with distinct characteristics with each other.

Based on the literature, we develop our first hypothesis. The assumption of Hypothesis 1 is that a green bond with ESG rating has a lower spread due to reduced uncertainty about the bonds shade of green. This potential divergence is called the directional effect and matches Gatti and Florio (2018) and Bachelet et al. (2019) who show that verification is associated with lower spreads. Even though an ESG rating alone is not a valid verification, it reduces the information asymmetry between issuer and investor regarding the greenness of the bond and potential greenwashing.

Hypothesis 1 Existence of an ESG rating leads to higher credibility!

Next, we will look at the specific characteristics of ESG and the magnitude effect. Recent research emphasizes that the relationship between ESG and CFP does not necessarily have to be linear. The idea behind this is that "too much of a good thing" can have negative consequences (Pierce and Aguinis 2013). Barnett and Salomon (2012) show that the relationship between CSR and CFP is u-shaped. Meaning that low social responsibility comes with a higher CFP than moderate social responsibility, but with a lower CFP than high social responsibility. Trumpp and Guenther (2017) find similar results investigating the relationship between CFP and corporate environmental performance (CEP). Companies with low CEP have a negative relationship to CFP while companies with a high CEP are positively related. They call this the "too little of a good thing" effect.

A negative green premium might be due to high demand for this new asset class, which fits quite well into the current political situation of growing environmental concern. Therefore, it is necessary to review the influence of CSP/CEP/ESG on bonds in general. We are especially interested in the influence on green bonds, as we aim to find out if green investors actually care about the shade of the green bond or if only the label counts.

We analyse the influence of ESG ratings on green bond pricing to determine if the greenness of the issuer matters for its pricing. A better ESG rating should lead to lower spreads as already found in some literature and corresponding with the CSP/CEP-CFP research (e.g., Polbennikov et al. 2016; Zerbib 2019).

Hypothesis 2 The better the ESG rating, the lower the spread!

Nollet, Filis and Mitrokostas (2016) examine the CSR and CFP relationship by using the S&P 500 universe and taking the Bloomberg ESG disclosure score as a proxy for CSP. Applying a linear model, they show a negative relationship between CSR and CFP. But by applying a nonlinear model, they find a u-shaped relationship. This implies a threshold amount of investments going into CSR, before the engagement will show positive effects with regards to the financial performance. When splitting up the ESG score into E, S and G, they show that the governance aspect is the main driver for translating CSR into CFP.

Finally, we separately analyse the impact of E, S and G on green bond pricing in order to draw conclusions on the composition effect. We expect that in particular the E- and G-score should have a significant effect on the bond spread as a negative green bond premium indicates that investors accept getting paid less through green assets. Therefore, a green bond issued with a better ESG rating, in particular a better E-rating, should have a lower spread than a bond issued with a lower ESG rating. In particular, we expect the E-score to have an influence (negative correlation to spread), as our objects of investigation are green assets. We assume that the social score is less important while the governance score should also be relevant as a low score would indicate low issuer trustworthiness. Since trust is important regarding the use of proceeds, the G-score is expected to be negatively correlated to the spread.

Hypothesis 3 For green bonds, environmental criteria dominate social and governance criteria!

Data and methodology

We use three different datasets for our analyses. Dataset 1, the Bloomberg Barclays Global Aggregate Index which will be used to examine whether a (negative) green bond premium exists. Dataset 2, a unique screening of the fixed universe to produce a sample of 466 bonds. Details of this screening process are provided below. This dataset is used to determine whether and how the issuers' ESG rating affects the respective green bond spreads. Finally, dataset 3, the ICE Bank of America Merrill Lynch Green Bond Index which is used to control the robustness of the results and to validate the screening rules applied to dataset 2. We will

henceforth refer to dataset 1, dataset 2 and dataset 3 as "the global aggregate index", "the custom universe" and "the green bond index".

We focus on the results of the custom green universe and use the green bond index and the green component of the aggregate index for validation purposes. The aggregate index includes green bonds and therefore these (green) bonds can be used as an additional database for validation of hypotheses 1 and 2. We apply MSCI ESG ratings to verify the impact of ESG ratings on bond spreads. There is a growing stream of literature that documents the divergence of ESG ratings (see, e.g., Berg et al. 2019; Chatterji et al. 2009, 2016; Semenova and Hassel 2015; Dorfleitner et al. 2015). The recent study of Berg et al. (2019) shows that the correlation between five ESG raters ranges between 0.42 and 0.73. This divergence can be mainly explained by measurement divergence, and the number of categories the ESG provider is using. In their findings, they show that while MSCI (previously KLD but was acquired by MSCI) nearly needs 25 categories to regress the rating, the other four rating providers need significantly less categories to explain their ratings. Their findings show how the divergence between the rating providers might explain the difference in the rating. However, the results also indicate that MSCI has the best overall ESG score and that could explain why it is the most used one in academic literature (Berg et al. 2019) to verify the impact of ESG ratings on bond spreads.

Data are as at October 31st, 2019. By using secondary bond spreads instead of primary spreads, we reduce the influence of possible macroeconomic influences. We obtain all bond control variables from Bloomberg.

As the first green bond was issued in 2007, we reduce the debt universe to bonds issued between January 1st, 2007 and October 31st, 2019. Next, we filter for green bonds. For the observed time period, 2456 issues are green labelled. As this sample also includes loans, we excluded them. Thereafter, we implement a size threshold of $100 million issue volume. This step reduces the sample down to 1077 bonds. In order to create a homogenous dataset, we look at bonds with maturity type "At Maturity" and "Callable" only. This reduces the sample size by 64 observations. Further homogenization is reached by excluding floating rate bonds. We also exclude bonds without a credit rating.[1] This reduces the sample by another 328 bonds. Adjusting for double counting through RegS and 144a issues as well as Tap issues the sample is left with 493 bonds. For further homogeneity 18 bonds whose coupon types are not fixed are removed. As a last step, 9 bonds are excluded due to missing data.

Table 2 Sample selection process

	Number of securities
Initial sample	2456
Less loans	− 109
Less bonds with amount issued < 100 mio $	− 1270
Less bonds with maturity type different from "at maturity" or "callable"	− 64
Less floating bonds	− 82
Less bonds with no credit rating	− 328
Less bonds with series "RegS"	− 57
Less bonds that are taps	− 53
Less bonds with coupon type different from "fixed"	− 18
Less bonds that miss necessary data (e.g. I-spread)	− 9
Final sample	466

The sample selection process reduces the number of green bonds from 2456 down to a final sample of 466 bonds. Table 2 summarizes the sample selection.

To test hypotheses 1 to 3, we need to further adjust the dataset. For Hypothesis 1, we use the final sample, respectively, the green bond index and the green part of the global aggregate index[2] for validation. For hypotheses 2 and 3, only bonds from issuers with an ESG rating can be used. Therefore, we match bonds with the issuers MSCI ESG rating. If a subsidiary who is not rated issued the bond, we used the ultimate parent's ESG rating. This method of matching ratings and bonds is rather problematic for government-related issuers, as the ultimate parent is (ultimately) the government. The matching for government-related issuers can therefore be inaccurate. To avoid this problem, we use two different datasets for each regression. The first dataset is our full dataset and the other dataset incluses coporate bonds only. When discussing the results, we will focus on corporate green bonds.

In order to determine the influence of different variables on bond spreads, especially the ESG rating, an ordinary least squares (OLS) regression is applied as followed:

$$\begin{aligned} Y_i = {} & \beta_0 + \beta_1 \text{ESG}_i + \beta_2 \text{Credit Rating}_i + \beta_3 \ln\left(\text{Amount Issued in \$}\right)_i \\ & + \beta_4 \ln\left(\text{Amount outstanding in \$}\right)_i + \beta_5 \ln\left(\text{Time to maturity in years}\right)_i \\ & + \beta_6 \text{Callable}_i + \beta_7 \text{USD}_i + \left(\beta_8 \text{Governm. related}_i\right) \\ & + \beta_9 \text{China}_i + \beta_{10} \text{Payment Rank}_i + u_i \end{aligned} \tag{1}$$

[1] We forgo to use a rating of a comparable bond. Credit ratings lower the information asymmetry between the issuer and the investors, and this might lead to a bias of the results in using comparable bonds.

[2] Floaters are not included in the green bond index as well as the global aggregate index.

Table 3 Variable definitions

Variable	Description
ESG related variables	
ESG rating	Dummy variable which takes value 1 if the issuer has a MSCI ESG rating, 0 otherwise
E-score	Environmental pillar of ESG Score from 0 (worst) to 10 (best)
S-score	Social pillar of ESG Score from 0 (worst) to 10 (best)
G-score	Governance pillar of ESG Score from 0 (worst) to 10 (best)
Weighted average ESG score	Combined ESG score from 0 (worst) to 10 (best)
Control variables	
Credit rating	Bloomberg composite rating (expanded if not available with S&P or Moody's rating.) AAA equals 1, AA + equals 2 etc
Amount issued	Issue size in USD
Amount outstanding UP	Amount outstanding (all bonds) of the ultimate parent in USD.
Time to maturity	Remaining time to maturity in years measured from October, 31, 2019
Callable	Dummy variable which takes value 1 if the bond is callable, 0 otherwise
USD	Dummy variable which takes value 1 if the bond is denominated in USD, 0 otherwise
Governm. related	Dummy variable which takes value 1 if the bond is issued by a government-related issuer, 0 otherwise
Green bond	Dummy variable which takes value 1 if the bond has a Green Instrument flag, 0 otherwise
China	Dummy variable which takes value 1 if the issuers country of risk is China, 0 otherwise
Payment rank	Normalized payment rank of the bond where 1 equals 1st lien Secured, 2 equals Secured, 3 equals Sr unsecured, 4 equals Subordinated, and 5 equals Jr Subordinated

Variables are described in Table 3. Slight changes to the base models are necessary depending on the hypothesis tested or the data used.[3]

Empirical results

Does a (negative) green bond premium exist?

To determine whether there is a statistically significant green bond premium, we follow the approach of Preclaw and Bakshi (2015). We use the global aggregate index and introduce a green bond dummy variable, which is one if the bond is green and zero otherwise. Table 4 shows the regression results. We control for collinearity of the variables by analysing the variance inflation factors (VIFs). The average VIFs are low and around 1.54 for the dataset including all bonds and 1.45 for the dataset focusing on corporates; hence, we may assume there is no collinearity of the variables.

The *Green bond* dummy variable is statistically significant and negative, indicating a negative green bond premium of 8 to 14 bps. These results suggest that investors are willing to receive a lower yield in order to buy green. Thus, we confirm a (negative) green bond premium. The findings are in line with Zerbib (2019).

Does having an ESG rating lower the spread?

Next, we test the directional effect of an ESG rating on the spreads of green bonds. To determine whether the ESG rating has a positive impact on spreads of green bonds, we analyse if a missing ESG rating leads to a higher spread. The ESG variable is a dummy variable with the value of one if the issuer has an ESG rating (from MSCI) and zero otherwise.

Table 5 shows the results of the OLS regression. It includes six different regressions, but our main focus is on the regressions that include corporates only.

Analysing the influence of *ESG Rating*, we find that all three corporates only regressions (Models 1, 3, 5) show a negative relation of ESG rating and spread. Model 1, however, shows no statistically significant effect of the *ESG* variable, but the regressions of the green bond index (Model 3) and the green part of the global aggregate index (Model 5) are both highly statistically significant. Depending on the estimated model, having an *ESG rating* lowers the spread by 9 to 19 bps. The insignificant results of Model 1 could be due to a dominance of green bonds that have an *ESG rating*.

A deterioration in *Credit Rating* of 1 step (e.g., AA to AA-) leads to a 28.66 bps higher spread (Model 1 of Table 5). The influence of the *Credit Rating* is positive and statistically significant for each regression. The positive coefficient is not surprising, as a lower rating indicates more risk. The *Amount Issued* is statistically significant at the 5% level for the green component of the global aggregate index

[3] Depending on the model, one or three ESG variables are used.

Table 4 Existence of a green bond premium

	Green bonds characteristic only		Green bond characteristic and ESG Yes/No		Green bond characteristic and E-,S- and G-Score	
	Corporates	All	Corporates	All	Corporates	All
Model	1	2	3	4	5	6
Green bond	−9.704*** (1.909)	−8.030*** (1.630)	−12.777*** (1.883)	−11.061*** (1.618)	−13.713*** (2.158)	−12.215*** (2.066)
ESG			−22.140*** (0.929)	−20.829*** (0.838)		
E-score					−2.495*** (0.204)	−2.467*** (0.201)
S-score					−1.407*** (0.267)	−1.281*** (0.267)
G-score					−1.543*** (0.310)	−1.205*** (0.303)
Credit rating	13.176*** (0.174)	12.206*** (0.155)	13.410*** (0.174)	12.412*** (0.155)	11.775*** (0.204)	11.248*** (0.197)
Amount issued	−4.621*** (0.617)	−5.220*** (0.422)	−2.710*** (0.611)	−2.794*** (0.432)	−2.130*** (0.624)	−1.858*** (0.483)
Time to maturity	41.111*** (0.463)	38.214*** (0.428)	40.607*** (0.456)	37.891*** (0.420)	43.980*** (0.506)	41.341*** (0.482)
Callable	−23.596*** (0.802)	−20.413*** (0.784)	−18.791*** (0.777)	−16.185*** (0.756)	−16.911*** (0.825)	−15.484*** (0.825)
USD	37.409*** (0.733)	39.404*** (0.684)	36.931*** (0.712)	38.573*** (0.664)	27.166*** (0.772)	29.210*** (0.746)
Payment rank	−3.193 (0.521)	−1.954*** (0.494)	−2.004*** (0.525)	−0.644 (0.498)	−2.743*** (0.685)	−2.149*** (0.680)
Intercept	16.237 (12.536)	33.006*** (8.626)	−12.921 (12.330)	−7.771 (8.756)	−3.119 (13.065)	−7.099 (10.253)
N	14,170	16,046	14,170	16,046	10,705	11,543
Adjusted R^2	0.65	0.67	0.67	0.68	0.68	0.69

Standard errors are reported in parentheses

*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$

(Model 5). This result holds when including government-related bonds (Model 6). This relationship is in line with the previous literature (Kapraun and Scheins 2019). For the green bond index (Model 1 and 2), the coefficients are not statistically significant, which might be due to the issue size threshold that was implemented. A required minimum issue size might lower the influence of issue size on the spread. The *Amount Outstanding* variable shows only weak significance for the green dataset including all bonds (Model 2).

The relationship between *Time to Maturity* and spread is positive, i.e., a longer time to maturity leads to a higher spread. For all regressions, this influence is statistically significant. The coefficient is in the range of 11–26. The loading factors for the variable in the regression analysis suggest, that, all else being equal, an increase of the time to maturity by 1 year is associated with a higher spread of between 6.808 bps and 22.737 bps. The direction of the influence is as expected.

The *Callability* of a green bond leads to a 44.7 bps lower spread (Model 1) and is statistically significant for all but one regression (Model 4). This is contrary to previous research (e.g., Kuhn et al. 2018) but could be due to the effect of the low-interest phase. If an increase in interest rates is expected rather than a further decrease the *Callability* of a bond is no disadvantage for an investor. However, the results should be interpreted carefully as the callability also depends on the accepted likelihood of being called. Alternatively, the call option has the feature of reducing the maturity and hence could lead to lower spreads if compared to a higher maturity non-callable bond.[4]

For the *USD* dummy variable, we find that USD denominated bonds are significantly wider in a range of 46 to 74

[4] We thank the anonymous reviewer for this alternative explanation.

Table 5 Regression results Hypothesis 1

	Custom universe		Green bond index		Global aggregate index	
	Corporates	All	Corporates	All	Corporates	All
Model	1	2	3	4	5	6
ESG rating	−9.512 (16.177)	−36.412*** (9.611)	−19.179*** (5.952)	−18.622*** (4.623)	−12.636*** (3.869)	−12.531*** (3.677)
Credit rating	28.655*** (3.614)	21.601*** (2.370)	12.252*** (1.320)	10.982*** (0.916)	11.837*** (0.818)	11.371*** (0.755)
Amount issued	3.423 (16.695)	−7.440 (5.818)	−5.148 (6.714)	−6.203** (2.675)	−13.288** (5.134)	−14.965*** (3.724)
Amount outstanding	−2.389 (2.578)	−4.994* (2.596)				
Time to maturity	17.100* (9.467)	11.743** (4.788)	26.311*** (3.262)	18.922*** (1.988)	26.440*** (2.956)	24.034*** (2.186)
Callable	−44.705** (19.885)	−36.799** (17.218)	−7.787* (4.549)	0.207 (4.538)	−19.951*** (4.178)	−16.344*** (3.990)
USD	74.424*** (15.753)	71.911*** (9.806)	56.641*** (3.924)	46.427*** (2.976)	51.596*** (3.387)	47.056*** (2.840)
Governm. related		−7.062 (8.724)		−14.090*** (4.067)		−10.787*** (3.324)
China	295.445** (137.771)	63.727* (36.236)	−2.724 (8.898)	0.082 (8.126)		
Payment rank	−76.575*** (26.777)	−59.191*** (20.007)	4.477 (9.351)	1.499 (9.220)	−10.894*** (3.488)	−10.977*** (3.540)
Intercept	61.010 (348.662)	378.628 (124.235)	34.455 (126.748)	84.503* (46.210)	247.955** (101.488)	289.409*** (72.886)
N	218	466	301	491	323	407
Adjusted R^2	0.67	0.60	0.61	0.68	0.74	0.75

Standard errors are reported in parentheses

*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$

bps.[5] It can be concluded that other currencies, such as Euro denominated green bonds, price tighter than USD denominated green bonds.

The variable *Government related* is only relevant for the regressions using the full sample. All three regressions (Models 2, 4, 6) show that government-related issuers receive a lower spread of 7 to 14 bps. However, only Models 4 and 6 show statistical significance for this variable. The dummy variable *China* only shows significance for the custom dataset (Model 1 and 2). The "corporates only" (Model 1) selection indicates that a bond from China has a 295 bps higher spread, while the whole sample shows an additional spread of only 64 bps. In general, the higher spread related to *China* seems comprehensible, as characteristics of green bonds in China differ from those of other markets. The China Green Bond Market Report (2019) points out that a high percentage of bonds from China and labelled green does comply with the internationally recognized definition of a green bond by the Climate Bonds Initiative. On the other hand, there are also green-labelled bonds that only comply with China's domestic definitions. Another takeaway is that Chinese companies that are not government related seem to be regarded as much riskier, which might be due to the government's strong influence on the economy.

The results of the influence of the *Payment Rank* are mixed. The green bond index (Model 3 and 4) indicates a positive relationship (1 = 1st lien Secured … 5 = Jr. Subordinated) between spread and payment rank, but these results are not significant. The custom data index (Model 1 and 2) and also the green part of the global aggregate index (Model 5 and 6) show a significant negative relationship. This might surprise first but considering that the *Payment Rank* is already included to some extent in the credit rating and that the majority of green bonds are senior unsecured the results could be driven by some outliers.

Overall, the results support our first hypothesis that having an *ESG rating* is rewarded with a lower spread, confirming a directional effect. Information asymmetry regarding

[5] In an alternative model, we have replaced the USD dummy variable with a variable controlling for bonds issued in Euro. Using this alternative variable does not change the results for the other variables. The results of this alternative model are not shown for reasons of brevity but are upon on request.

Table 6 Regression results Hypothesis 2

	Custom universe		Green bond index		Global aggregate index	
	Corporates	All	Corporates	All	Corporates	All
Model	1	2	3	4	5	6
Weighted average ESG score	−13.570*** (3.426)	−10.603*** (2.918)	−6.091*** (1.811)	−6.444*** (1.719)	−9.634*** (1.701)	−8.918*** (1.684)
Credit rating	14.128*** (3.280)	12.739*** (2.333)	4.669*** (1.006)	5.251*** (0.795)	7.886*** (1.020)	7.370*** (0.970)
Amount issued	−17.469*** (6.064)	−16.462*** (5.870)	−16.951*** (3.589)	−16.485*** (2.524)	−16.698*** (4.043)	−18.384*** (3.880)
Amount outstanding	−2.745* (1.461)	−1.921* (1.147)				
Time to maturity	25.535*** (4.096)	19.763*** (4.583)	32.125*** (3.055)	28.731*** (2.725)	27.967*** (3.927)	26.675*** (3.407)
Callable	−11.059 (6.801)	−3.450 (7.449)	−0.905 (3.934)	0.384 (3.880)	−9.797* (5.213)	−8.559* (5.011)
USD	46.769*** (8.736)	52.413*** (8.469)	37.905*** (4.336)	41.350*** (4.106)	33.406*** (4.745)	34.858*** (4.447)
Governm. related		0.957 (7.896)		−19.288*** (5.098)		−9.467 (6.010)
Payment rank	0.996 (11.332)	7.830 (9.484)	39.400*** (4.027)	38.987*** (3.855)	−1.326 (3.986)	−0.625 (4.076)
Intercept	417.476*** (125.317)	353.842*** (113.736)	229.635*** (71.932)	223.608*** (49.807)	348.581*** (85.167)	380.701*** (81.310)
N	163	211	192	228	193	208
Adjusted R^2	0.65	0.64	0.76	0.78	0.74	0.74

Standard errors are reported in parentheses

*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$

the greenness of the green bond and the risk of financing greenwashing is reduced. The existence of an ESG rating leads to higher credibility of the company, represented through a more favourable spread when issuing green bonds. The results are in line with the majority of CSP/CEP—CFP research.

Does a higher ESG rating lead to a lower spread?

Following the result that having an *ESG rating* is correlated to a lower spread, we now only investigate green bonds that have an ESG rating to determine the magnitude effect and if the greenness of a green bond matters for its pricing. Table 6 shows the results for the model using the weighted average ESG score.

Looking at the ESG influence on the spread, for every single regression the *Weighted Average ESG Score* is statistically significant on the 1% level. An improvement in the ESG rating of 1 point (scale is 0–10) leads to a decrease of the spread by 6 to 13 bps. Correlation does not automatically imply causality, but the results indicate that the greenness of a green bond does matter. The greener the issuer, expressed by the ESG rating, the more an investor is ready to give up.

Unsurprisingly, the results of Table 6 show that the variable of *Credit Rating* has a statistically significant negative relationship to the bond spread. A one notch lower rating (e.g., BB + to BB) increases the spread by 5 to 14 bps depending on the sample. A higher *Amount Issued* is associated with a lower spread but the *Amount Outstanding* is only weakly statistically different from zero. The coefficient *Time to Maturity* is positive and strongly significant for all regressions with a 10% increase leading to a 2–3 bps higher spread. The dummy variable, *Callable*, has as for Hypothesis 1, a negative coefficient but lacks significance at the 5% level. Moreover, the relationship between the spread and the dummy variable *USD* has not changed. This result is significant for all regressions. As expected, the dummy variable *Government related* is negatively related to the spread but only in Model 4.

Looking at Hypothesis 2, we conclude that the higher the ESG rating, the lower the spread of green bonds. The results confirm our second hypothesis and provide evidence for the magnitude effect.

Table 7 Regression results Hypothesis 3

	Custom universe		Green bond index		Global aggregate index	
	Corporates	All	Corporates	All	Corporates	All
Model	1	2	3	4	5	6
E-score	−2.355 (1.926)	−2.703 (2.004)	−0.703 (0.966)	−0.541 (0.944)	−1.407 (1.034)	−1.209 (0.994)
S-score	−4.631* (2.514)	−2.451 (2.332)	−1.757 (1.169)	−2.117* (1.164)	−1.914 (1.313)	−2.066 (1.286)
G-score	−5.504*** (2.072)	−3.428** (1.567)	−2.730** (1.129)	−3.230*** (1.068)	−4.486*** (1.195)	−4.304*** (1.183)
Credit rating	13.445*** (3.373)	12.571*** (2.390)	4.240*** (0.943)	4.960*** (0.766)	7.286*** (1.063)	6.870*** (0.972)
Amount issued	−20.386*** (6.536)	−17.945*** (6.064)	−18.674*** (3.795)	−17.508*** (2.574)	−19.286*** (4.498)	−20.188*** (4.142)
Amount outstanding	−3.429* (1.741)	−1.816 (1.163)				
Time to maturity	25.025*** (4.234)	19.270*** (4.902)	31.753*** (3.069)	28.745*** (2.770)	26.575*** (4.044)	25.679*** (3.583)
Callable	−18.450** (7.436)	−7.836 (8.243)	−2.639 (4.013)	−2.028 (3.874)	−11.500** (5.477)	−10.751** (5.179)
USD	47.935*** (8.629)	53.908*** (8.464)	38.666*** (4.199)	42.202*** (4.011)	35.502*** (4.546)	36.915*** (4.293)
Governm. related		−4.223 (9.075)		−17.833*** (5.482)		−10.956* (5.906)
Payment rank	3.501 (10.590)	9.512 (9.209)	40.425*** (3.905)	39.957*** (3.714)	0.315 (4.021)	0.980 (4.064)
Intercept	485.699*** (132.926)	368.290*** (118.582)	259.018*** (76.161)	239.152*** (51.211)	389.780*** (94.151)	407.613*** (87.055)
N	163	211	192	228	193	208
Adjusted R^2	0.64	0.62	0.75	0.78	0.72	0.73

Standard errors are reported in parentheses

*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$

For green bonds, environmental criteria should dominate social and governance criteria

We now separate the ESG rating into the E-, S- and G-score. Table 7 shows the regression results for the model including the three components.

We find that the E-Score coefficient is not significant in any model. The *S-Score* shows only weak significance in the first model but lacks significance in the other models, while the G-Score is strongly significant in all regressions.

This result is interesting, since it implies that the governance part of the ESG score is the main driver behind lower spreads, not the E-Score as expected. One possible explanation for this result could be the characteristic of a green bond itself. The main characteristic of a green bond is the use of proceeds. These need to be directed towards an environmentally friendly purpose. From an investors' point of view, the results indicate that the trustworthiness represented through the G-Score is more relevant than the environmental friendliness represented through the E-Score. Trust is a crucial point for green bonds due to the special use of proceeds. Therefore, the results suggest that the belief the issuer uses the proceeds in the stated way is more important than the environmental image of the issuer. We conclude that companies with high governance scores are able to issue green bonds more successfully.

We now return to the global aggregate index and our first question of the existence of a (negative) green bond premium. Running a correlation matrix,[6] it is obvious that the green bond characteristic shows almost no correlation with the other variables. This is particularly interesting for the E-Score. It indicates that bonds from environmental-friendly companies are not more likely to be green than bonds from less environmental-friendly firms. This supports the conclusion that the environmental friendliness of an issuer are not the most important characteristic for the spread of a green

[6] For reasons of brevity, the correlation matrix is not shown in the paper but is available upon request.

bond. We need to reject our third hypothesis, as a domination of E versus S and G could not be found. However, we find that governance seems to be the main driver of spreads of green bonds.

Conclusion

First of all, the evidence provided in our paper supports the (negative) green bond premium found in previous studies. For our sample, we report a negative premium of 8 to 14 basis points (directional effect). Addressing the question of potential greenwashing, we show that the existence of an ESG rating lowers the spread of green bonds. We offer the explanation of reduced information asymmetry and additional certification by the rating agency. Further, a higher ESG score (better rating) additionally lowers the spread for green bonds (magnitude effect). Remarkably, not the influence of the E-Score is the main driver for green bond spreads, but the G-Score (composition effect).

Our findings contribute in several ways to the literature: First, the ongoing existence of a negative green bond premium is underlined. Second, it is important for issuers to have an ESG rating in order to be investable for ESG-dedicated investors. Third, having a good rating does pay off spread-wise, as a good ESG rating will attract more investors. The shade of green matters for the pricing of green bonds. As the governance pillar has the strongest and most significant influence on the spread, we conclude that governance is an important driver of credit risk, even in the case of green bonds.

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