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Investigating the Existence of the Green Bond Premium

The Impact of Market Interest Rates

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The views stated in this thesis are those of the author and not necessarily those of the supervisor, second reader, Erasmus School of Economics or Erasmus University Rotterdam.

ABSTRACT

This thesis investigates the green bond premium (greenium) in the US corporate bond market from 2017 to 2023. It explores whether green bonds are issued at lower yields to maturity compared to conventional bonds. This is further investigated in the context of rising interest rates. This study uses ordinary least squared and fixed effects regressions, with yield to maturity being used as the dependent variable. The independent variable of interest is a dummy variable that indicates whether a bond is green. The results show that a significant greenium exists. Notably, green bonds issued in 2023 show a significantly lower yield compared to other years, which is reflected by the impact of recent economic conditions. The findings also confirm that higher ESG scores lead to lower bond yields, which emphasizes a firm's advantage of strong ESG performance. This research enhances the understanding of the dynamics of green bonds and offers insights for issuers and investors in the sustainable debt market.

Keywords: Green Bond Premium, Enviornmental Social Governnance (ESG), Climate Finance, Corporate Bonds

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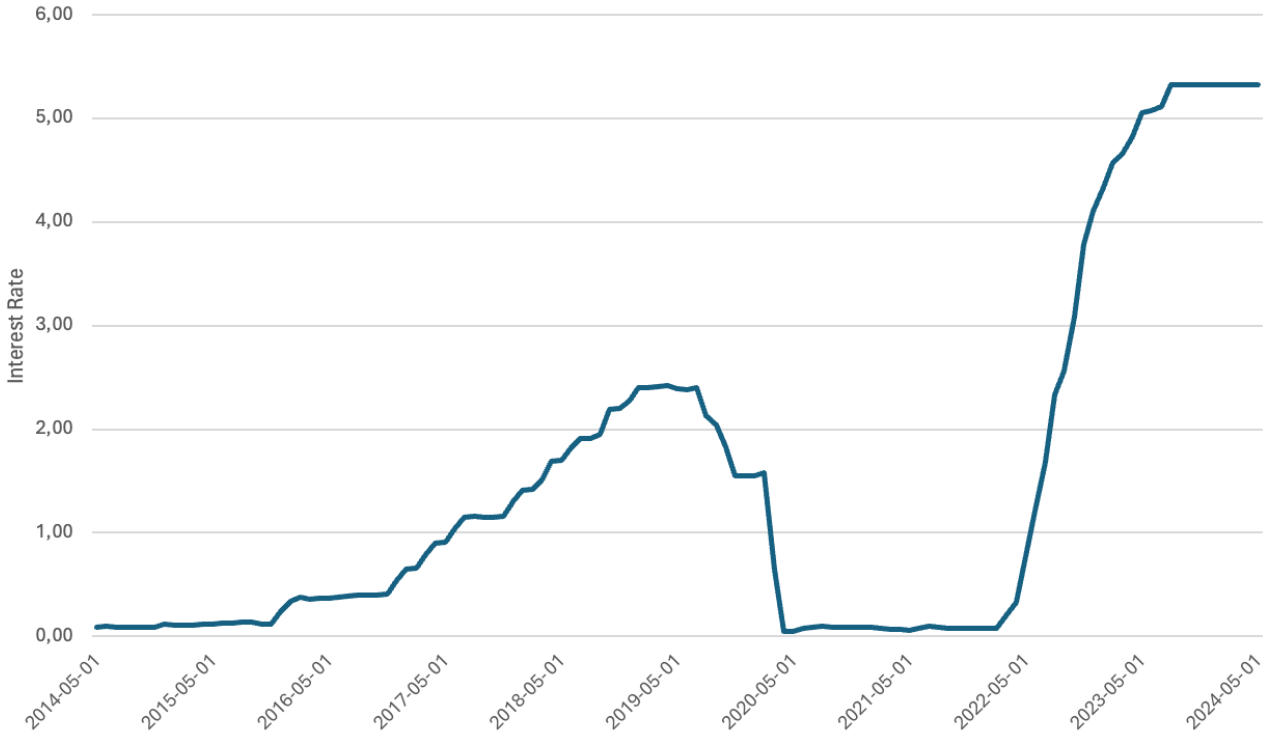
CHAPTER 1 Introduction

In today's world, environmental, social, and governance (ESG) considerations are becoming increasingly important. Companies are striving to align with these principles, which cover a wide range of issues including climate change, human rights, corporate governance, and sustainable supply chain management (UNPRI, 2022). Firms try to show their commitment to corporate social responsibility and to manage the risks of various ESG factors (CCBJ, 2023). In response, financial markets have developed sustainable instruments such as green bonds, which have been growing steadily since the European Investment Bank issued the first one in 2007 (World Economic Forum, n.d).

Green bonds are debt securities specifically used to finance projects with positive environmental impacts (CFI, 2022). By 2023, nearly 1 trillion USD in sustainable bonds had been issued, a significant increase from less than 50 billion USD in 2014 (Bloomberg 2024). Althgouh green bonds allow firms to enjoy various tax benefits, companies are required to disclose exact information about the projects being financed. This transparency provides investors with a credible way to invest in sustainability. This allows firms to become more environmentally friendly while also attracting investors interested in support these initiatives. These fixed-income product also provide firms with benefits such as risk mitigation and improved credit ratings, which can reduce borrowing costs.

The term "greenium" refers to the yield advantage that green bonds may have over conventional bonds. Most research suggests that a significant borrowing cost advantage exists. Papers by Zerbib (2018) and Caramicheal and Rapp (2022) show that yield spreads between green and conventional bonds range from -2 to -12 basis points. However, the magnitude and size of this greenium can vary, as some studies indicate that it is higher for certain types of issuers or under specific conditions. For example, Kapraun et al. (2021) found that the greenium is significant for government and supranational issuers, but also for corporations issuing large bonds. According to Caramicheal and Rapp (2022), a greenium appears mainly after 2019, which aligns with the growth of the sustainable asset management industry. Despite the general agreement on the existence of a greenium, its consistency and significance over time remain uncertain. Most research has focused on the period from 2013 to 2019, while often overlooking economic shocks and changing interest rates. The economic conditions of late 2022 and 2023 are characterized by rising interest rates and inflation and provide a new context to analyse the greenium. The rising interest rates can be seen in graph 1, which shows the federal funds rate in the United States. This is the interest rate at which depository institutions trade funds with each other overnight.



Graph 1: Federal Funds Effective Rate United States (Federal Reserve Bank of St. Louis, 2024)

The aim of this thesis is to determine whether a green bond premium exists in US corporate bonds from 2017 to 2023 and to evaluate how economic conditions affect this greenium. The study uses data from Wharton Research Data Services (WRDS) and Bloomberg's fixed income database. The analysis will include a cross-sectional regression to compare the yields of green and conventional bonds, considering various control variables such as bond characteristics and firm-specific factors. Additionally, a regression with industry and rating fixed effects is used to account for time-specific influences. This thesis only considers the primary market, as this is the time firms are most concerned with the yield they must offer when issuing a bond. Although this yield may fluctuate in the secondary market, the absolute costs of a fixed bond do not change.

The findings of this research are expected to give more insight into the financial dynamics of green bonds and their role in sustainable finance, especially under different economic conditions. This research will also explore whether the green bond premium is influenced by the broader economic environment, providing insights on how firms and investors might navigate the evolving landscape of sustainable finance.

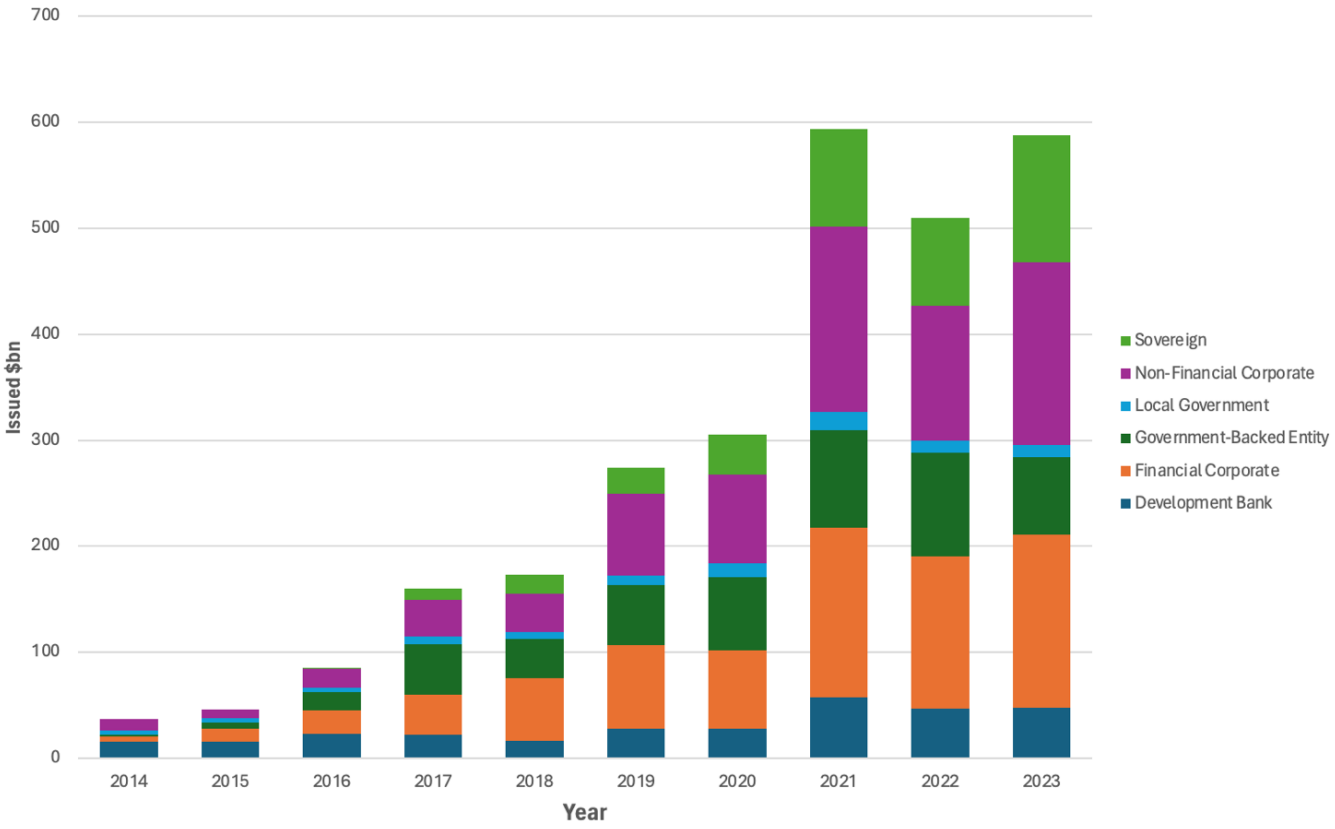
This thesis finds the precence of a green bond premium in US corporate bonds between 2017 and 2023, though the exact size of this remains somewhat uncertain. This premium stays constant throughout these years but notably in 2023 increases in magnitude. This suggests that rising interest rates may be advantagous for firms issuing green bonds. Lastly, ESG scores are found to negatively impact bond yields.

The remainder of this thesis is stuctured as follows. Chapter 2 discusses the findings and methods used by past literatue. The next section introduces the dataset used for the analysis. Chapter 4 discusses the empirical methodology. Chapter 5 presents and discusses the results of the main hypotheses. The last section recaps the analyses that are conducted and provides a conclusion to the research. Additional supportive tables are provided in the Appendix.

CHAPTER 2 Theoretical Framework

2.1 Intoduction to Green Bonds

Green bonds are one of the most notable sustainable instruments available on financial markets. They are similar in structure to conventional bonds issued by corporations and governments but are meant to fund projects with environmental benefits (Reboredo, 2020). Green bonds exist in various formats, including plain vanilla bonds, securitized bonds, and project bonds (Cortellini, 2021). Since their inception in 2007 with the European Investment Bank's first issuance, green bond imissions have gradually grown and experienced a significant surge in the early 2020s (World Economic Forum, 2023). Graph 2 shows that corporates are the largest issuers, while financial institutions, sovereign governments, supranational organizations, and development banks also participating in green bond markets (Climate Bonds, 2023).



Graph 2: Green Bond issuance by issuer type (Climate bonds, 2024)

Corporations are motivated to issue bonds to access capital and labeling them as green can potentially lower their capital costs. This reduced cost of capital can lead to savings for issuers over the lifespan of the bond, which incentivizes companies to use green bond issuance to fund sustainable initiatives. Although financial incentives drive issuers, there are also several non-financial factors firms care about (Maltais 2020). Firstly, issuing green instruments requires more transparency about bond

usage, attracting a broader, more sustainable investor base. This base may include organizations and individuals with strong intrinsic motivations, ESG investment objectives, or external pressures to support sustainable initiatives (Flammer 2020). Although investors may be willing to accept lower yields on green bonds compared to conventional ones, the extent of this yield difference is still somewhat debated among researchers. This is a topic this paper will further discuss.

Additionally, Tang and Zhang (2020) argue that issuing green bonds brings notable non-financial advantages, mostly due to increased media attention. This attention comes with higher institutional ownership of shares and a higher stock liquidity. When companies demonstrate a strong commitment to the environment, it tends to also lead to positive abnormal returns in share prices. However, such media exposure is short-lived, as it occurs mainly during the first issuance of a sustainable bond. Finally, by financing environmentally sustainable projects, companies have the potential to mitigate regulatory, reputational, and operational risks associated with environmental concerns.

2.2 Determinants of Bond Yields

The yield investors receive from companies is influenced by various factors. Economic factors, such as interest rates set by central banks and the market-generated yield curve, directly affect bond yields. High interest rates increase borrowing costs for companies, which leads to higher yields on new bond issuances. These changes in interest rates also impact investor demand for bonds. Higher rates generally enhance a bonds appeal as a long-term investment. Inflation expectations and economic growth also shape investor demand and the interest rates investors seek.

Corporate bond yields are further influenced by company-specific factors. Idiosyncratic risk, which reflects the likelihood of default, directly affects debt repayment probabilities and is often assessed through credit ratings by agencies such as S&P, Moody's, and Fitch. Higher credit ratings typically indicate lower default risk, resulting in investors requiring a lower risk premium. These credit ratings incorporate factors such as financial performance, debt levels, industry outlook, and market power. Additionally, Environmental, Social, and Governance (ESG) risks are becoming increasingly relevant for bond investors. ESG risks are evaluated by firms such as Sustainalytics, who assess a company's sustainability and ethical performance. ESG scores are generally set between 1 and 100. Higher ESG scores propose that companies have a better ESG performance and are less vulnerable or better equipped to face these challenges. This leads to lower perceived risks by investors focused on sustainability, who therefore require lower risk premiums (Badoer & James, 2016)

2.3 The Legitimacy of Green Bonds

The primary challenge associated with green bonds is verifying their credibility, which involves assessing the extent of the environmental impact. This concern is known as greenwashing and is defined by the NRDC (2023) as "the act of making deceptive claims about the environmental benefits of products or practices." In the context of green bonds, this refers to misleading claims about the enviornmental and sustianablility benefits of these bonds. Greenwashing often involves firms highlighting minor green initiatives to distract from their actual detrimental actions. This can undermine consumer trust and disproportionately affect low-income communities, all while hindering genuine environmental progress (NRDC, 2023). Xianwang et al. (2023) examine greenwashing in China and find that while green bonds generally lead to more green patent applications, these are often non-innovative. Non-innovative patents generally contribute little to real innovation and are typically of low quality. This can be seen by fewer approvals and citations, which suggests that companies may focus more on improving observable green metrics over actual innovation.

Greenwashing partly arises from the lack of public regulation for corporate green bond issuances. The main guidelines for classifying bonds as green are the Green Bond Principles (GBP) and the Climate Bond Initiative (CBI). Both are private entities relying on certification by independent third parties. This certification process involves pre- and post-issuance screening to ensure, to some extent, that the proceeds are allocated to the designated green projects. Since these guidelines are enforced by private organizations, compliance demands significant effort and is often costly (Flammer, 2021). For green bonds to achieve a lower cost of capital, the green bond premium must outweigh these associated costs.

2.4 Findings on Green Bonds Premiums and Applications of Methods

Early studies on green bond premiums prior to 2018 present mixed evidence. Febi et al. (2018) investigated green bond premiums from 2013 to 2016 in the UK and parts of the EU using a fixed effects regression model, based on unbalanced panel data. They found a significant premium of 69 basis points in 2016, however with merely a 10% significance level. Hachenberg and Schierek (2018) reported an average global green bond premium of only 1 basis point for 2015 and 2016, while lacking statistical significance. This paper employed a different research strategy, using a matching method where green bonds are matched with similar conventional bonds based on time to maturity, industry, country, type of issuer and credit ratings. These two studies represent some of the earliest applications of the two main methodologies for samples in this field: unbalanced panel data and the matching method for bond data. This sample is then used to run different kinds of regressions. Using a matching method that included nearest neighbors matching, Larcker and Watts (2020) found no evidence of a greenium in U.S. green corporate bonds from 2013 to 2018. In contrast, Karpf and Mandel (2018) observed a premium averaging 7.8 basis points for US companies between 2010 and 2016 using a regression model. Further evidence of a premium was provided by Gianfrate and Peri (2019) and Zerbib (2019), who reported

significant greeniums of 5 to 13 basis points and 2 basis points, respectively, for the period from 2013 to 2017. Gianfrate and Peri (2019) utilized a prosperity score matching while Zerbib (2019) used a matching method and fixed effect regression. Additionally, Nanayakkara and Colombage (2019), Hyun et al. (2020), and Kanamura (2020) all identified significant greeniums in their analyses of various years within the 2010s, all using global samples and different forms of regressions and matching methods. Lastly, Immel et al. (2021), focused on the effect of ESG scores on green bond yields and found that higher ESG scores lead to statistically significant negative premium.

More recent analyses of green bonds have devoted more time to greenwashing and the lasting environmental impact of green bonds. Additionally, researchers are finding more consistent findings regarding green premiums, which generally appear to be low but significant. Caramichael and Rapp (2022) investigate the borrowing cost advantage of green corporate bonds relative to conventional bonds in the primary market using an ordinary least squared (OLS), but also a fixed effect regression. They found a greenium that ranges from 3 to 8 basis points (bps), which corresponds to a cost saving for corporations of 2% to 7%, which becomes significant only from 2019 onward. Specifically, a 15-basis point greenium emerged in 2019. This decreased to 10 basis points in 2020 and further to 8 basis points in 2021, which suggests a potential downward trend as the green bond market matures. It was also found that this greenium mostly benefits large, investment-grade issuances denominated in euros or US dollars within developed economies. Furthermore, high-quality sustainability projects do not seem to receive preferential treatment. The study also concludes that there is no "green halo effect," meaning the issuance of green bonds does not lower a company's overall borrowing costs across all fixed income products. Additionally, the paper did not definitively determine whether green bonds incentivize additional sustainability investments or merely reward existing green projects. Therefore, the greenium is unlikely to significantly drive large-scale green investments, while remaining at risk to greenwashing.

Li et al. (2022) investigate the green bond premium in China between 2016 and 2020. This study uses propensity score matching to create a control group of conventional bonds that can be compared to green bonds. They then apply different matching methods and conduct a logistic regression analysis. The results show that at issuance, green-labeled bonds have a financing advantage of 12 basis points. This is caused largely by government support policies. Furthermore, this advantage can be traced back to increased investor demand for green financial products, which is mostly driven by anticipated policy guarantees. However, the authors warn that the success of policy-supported green bonds could lead to risks such as capital concentration in government-owned entities and widespread greenwashing. Li et al. suggest a more restrained role of the government to encourage a greater private sector participation, improved monitoring and stricter regulations to address greenwashing in the Chinese sustainable bond market.

Flammer (2021) investigated green corporate bonds and focusing closely on the effect of industries and countries of operation. Using a matching method, the paper aligns green bonds with comparable conventional bonds based on maturity, industry, country, issuer type, and credit ratings. The

findings show that China, the USA, and Western Europe are the leading issuers of green bonds, with the banking sector issuing the most green capital, followed by the real estate, renewable energy, and utilities sectors. Furthermore, issuers of green bonds tend to improve their environmental performance and ESG ratings after issuance. This contradicts with some of the findings by Caramicheal and Rapp (2022). Notably, Flammer finds no significant difference in yields between green bonds and conventional bonds.

Kapraun et al. (2021) analyze green bonds in both primary and secondary markets and use a matching method similar to that of Flammer (2021). This paper finds that the most significant green premiums occur in bonds issued by governments or supranational entities, that are denominated in euros, but also in corporate bonds with very large issue sizes. Kapraun et al. also find that investor demand for green bonds and greeniums are higher when these instruments are certified by a third party and when the issuer is credible and expected to have a genuine sustainable impact. Additionally, issuers with higher ESG ratings tend to have lower yields on their green bonds, which indicates that investors place trust in their sustainability efforts.

2.5 Theoretical Model and Hypothesis Development

From the reviewed papers, there does not seem to be a common approach to comparing green bonds to conventional bonds to find the yield difference. Several papers utilize a bond matching method where green bonds are matched with usually two conventional bonds that are similar in maturity, industry, country, issuer type, and credit ratings. However, studies like Caramichael & Rapp (2022) use an unbalanced panel of bonds and utilize an ordinary least squared and fixed effect regression to compare green and regular bonds. This is the process thesis will closely follow. Caramichael & Rapp (2022) focus on the primary market and therefore only have one observation per bond. However, this is considered panel data as firm-level fixed effects are used. Therefore, there are multiple observations per firm. This allows them to account for potential nonlinearities as well as bond- and issuer- specific time variation in the regressions. This is preferred over matching methods used by Flammer (2021), Kapraun et al. (2021), and others, as a matching procedure requires three bonds by the same issuer (one green and two conventional) or a set of comparable bonds that produce a balanced sample. This greatly reduces the number of green bonds available for analysis and biases the sample towards large issuers with frequent bond issuances, underrepresenting small and medium-sized firms and issuers in emerging markets (Caramichael & Rapp 2022).

This thesis investigates the yield-to-maturity discrepancies at issuance between green and conventional bonds (referred to as the greenium) issued on the US bond market since 2017. It also assesses whether bond issuances during periods of elevated interest rates, particularly in 2023, influence the green premium.

Despite the literature review indicating uncertainty about the magnitude and significance of the green premium, this research anticipates finding a small, yet statistically significant premium across the sample, with a greater premium during periods of high interest rates. This is based on the influence of

central bank interest rates on bond yields, in particular the rates set by the Federal Reserve in the US. Higher federal interest rates may drive corporations to seek more affordable capital sources, including green bonds. Thus, the primary hypotheses of this research are:

H1: Green bonds are issued at a negative premium relative to conventional bonds

H2: Green bonds are issued with consistent yields to maturity, regardless of market interest rates

H3: ESG Scores negatively affect the yield of (green) bonds

CHAPTER 3 Data

3.1 Method of Data Collection

For this research, data is extracted from three different databases. The Wharton Research Data Services (WRDS) database provides cleaned and user-friendly data on US corporate bond issuances from July 2002 to December 2023, that includes monthly data for each bond. WRDS allows extraction of up to 59 variables describing bond characteristics, including identification variables such as ISIN and CUSIP ID. This database is the source of variables used to explain the yield to maturity of both conventional and green bonds, which includes coupon rate, time to maturity, issue price, offering amount, and credit rating. The analysis in this thesis focuses on the period from January 2017 to December 2023, covering approximately 77,000 corporate bond issuances in the US. However, many of these issuances have a very low offering amount and no information on the bonds yield-to-maturity.

Additionally, WRDS supplies firm-specific data through the "Financial Ratios Firm Level" database, which includes ratios such as return on assets, gross profit as a percentage of total assets, leverage ratio, and interest coverage ratio. A limitation of this data is that not all firms in the bond database have available financial data, and some ratios are missing.

The second database utilized is the Bloomberg Terminal fixed income database, which indicates which bond products are labeled as "green." Bloomberg classifies green bonds based on four criteria: 100% of proceeds must be used for environmental causes, the issuer must clearly state the specific green projects, the net proceeds must be tracked and attested by a formal internal process, and the issuer must report on the financed projects annually (Bloomberg, 2023). Using this criteria, all US corporate green bonds are identified, and their unique identifiers (ISINs) are extracted.

Lastly, the Refinitiv database was used to extract ESG scores and total assets for all US firms included in the bond sample. Refinitiv, a provider of financial market data, offers the most recent ESG scores based on ISINs obtained from the bond data provided by WRDS.

3.2 Overview of Variables and Descriptive Statistics

Table 1: Descriptive Statistics of Primary Market US Corporate Green and Conventional Bonds

	Green					*Conventional*				
Variable	**Obs**	**Mean**	**Std. dev.**	**Min**	**Max**	**Obs**	**Mean**	**Std. dev.**	**Min**	**Max**
Yield-to-Maturity	162	0.045	0.057	0.008	0.473	13,501	0.078	0.137	-0.402	2.564
Years to Maturity	162	15.194	9.886	3.014	40.033	13,501	7.258	8.970	0.756	100.668
Offering Amount	162	612,038	333,837	50,000	2,500,000	13,501	402,269	627,686	100	9,518,964
Coupon Rate (%)	162	3.333	1.240	0.750	6.750	13,449	5.361	3.450	0	33.75
Numerical Rating	159	3.421	0.599	1.000	5.000	8,363	3.468	0.758	1	8
Total Assets	156	648 M	7.14 B	0.027 M	90.1 B	12,882	6.23 B	50.6 B	7500	7.16 T
Return on Assets	102	0.097	0.045	0.007	0.271	7,818	0.078	0.074	-0.529	0.431
Leverage Ratio (D/E)	102	0.687	0.113	0.308	0.940	7,818	0.795	0.166	0.037	2.359
Interest Coverage Ratio	102	5.837	5.387	1.412	29.040	7,818	10.331	194.508	5.486	95.474
ESG Score	158	68.230	17.436	19	94	13,277	74.379	13.905	5	95

The yield to maturity of bonds, which is used as the dependent variable, is influenced by several variables outlined in the theoretical framework. The analysis focuses on bond and firm characteristics at issuance, which is known as the primary market. The main variable of interest is a dummy variable called *Green Bond*, which takes on the value 1 if a bond is classified as green. The cleaned sample for the analysis includes 162 US corporate green bonds and 13,501 regular bonds.

The first control variable, *Years to Maturity,* indicates the number of years until a bond reaches maturity and the principal is repaid. On average, green bonds have a longer time to maturity than conventional bonds. The variable *Offering Amount* represents the total debt issued through a particular bond and is higher for green bonds. The *Coupon Rate* describes the annual percentage of the face value that is paid to debt holders, a metric that is also higher for green bonds. *Numerical Rating* represents the credit rating at the time of issuance, taking into account ratings from S&P, Moody's, and Fitch and ranging from 1 (AAA) to 8 (D). However, there are some missing values for this variable, as not all firms issuing bonds are rated by these agencies.

The dataset also includes firm-specific control variables. The size of a firm is controlled for using the variable *Total Assets*. *Return on Assets* measures how efficiently a firm can generate profits from its operating assets. The *Leverage Ratio* represents total debt divided by equity, and the *Interest Coverage Ratio* is calculated by dividing EBIT by interest expense.

As seen in Table 1, firms issuing green bonds tend to be more profitable, have higher interest coverage ratios, and have less leverage compared to firms issuing conventional bonds. It is also important to note that firms issuing green bonds tend to have a lower ESG score.

CHAPTER 4 Methodology

4.1 Choice of Method

Selecting the right method is crucial for obtaining accurate and reliable results. As mentioned in the theoretical framework, there are numerous approaches for analyzing the impact of a bond being green on its yield to maturity. This research utilizes cross-sectional data, which is made up of bonds observed at issuance, on the primary market. There is therefore one observation per bond. This cross-sectional data is cleaned, but not modified in any other way, such as matching green and conventional bonds. While many studies use a matching method for bonds, this has significant drawbacks. Matching methods require groups of bonds (one green bond and two conventional bonds) with similar characteristics, which reduces the number of green bonds included in the analysis. Given the limited number of green bonds, this method would further reduce the sample size and introduce bias towards large issuers. This approach is seen in the studies by Hachenberg & Schiereck (2018), Tang & Zhang (2020), and Larcker & Watts (2020).

Several steps are required to combine data from different databases before any analyses can be run. First, the variable *Green Bond* is created by matching the ISINs of green bonds from Bloomberg with bond data from WRDS. Firm-specific data, available monthly, is matched to each firm by date and ticker. ESG scores are obtained from Refinitiv based on the most recent publication for each company using its ISIN and then matched to the main dataset. The data is subsequently cleaned to account for any outliers not feasible for this analysis. Bonds with low offering amounts that have no data on yield to maturity are also removed from the sample.

This thesis employs a fixed effect regression, a method also used by Caramicheal & Rapp (2022), Febi et al. (2018), and Zerbib (2019). A fixed effect model controls for unobserved heterogeneity by accounting for time-invariant characteristics that influence bond yields, which isolates the effect of a bond being green. In this case, industry and rating level fixed effects are applied to the cross-sectional data, to control for the differences across these groups. Prior to implementing a fixed effect regression, an ordinary least squares regression is performed for initial analysis due to its straightforward nature and ease of interpretation. To address potential unobserved heterogeneity, which is likely present in the sample, the OLS regression uses heteroskedastic-robust standard errors. Although this approach is less common in quantitative green bond analyses, it is applied in the research by Immel et al. (2021), who specifically analyses the effect of ESG scores on green bond yields.

4.2 Application of Statistical Techniques

These techniques are applied to investigate the impact of a bond being green on its yield to maturity at issuance for US corporate bonds from 2017 to 2023. For this, the following multiple linear regression model is used:

$$YieldToMaturity_i = \alpha_0 + \beta_1 GreenBond_i + \sum \beta_2 BondControls_i + \varepsilon_i$$

In this model, $YieldToMaturity_i$ is the dependent variable representing the yield to maturity of bond *i* at issuance, and is calculated as follows:

$$Yield\ to\ Maturity = \left(\frac{Face\ Value - Price\ at\ Issuance}{Number\ of\ Periods\ to\ Maturity}\right) + \left(\frac{Coupon\ per\ Period}{Price\ at\ Issuance}\right)$$

The primary independent variable, $GreenBond_i$, is a dummy variable taking the value 1 if the bond is classified as green. The ESG score of the issuing firm is also considered a potential determinant of bond yields. To ensure the reliability and validity of the estimated relationship between $GreenBond_i$ and $YieldToMaturity_i$, control variables are included to account for potential issues related to endogeneity, which in this case can be caused by omitted variable bias.

The first set of control variables encompasses bond-specific characteristics. *Years to Maturity* reflects the time between the bond's issuance and its maturity, impacting the yield due to longer durations leading to greater uncertainty and risk. *Offering Amount* indicates the total debt issued through the bond. Larger offerings often benefit from economies of scale in issuance costs, increased market liquidity, and may signal the credit strength of the issuing firm. This is transformed by taking the natural logarithm in order to address skewness and reduce outliers. The *Coupon Rate* not only directly, but also indirectly impacts the yield to maturity since higher coupon rates are less sensitive to interest rate changes but pose reinvestment risks due to interest rate uncertainty.

The second set of control variables consists of firm-specific variables. The *Numerical Rating* or credit rating provides investors with an assessment of the risk associated with a particular firm and the default risk of their debt. A high-risk rating generally results in lower demand and higher required yields, especially during economic uncertainty. *Return on Assets* indicates whether a company efficiently generates profits from its assets, signaling financial stability. The *Leverage Ratio* assesses the firm's debt relative to equity, indicating its ability to meet financial obligations, while the *Interest Coverage Ratio* measures how well it can pay the interest on its outstanding debt. The natural logarithm is also taken of the *Total Assets,* which describes the size of a firm.

Within the cross-sectional data, the month and year a bond is issued is used as the time fixed effect in the fixed effect regression and both industry and credit rating fixed effects are used. This fixed effect regression employs the same variables as the OLS regression, and is specified as:

$$YieldToMaturity_{i,t} = \alpha_0 + \beta_1 GreenBond_{i,t} + \sum \beta_2 BondControls_{i,t} + \mu_i + \varepsilon_{i,t}$$

To ensure the validity of the results, robustness tests are run. For the OLS regression, a white test is run to test for any potential heteroskedasticity. For the fixed effect regression, a Hausman test is run, which compares a fixed and random effect model in order to determine which one is the most appropriate. Furthermore, a modified Wald test is conducted to test for heteroskedasticity in the fixed effect regression.

CHAPTER 5 Results & Discussion

5.1 Results

Table 2: Ordinary Least Squared Regression Results

	Yield to Maturity (1)	**Yield to Maturity** (2)	**Yield to Maturity** (3)	**Yield to Maturity** (4)
Green	-0.034***	-0.021***	-0.019***	-0.014***
	(0.005)	(0.005)	(0.005)	(0.005)
Time to Maturity		-0.002***	-0.002***	-0.002***
		(0.000)	(0.001)	(0.000)
ln Offering Amount			0.006***	0.008***
			(0.000)	(0.000)
Coupon Rate			0.008***	0.019***
			(0.000)	(0.001)
Numerical Rating				0.020***
				(0.002)
R-squared	0.001	0.012	0.042	0.087
Number of observations	13,664	13,664	13,662	8,522

Notes: This table shows four OLS regressions created in Stata, that describe the impact of a bond being labeled as green on its yield to maturity at issuance. Three of these include control variables that further describe the yield. Time to maturity describes the years to maturity, offering amount shows the amount issued in US dollars, the coupon rate describes the annual % paid as a coupon and numerical rating describes the rating by S&P, Fitch and Moody`s. *Error in parentheses. *: p-value < 0.1, **: p-value < 0.05, ***: p-value < 0.01.*

The results of the ordinary least squared regression, which can be seen in Table 2, illustrate the impact of a bond being classified as green on its yield to maturity. In the first column, the yield to maturity is regressed on the dummy variable Green, which takes the value 1 if a bond is green. The findings indicate that, on average, green bonds have a yield to maturity at issuance that is 3.4 percentage points (p.p.) lower than that of conventional bonds. This result is significant at a 99% significance level. As control variables are added, which is done incrementally according to the SPECS (specific to general) principal, the variable *Green* remains significant, however decreases in magnitude. When controlling for time to maturity of a bond, green bonds exhibit a lower yield of 2.1 p.p. than conventional bonds, as shown in column (2). The *Time to Maturity* reveals that each additional year of a bond's maturity results in a lower yield of 20 bps. In column (3) further control variables are added. These include the natural logarithm of the offering amount and the annual coupon rate. In this specification, the effect of the variable *Green* is reduced to 1.9 percentage points on average. Finally, column (4) incorporates the

rating of the firm into to the regression. With this additional control, green bonds show a 1.4 p.p. lower yield compared to regular bonds. The analysis indicates that larger offering amounts and higher coupon rates significantly increase yields. The numerical rating shows that each downgrade in rating category, for example from A to BBB, significantly increases the yield by 2 p.p. The R-squared values of the regressions improve with the inclusion of control variables. However, with all bond specific variables added, the variables only explain 8.7% of the variation in the data.

Table 3: Fixed Effect Regression Results

	Yield to Maturity (1)	**Yield to Maturity** (2)	**Yield to Maturity** (3)	**Yield to Maturity** (4)	**Yield to Maturity** (5)
Green	-0.019***	-0.027***	-0.012*	-0.020***	-0.011*
	(0.005)	(0.006)	(0.006)	(0.006)	(0.007)
Time to Maturity		-0.002***	-0.003***	-0.002***	-0.003***
		(0.000)	(0.000)	(0.000)	(0.000)
ln Offering Amount		0.001	0.002**	0.005***	0.002**
		(0.001)	(0.001)	(0.001)	(0.001)
Coupon Rate		0.008***	0.031***	0.029***	0.033***
		(0.001)	(0.004)	(0.004)	(0.004)
ln Total Assets			0.002		0.003**
			(0.001)		(0.002)
Return on Assets			0.057		0.067*
			(0.036)		(0.036)
Leverage Ratio			-0.058***		-0.067***
			(0.016)		(0.016)
Interest Coverage Ratio			-0.000		0.000
			(0.000)		(0.000)
ESG Score			-0.001***		-0.001***
			(0.000)		(0.000)
Green * ESG Score			0.000		-0.000
			(0.002)		(0.000)
Fixed Effect	Industry Rating Month	Industry Month	Industry Month	Industry Rating Month	Industry Rating Month
Adj. R-squared	0.140	0.088	0.168	0.172	0.213
F-Statistic	12.91***	197.85***	26.71***	38.55***	12.95***
Number of observations	13,601	13,601	7,791	8,460	5,495

Notes: This table shows fixed effect regressions created in Stata, that describe the impact of a bond being labeled as green on its yield to maturity at issuance. Industry and rating fixed effects are used, while the month of issuance is used as the time fixed effect. These include control variables that further describe the yield. *Error in parentheses.* **: p-value < 0.1, **: p-value < 0.05, ***: p-value < 0.01.*

The fixed effect regression controls for time-invariant characteristics that influence bond yields, which isolates the effect of a bond being green. A Hausman test confirms that a fixed effect regression is preferable over one utilizing random effects. Additionally, a Wald test indicates the presence of groupwise heteroskedasticity in the sample. Therefore, the fixed effect regressions are run using clustered standard error and can be seen in Table 3. Columns (2) and (3) show regressions with time fixed effect and industry fixed effect. Columns (1), (4) and (5) further include a rating fixed effect. The fixed effect regression in column (1) shows the effect of a bond being green on its yield to maturity is still on average negative, when using all three fixed effects. Green bonds have a lower yield of 1.9 p.p (190 bps), when not controlling for any other variables. In column (2), where only industry and time fixed effects are used and bond specific control variables are included, the effect of *Green* on the yield increases to 2.7 p.p. (270 bps) and remains significant at a 99% confidence level. Notably, the offering amount is no longer significant in this specification.

However, when firm-specific control variables, including the *ln Total Assets, Return on Assets, Leverage Ratio* and *Interest Coverage Ratio* are added in column (3), the effect of a bond being green on the YTM decreases to 1.2 p.p. and is only significant at a 90% confidence level. The only firm specific control variables that are significant are *Leverage Ratio* and *ESG score*. The interaction variable *Green * ESG* Score is not significant. This regression indicates that the leverage ratio and ESG score of a firm are associated with lower bond yields. In column (4), bond specific control variables are added while both industry and rating are used as fixed effects. This adjustment does not significantly change the results from column (2), however the effect of *Green* is slightly lower and the offering amount becomes significant again. The last column (5) includes industry and rating fixed effects, along with all control variables. The average effect of a bond being green on its YTM is 1.1 p.p. (110 bps), which is significant at a 90% confidence level. Furthermore, *Time to Maturity, Leverage Ratio* and *ESG scores* have a negative effect on bond yields, while the *ln Offering Amount, Coupon Rate, ln Total Assets* and *Return on Assets* positively impact yields.

In appendix A, an additional fixed effect regressions are run. In column (1) of Table 4, YTM is regressed on the variables *Green* and the interaction variable *Green * ESG Score*. The result of this shows that the interaction variable in not significant and does not affect bond yields.

Finally, Table 5 in Appendix A shows an OLS regression with interaction variables for specific years in which a green bond was issued. The interaction variables represent the average yield differential for a green bond issued in specific years, using 2017 as a reference point. Green bonds issued in 2023 have a yield to maturity that is 2.5 p.p. lower than ones issued in 2017, when controlling for bond specific variables. This is significant at a 95% confidence level and greater than any other year since 2017.

5.2 Discussion

Comparing the findings of this thesis with existing literature provides valuable insights. This research shows that, on average, green bonds have lower yields to maturity than regular bonds. Although this premium decreases as control variables are added, it remains substantial and significantly negative, making green bonds an attractive option for certain firms. This aligns with most past research, which also finds a negative yield premium on green bonds, regardless of the method used. However, the premium identified in this thesis is greater than most research. Caramichael and Rapp (2022), Zerbib (2019) and Li et al. (2022) all report lower premiums.

Caramichael and Rapp (2022) found a greenium ranging from 3 to 8 basis points, while this thesis found it to be as high as 120 basis points, though only significant at a 90% confidence level. Several factors could explain this difference. Caramichael and Rapp (2022) analyze the US primary market issuances from 2014 to 2021, a slightly different period than this thesis. They also had approximately ten times as many observations, possible due to using different databases. Caramichael and Rapp (2022) also used a different set of control variables that focused more on the quantitative aspects of bonds. These controls include curvature, slope, realized volume, callability and a number of interaction variables. Consequently, they achieved a higher adjusted R-squared of 76%, compared to a maximum of 21% in this thesis.

Furthermore, many papers, including those by Kanamura (2020), Stubbington (2021) and Karpf and Mandel (2018), argue that the green bond premium is diminishing. The analysis of Table 4 shows no statistical significance in the interaction terms between green bond and each year in the sample up to 2022. This suggests that green bond premiums at issuance have remain relatively stable, which contradicts with research that believes a slight negative premium exists but is diminishing. Furthermore, the interaction term for the year 2023 is significantly negative, indicating a lower yield for green bonds issued in 2023 compared to the other years. This lack of a systematic trend inducates that economic shocks, such as a rising market interest rates, may affect the green bond premium. This leads to the rejection of the second hypothesis, which predicts that green bonds are issued with consistent yields to maturity, regardless of market interest rates.

Additionally, it was found that ESG scores are negatively correlated with bond yields. This aligns with the research of Immel et al. (2021), who show that ESG scores negatively affect the yield on all bonds. This thesis shows that a 10-point improvement in a firm's ESG score, on a scale of 1 to 100, on average reduces yields by approximately 45 basis points. This indicates that firms with higher ESG performance and lower ESG related risks can reduce their cost of capital. However, this thesis finds that ESG scores are not significant for green bonds. This may indicate that ESG scores are being overshadowed by the other variables affecting green bond yields. It may be good enough for investors that a firm is investing in a green project, and they might not additionally care about the other practices

of a firm. Thus, the hypothesis that ESG scores negatively impact bond yields cannot be rejected for bonds in general but can be rejected for green bonds.

These findings have large implications for financial markets. Firms may consider green bonds as an alternative to other financing methods, if they can issue them at lower yields, given that the cost savings outweigh the additional issuance costs. This lower cost could incentivize firms to invest in more sustainable projects, as this can increase the number of positive net present value projects available. As Tang and Zhang (2020) argue, issuing green bonds could also provide non-financial advantages, such as increased media attention, higher institutional ownership of shares, a higher stock liquidity and a positive shock to stock prices.

CHAPTER 6 Conclusion

6.1 Conclusion

This thesis investigates the existence and impact of the green bond premium in US corporate bonds from 2017 to 2023 in the primary market. Previous research on this topic shows that such a greenium does exist in this setting. However, many recent papers have found greeniums to be decreasing, while also suggesting these are disappearing. It therefore remained unclear whether green bonds are still issued at a significantly lower yield than conventional bonds and how the increase in market interest rates in late 2022 and 2023 impacts this. Together with the effect of a firm's ESG score, is the main question studied in this thesis.

To answer this question, all US corporate bonds in the selected time period are used. The main statistical methods used in this research are an ordinary least squared regression and a fixed effect regression that uses industry and credit rating fixed effects. Both of these regressions have the *Yield to Maturity* as the dependent variable and the dummy *Green* as the main independent variable. Several bond and firm specific control variables are added to prevent endogeneity in the models.

The analysis confirms that the green premium does indeed exist, as green bonds are issued at a significantly lower yield to maturity than conventional bonds. This finding aligns with the majority of past literature, however this thesis finds a greenium that is larger but has a lower significance. This study also investigates whether market interest rates have any impact on green bond yields and finds that green bonds issued in 2023 have a significantly lower yield compared to the other years in the sample. This suggests that economic factors such as changing interest rates can influence the green bond premium. This challenges some of the newer research that believes a green premium in bonds is diminishing and may be disappearing. It aligns well with the part of the research that believes a significant greenium exists in the US corporate bond market. Lastly, the research analyses the effect of ESG scores on bond yields and finds that ESG scores are negatively correlated with bond yields. This emphasizes the importance of ESG considerations in financial markets and shows that investors value sustainable practices. However, ESG scores do not significantly affect the yields of green bonds. For bonds in general, this may reduce financing costs for firms that place lots of emphasis on various ESG factors, however not in particular for those issuing green bonds.

6.2 Limitations

While this study provides valuable insights, several limitations should be acknowledged. The data set may contain inaccuracies, specifically missing data on corporate debt with low offering amounts. This may not accurately represent the broader market trends. Furthermore, the market for sustainable financial instruments was relatively small until 2019 and even in 2023 continues to make up only a small portion of all fixed income products. With this somewhat short time span, it is unclear whether long-term trends can be captured.

Furthermore, using a fixed effect model with a limited number of variables compared to other research may not fully account for all biases. This can be seen by the adjusted R-squared value being lower than comparable research. According to Larcker and Watts (2020), using fixed effects with several control variables may be ineffective at removing biases. This problem may be solved when using a matching method. However, Larcker and Watts (2020) focus primarily on municipal bonds, and it is uncertain whether this problem applies to corporate bonds. Therefore, to solve any controversies, it would be beneficial to also apply a matching method to this research and including additional control variables that have a significant influence on the yield to maturity.

To conclude, it is hard to say whether any current research shows the full picture, since the size of the green bond market is increasing steeply in size each year. Every new research will make the picture more and more clear, and as the market expands, it is very possible that findings will differ as green bond investing can change its course.

REFERENCES

Badoer, D., & James, C. (2016). The Determinants of Long-Term Corporate Debt Issuances. *The Journal of Finance*, *71*(1), 457–492. http://www.jstor.org/stable/43869105

Bloomberg. (2023). Bloomberg global aggregate green social sustainability bond index methodology. https://assets.bbhub.io/professional/sites/10/Bloomberg-Global-Agg-GSS-Methodology3.pdf

Caramichael, J., & Rapp, A. C. (2022). The green corporate bond issuance premium. *Journal of Banking & Finance*, *162*, 107126. https://doi.org/10.1016/j.jbankfin.2024.107126

CCBJ. (n.d.). Why should your company care about ESG? https://ccbjournal.com/articles/why-should-your-company-care-about-esg

Corporate Finance Institute. (n.d.). Green bond. https://corporatefinanceinstitute.com/resources/esg/green-bond/#:~:text=A%20green%20bond%20is%20a,known%20as%20a%20climate%20bond

Febi, W., Schäfer, D., Stephan, A., & Sun, C. (2018). The impact of liquidity risk on the yield spread of green bonds. *Finance Research Letters*, *27*, 53–59. https://doi.org/10.1016/j.frl.2018.02.025

Flammer, C. (2020). Green bonds: Effectiveness and implications for public policy. *Environmental and Energy Policy and the Economy*, *1(1),* 95–128. https://doi.org/10.1086/706794

Gianfrate, G., & Peri, M. (2019). The green advantage: Exploring the convenience of issuing green bonds. *Journal of Cleaner Production*, *219*, 127–135. https://doi.org/10.1016/j.jclepro.2019.02.022

Hachenberg, B., & Schiereck, D. (2018). Are green bonds priced differently from conventional bonds? *Journal of Asset Management*, *19*, 371–383. https://doi.org/10.1057/s41260-018-0088-5

Hyun, S., Park, D., & Tian, S. (2020). The price of going green: The role of greenness in green bond markets. *Accounting & Finance*, *60*, 73–95. https://doi.org/10.1111/acfi.12515

Immel, M., Hachenberg, B., Kiesel, F., & Schiereck, D. (2021). Green bonds: Shades of green and brown. *Journal of Asset Management*, *22*, 96–109. https://doi.org/10.1057/s41260-020-00192-z

Kanamura, T. (2020). Are green bonds environmentally friendly and good performing assets? *Energy Economics*, 88, 104767. https://doi.org/10.1016/j.eneco.2020.104767

Kapraun, J., Latino, C., & Scheins, C. (2019). (In)-credibly green: Which bonds trade at a green bond premium? *In Proceedings of Paris December 2019 Finance Meeting EUROFIDAI – ESSEC*. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3347337

Karpf, A., & Mandel, A. (2018). The changing value of the "green" label on the US municipal bond market. *Nature Climate Change*, *8*, 161–165. https://doi.org/10.1038/s41558-017-0062-0

Larcker, D. F., & Watts, E. M. (2020). Where's the greenium? *Journal of Accounting and Economics*, 69, 101312. https://doi.org/10.1016/j.jacceco.2020.101312

Li, Q., Zhang, K., & Wang, L. (2022). Where's the green bond premium? Evidence from China. *Finance Research Letters*, *48*, 102950. https://doi.org/10.1016/j.frl.2022.102950

Lindwall, C. (2023). What is greenwashing? NRDC. https://www.nrdc.org/stories/what-greenwashing#:~:text=Greenwashing%20is%20the%20act%20of,of%20a%20product%20or%20practice

Maltais, A., & Nykvist, B. (2020). Understanding the role of green bonds in advancing sustainability. *Journal of Sustainable Finance & Investment*, 1–20. https://doi.org/10.1080/20430795.2020.1724864

Nanayakkara, M., & Colombage, S. (2019). Do investors in green bond market pay a premium? Global evidence. *Applied Economics*, *51(40),* 4425–4437. https://doi.org/10.1080/00036846.2019.1591611

Shi, X., Ma, J., Jiang, A., Wei, S., & Yue, L. (2023). Green bonds: Green investments or greenwashing? *International Review of Financial Analysis*, *90*, 102850. https://doi.org/10.1016/j.irfa.2023.102850

Stubbington, T. (2021). Squeeze on "greenium" as ESG bond investors demand more value. *Financial Times*. https://www.ft.com/content/ecbed322-1709-4ed6-9f7f-d974f6e181da

Lau, P., Sze, A., Wan, W., Wong, A., 2022. The economics of the greenium: how much isthe world willing to pay to save the Earth? *Enviornmental and Resource Economics*, 81 (2), 379–408. http://dx.doi.org/10.2139/ssrn.3607791

Tang, D. Y., & Zhang, Y. (2020). Do shareholders benefit from green bonds? *Journal of Corporate Finance*, 61. https://doi.org/10.1016/j.jcorpfin.2018.12.001

UNPRI. (n.d.). Environmental, social, and governance (ESG) issues. https://www.unpri.org/sustainability-issues/environmental-social-and-governance-issues

World Economic Forum. (2023). What are green bonds and how can they finance climate change? https://www.weforum.org/agenda/2023/11/what-are-green-bonds-climate-change/#:~:text=The%20first%20green%20bond%20was,market%20to%20finance%20green%20projects

Zerbib, O. D. (2016). Is there a green bond premium? The yield differential between green and conventional bonds. *Journal of Banking and Finance*, *98*, 39-60. http://dx.doi.org/10.2139/ssrn.2889690

APPENDIX A. Ordinary Least Squared Regressions

Table 3: Ordinary Least Squared Regression Result including the Effect of ESG Score

	Yield to Maturity
	(1)
Green	-0.029**
	(0.014)
Green * ESG Score	-0.000
	(0.000)
Fixed Effect	Industry
	Rating
	Month
R-Squared	0.140
F-Statistic	8,32***
Number of observations	8,354

Notes: This table shows an OLS regressions created in Stata, that describes the impact of a bond being labeled as green and the ESG score of a firm on a green bond's yield to maturity at issuance. *Error in parentheses.*

**: p-value < 0.1, **: p-value < 0.05, ***: p-value < 0.01.*

Table 4: Ordinary Least Squared Regression Result including Interaction Variables

	Yield to Maturity (1)
Green	-0.018*
	(0.010)
Time to Maturity	-0.002***
	(0.000)
ln Offering Amount	0.008***
	(0.001)
Coupon Rate	0.019***
	(0.001)
Numerical Rating	0.020***
	(0.002)
GreenBond 2017	Omitted
GreenBond 2018	-0.010
	(0.013)
GreenBond 2019	-0.002
	(0.012)
GreenBond 2020	-0.000
	(0.012)
GreenBond 2021	0.013
	(0.016)
GreenBond 2022	0.017
	(0.019)
GreenBond 2023	-0.025**
	(0.011)
R-squared	0.087
Number of observations	8,522

Notes: This table shows an ordinary least squared regression created in Stata, that describes the impact of a bond being labeled as green on its yield to maturity at issuance. This includes control variables that further describe the yield and interaction variables between *Green* and the year of issuance. Error *in parentheses. *: p-value < 0.1, **: p-value < 0.05, ***: p-value < 0.01.*