ON THE RELATIONSHIP BETWEEN ESG AND GREEN BOND YIELD

A Thesis

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ABSTRACT

I explore the relationship of Environment, Social, and Governance (ESG) score on the yield spread of global corporate green bonds. Through both aggregate and segmented OLS regression analyses of the sample, I examined the impact of ESG scores on the overall sample and compared the differential effects on green bonds and conventional bonds based on the cross-sectional data. Additionally, I provided evidence of the impact of ESG scores on corporate bond yield spreads across various industries. I find that there is a negative relationship between ESG score and corporate bond yield spreads generally while G-Score contributes most to the relationship, but green bonds have a yield spread premium over conventional bonds at the special given day. In heterogeneity analysis, results show that (i) ESG score has a positive relationship with green bonds yield spread; (ii) Green bonds in the bank and electric utilities industry exhibit a significant higher yield spread. (iii) ESG score has a significant negative relationship with Eurobonds yield spread while it has a significant positive relationship with US corporate bonds yield spreads. (iv) Bonds issued by the A, B, and C-graded firms had significantly lower bond yields (higher bond prices) than the lowest ESG D-grade. The findings are broadly coherent with the argument in the existing literature that ESG score has a negative relationship with corporate bond yield. However, the positive relationship between ESG scores and green bond yield spreads observed in the results indicates that the "greenium" is diminishing now, guiding us towards further research on greenwashing and bond pricing mechanisms.

BIOGRAPHICAL SKETCH

Xuanming Jin is a graduate student in EERE concentration at MS. Applied Economics and Management program at The Charles H. Dyson School at Cornell University. She has a strong research interest in green finance. This master's thesis encapsulates her research findings in the field of green bonds and ESG during her master's studies.

Prior to her graduate studies at Cornell, Xuanming completed her undergraduate study at Jinan University in Guangzhou in 2022 and obtained dual degrees(BEng in Environmental Engineering and BSc in Economics). She conducted research on carbon capture membranes and emission trading policy in China during her undergraduate studies.

This document is dedicated to all Cornell faculty and graduate students.

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CHAPTER 1

INTRODUCTION

1.1 ESG Investing

In recent years, there has been a remarkable and global proliferation of Environmental, Social, and Governance (ESG), driven by the growing recognition of the intricate connections between social, environmental, and economic factors. ESG Investing refers to investing which prioritizes optimal environmental, social, and governance factors or outcomes. It is widely seen as a way of investing "sustainably", where investments are made with consideration of the environment and human wellbeing, as well as the economy (Daugarrd, 2020)[12]. It is based upon the growing assumption that the financial performance of organizations is increasingly affected by environmental and social factors. ESG investing may have officially entered mainstream investing discourse following the release of the Principles for Responsible Investments (PRI) in 2006, a set of United Nations guidelines for the incorporation of ESG factors into business policy and strategy. The PRI have over 2,000 signatories and are widely considered the official point of reference for all things ESG investing. Notably, the outbreak of the COVID-19 pandemic acted as a catalyst for this phenomenon. The disruptions and uncertainties that pervaded the market in 2020 prompted a considerable number of investors to turn their attention toward ESG funds in pursuit of enhanced resilience. This shift in investment sentiment is underscored by the staggering influx of capital into ESG funds during the first three months of 2020, amounting to a substantial $45.6 billion USD globally. According to Morgan Stanley, sustainable funds attracted cumulative inflows of $57 billion USD, with almost all flows in Europe in the first half of 2023. Investors are increasingly inclined to support organizations and products that align with principles of sustainability and comply with emerging regulatory frameworks, particularly those related to climate change.

This surge in demand has elicited a corresponding increase in corporate engagement with ESG issues within the business landscape. Furthermore, ESG funds have demonstrated a commendable track record of resilience in the face of conventional market disruptions, often yielding superior returns on investment. Portfolios that incorporate ESG and sustainability criteria frequently exhibit stronger long-term performance relative to their non-ESG counterparts. According to Morningstar's ten-year research, a striking 80% of blend equity funds emphasizing sustainability outperformed traditional funds. Additionally, 77% of ESG funds that were established a decade ago have endured, as opposed to only 46% of traditional funds, reflecting the enduring appeal and durability of ESG-focused investment strategies.

1.2 Green Bond

In the realm of ESG investing, green bonds stand out as one of the key players. Green bond is a type of fixed-income instrument that is specifically earmarked to raise money for climate and environmental projects. They are designated bonds intended to encourage sustainability and to support climate-related or other types of special environmental projects. More specifically, green bonds finance projects aimed at energy efficiency, pollution prevention, sustainable agriculture, fishery and forestry, clean transportation, clean water, and sustainable water management. They also finance the cultivation of environmentally friendly technologies and the mitigation of climate change. These bonds are typically asset-linked and backed by the issuing entity's balance sheet, so they usually carry the same credit rating as their issuers' other debt obligations, and should, therefore, face the same yield as equivalently-rated conventional bonds. Examining this proposition is central to the research presented in this thesis. More specifically, while the maintained null hypothesis is that there is no premium differential between green and conventional bonds of the same credit rating (or issued by the same entity), part of the conventional wisdom is the presence of a bond 'greenium' - that is the environmental and social benefits of green bonds provide positive affect, or a 'green glow', that suggests a willingness for investors to pay a bond premium, or accept a lower yield, for a green bond. This suggests a positive relationship between ESG and the bond price, and negative relationship between ESG and bond yield between green and conventional bonds. However, in a recently released report by Morgan Stanley (January 2024)[1] titled "O 'Greenium', Where Art Thou?", it is found that the greenium has in recent years all but disappeared with some green bonds selling at premiums and others at a discount to conventional bond yields.

[1] J.P. Morgan Insights

While all green bonds represent a form of debt financing for an environmental project, the specific characteristics of each instrument may differ based on its issuer, what the proceeds are used for, and the recourse of bondholders to the issuer's assets in case of a liquidation, among other factors. The following list describes some of the different types of green bonds that may be available on the market:

"Use of Proceed" Bonds: This type of instrument is dedicated to financing green projects, but in the case of a liquidation, the lenders have recourse to the issuer's other assets. These instruments carry the same credit rating as the issuer's other bonds.

Asset-Backed Securities (ABS): These securities may finance or refinance green projects, but the collateral for the debt comes from streams of revenue collected by the issuer, such as taxes or fees, or carbon offset credits. State and municipal entities may opt for this type of setup when issuing green bonds.

Project-Backed Bonds: This type of bond is limited in scope to a particular underlying green project, meaning that investors have recourse only to assets (e.g. carbon credits) related to the project.

In 2006, the Principles for Responsible Investment (PRI) introduced a novel investment concept by advocating the integration of Environmental, Social, and Governance (ESG) factors into investment decisions and active ownership. The year of 2007 is generally considered the year of climate bonds' birth: the European Investment Bank (EIB) issued the first green bond, the new fixed-income instrument labeled as the Climate Awareness Bond (CAB), which raised around

0.9 USD billion funds to allocate to eligible green projects. From that time, green bonds have continuously gained importance among the set of green financial instruments available on the market. According to the Climate Bond Initiative (CBI), in 2020, approximately USD 290 billion were issued, an increase of 9% compared with 2019 (Cortellini and Panetta, 2021)[10].

A clear, unmistakable landmark of green bond market development was the release of Green Bond Principles in 2014: A voluntary coalition of banks, issuers, and investors named ICMA developed guidelines and issued non-prescriptive recommendations for the best practices in the market, the so-called "Green Bond Principles" (GBP). This first internationally recognized standard became a key catalyst for subsequent market development and the basis for many existing green labels (Ehlers and Packer, 2017)[13]. The distinction between labeled and unlabeled bonds, sponsored by the GBP, boosted the growth of green bonds issuance. From that year, government and private institutions entered this market and played a crucial role (Ehlers and Packer 2017; Broadstock and Cheng 2019; Monk and Perkins 2020)[7, 13, 30].

In 2016, following the signing of the Paris Agreement, green bonds began to emerge. Much of the action was attributable to Chinese borrowers, who accounted for $32.9 billion of the total, or more than one-third of all issuances. But the interest is global, with the European Union and the United States among the leaders, too. Many Countries have also launched many programs to promote the development of the green bond market. U.S. federal government Clean Renewable Energy Bonds (CREBs) and Qualified Energy Conservation Bonds (QECBs) program allows for the issuance of taxable bonds by municipalities for the purposes of clean energy and energy conservation, where 70% of the coupon from the municipal is provided by a tax credit or subsidy to the bondholder from the federal government. Japan had launched the subsidy program in 2018 to provide financial support for green bond issuance.

In 2017, green bond issuance soared to a record high, accounting for $161 billion worth of investment worldwide, according to a report from the rating agency Moody's. Growth slowed a bit in 2018, hitting only $167 billion, but rebounded the following year thanks to an increasingly climate-aware market. Green issuances reached a record $266.5 billion in 2019 and nearly $270 billion the following year. The World Bank is a major issuer of green bonds and issued $14.4 billion of green bonds from 2008 through 2020. These funds have been used to support 111 projects around the world, largely in renewable energy and efficiency (33%), clean transportation (27%), and agriculture and land use (15%). One of the bank's first green issuances financed the Rampur Hydropower Project, which aimed to provide low-carbon hydroelectric power to northern India's electricity grid. Financed by issuances of green bonds, it produces nearly 2 megawatts per year, preventing 1.4 million tons of carbon emissions.

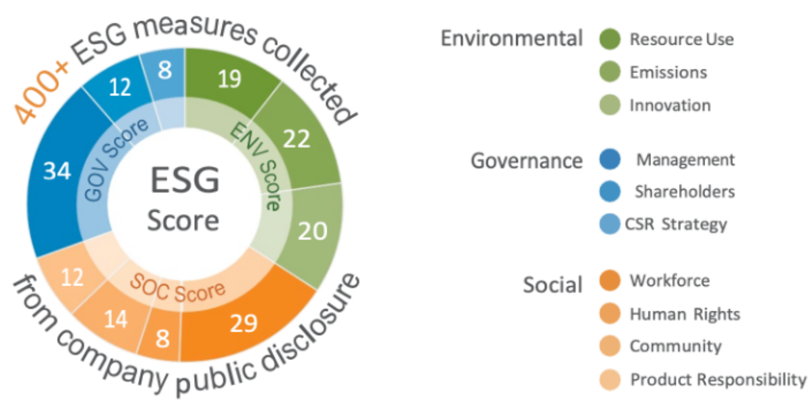
1.3 ESG Score

ESG scores are a measure of how well a company addresses risks and concerns related to environmental, social, and corporate governance issues in its day-to-day operations. These scores are important for socially responsible investors who want to invest in companies with strong ethical and sustainability practices, as they provide an insight into a company's long-term performance and resilience.

Influential ESG ratings include the Morningstar Sustainalytics, the MSCI ESG Rating, the Bloomberg ESG Scores, and the Refinitiv ESG Score. Amongst the aforementioned rating agencies, Refinitiv ESG Score, formerly known as the ASSET4 database, captures and calculates over 400 company-level ESG measures, of which selected a subset of 178 most comparable and relevant fields to power the overall company assessment and scoring process.

Reuters ESG Scores are designed to transparently and objectively measure a company's ESG performance, commitment and effectiveness across 10 main themes (emissions, environmental product innovation, human rights, shareholders, etc.) based on company-reported information, weighted proportionately to the count of measures within each category formulates the three pillar scores and the final ESG Score, reflecting the company's ESG performance, commitment and effectiveness based on publicly reported information.

Figure 1.1: Components of Reuters ESG Score



1.4 Research Problem

With the rise of green investment, the scale of the green bond market is gradually expanding. More and more corporations issue green bonds to raise capital for green projects and also aim to promote their ESG performance. In order to explore the difference of risk between green and conventional bonds, I proposed the research problem about the relationship between ESG score and yield spreads of corporate bonds, and whether the green bonds have a yield premium or discount over conventional bonds.

1.5 Bond Pricing Basis

According to Merton (1974), “the value of a particular issue of corporate debt depends essentially on three items: (1) the required rate of return on riskless (in terms of default) debt (e.g., government bonds or very high grade corporate bonds); (2) the various provisions and restrictions contained in the indenture (e.g., maturity date, coupon rate, call terms, seniority in the event of default, sinking fund, etc.); (3) the probability that the firm will be unable to satisfy some or all of the indenture requirements (i.e., the probability of default or the inability of carbon offset markets to cover the project’s net present value.)”[29]. In this paper, the three elements refer to the bond’s yield spread, bond attributes (such as maturity date, coupon rate, etc.) and corporate performance measure (such as ROA, ROE, beta, etc., and in this case, ESG). Since the risk structure like the corresponding term structure is a ”snapshot” at one point in time, it seems natural to define the riskiness in terms of the differences in yields between green bonds and conventional bonds, particularly if the green bond faces additional risk factors such as the variability in the price of carbon and carbon offsets, and greenwashing.

Due to the inherent characteristics of the bond, the relationship between a bond’s yield is inversely proportional to its price. Furthermore, the price of bonds is contingent upon the fluctuations in the value of the underlying assets with which the bonds are associated. In the realm of green bonds, there are three main categories: project-backed bonds, asset-backed bonds, and use of proceeds bonds.

The dynamics of project-backed bonds mirror those of asset-backed bonds. Bonds tied to green projects fluctuate in price based on the performance and revenue generated by the project, much like assets. Therefore, the pricing dynamics of all three bond types are consistent and are exemplified in the following model, which is primarily based on asset-backed bonds such as carbon-linked bonds.

Assume two investments of equal value with one being an environmental project linked to the price of carbon. The entity issues a green bond to finance the investment. The second bond is issued on a conventional project. The conventional bonds with coupons, c, are backed by the cashflow of the issuing entity, but by design the green bond is backed by the value of carbon offsets it generates. That the cashflows of the green project are contingent on the market price of carbon offsets suggests that if carbon prices fall below a breakeven target, the project will have insufficient funds to pay its coupons. For this reason I subscript the coupon with time, i.e. C_t. The formulas reflecting bond price are as follows:

$$B_G = \sum \left[\frac{C_t}{(1+r)^t} + \frac{F(T)}{(1+r)^T} \right]$$

$$B_C = \sum \left[\frac{C}{(1+r)^t} + \frac{F(T))}{(1+r)^T} \right]$$

where B_G and B_C are bond prices of green bonds and conventional bonds respectively; C_t and C represent coupon of green bonds and conventional bonds respectively. The subscript t on the green coupon represents that possibility that the market price of carbon is risky and may be insufficient at times to cover the coupon payment (C_t) , indicating that the coupon can vary over time; $F(T)$ is the face value of bonds; r is risk-free rate; t represents time point; T is maturity.

Under this construction, the green-bond investor is aware that carbon-contingent coupons (and face value) may not pay if the price of carbon offsets falls. They are, as Merton suggests, accepting to share the risk with the issuer by, in effect, writing a put option. The value of this put option is Max(z-f,0) where z, the option strike price, is the breakeven price of carbon that results in a zero net present value (NPV) project, and f is the market price of a carbon offset. If the market price of carbon falls below the breakeven strike price, the green bond issuer's obligation to pay the coupon is reduced accordingly. If the price of carbon exceeds the strike, the coupon is paid in full. Using this construction the spread between the prices of green and conventional bonds price is

$$B_G - B_C = \sum \frac{C_t - C}{(1+r)^t} = \sum \frac{c\left(1 - k \times \frac{\max(z-f,0)}{z}\right) - c}{(1+r)^t} = \sum -\frac{ck \times \frac{\max(z-f,0)}{z}}{(1+r)^t}$$

where k is a scalar that converts units of carbon to dollars, z indicates the option strike price, f is the market price of carbon offsets. If $z > f$, $\max(z - f, 0) > 0$, $B_G - B_C = \sum -\frac{ck \times \frac{\max(z-f,0)}{z}}{(1+r)^t} < 0$. If $z \leq f$, $\max(z - f, 0) = 0$,

$B_G - B_C = \sum -\frac{ck \times \frac{\max(z-f,0)}{z}}{(1+r)^t} = 0$. Therefore, we can infer that

$$B_G - B_C = \sum -\frac{ck \times \frac{\max(z-f,0)}{z}}{(1+r)^t} \leq 0$$

$$B_G \leq B_C$$

$$Yield_G \leq Yield_C$$

This bond pricing relationship suggests that the price of green bonds is less than or equal to conventional bonds, and the difference is equal to the present value of the implicit put options over the life of the bond. The presence of a bond greenium under these characterizations, suggests that green glow requires investors to ignore (at least) the implicit put option embedded in the bond structure. If, however, the green bond coupons (and redemption value) are backed by the cashflows of the issuing entity and untied from the cashflows of the specific project the project risk is born by the issuer and not the investor, and the option value will diminish towards zero so that green bond prices and yields should be at least (at most) equal to those of conventional bonds in the same credit class.

Based on the above analysis, I will test the following null hypotheses:

H1. ESG score has no effect on yield spreads.

H2. There is no significant difference between the yield spread of green bonds and conventional bonds. If this assumption is rejected, then there are two scenarios for the alternative hypothesis: (i) Green bonds have a yield premium compared to conventional bonds because of greenwashing and the unstable underlying market. (ii) Green bonds have a yield discount compared to conventional bonds. Investors are willing to pay more for green bonds than conventional bonds because of the social benefits green bonds created.

CHAPTER 2

LITERATURE REVIEW

After the release of GBP in 2014, there was a significant increase of green bond issuances of about 36.6 billion USD, more than triple the 2013 issuance (Climate Bond Initiative (CBI) 2015)[22]. International research on green bonds has gradually developed since 2014.

Research on green bonds achieved exponential growth in 2018. In 2018 - 2020, scholars mainly studied the green bonds pricing and the ”Greenium”. Hachenberg and Schiereck (2018) found that green bonds issued by corporations and financial institutions trade at a premium relative to comparable, matched non green bonds, but they find no difference in sovereign bonds[17]. Karpf and Mandel (2018) found that following the rise of the credit quality of green bonds on the municipal market, green bonds’ premium has eventually turned positive[23]. Febi et al. (2018) investigated the effects of the liquidity premium on the green bond yield spread and found that compared to conventional bonds, the impact of liquidity risk on yield spread for green bonds has become negligible in recent years and this observation may hint at a growing maturity of green bonds markets[14].

The Greenium research topic has constantly been growing after the pioneering works of Febi et al. (2018), Hachenberg and Schiereck (2018) and Karpf and Mandel (2018)[14, 23, 17]. The following works were intended to investigate greenium in several market segments (primary and secondary markets) and different geographical areas (e.g., China or EU). Focusing on green bond pricing in the primary market, Nanayakkara and Colombage (2019) discovered that green bonds are traded with a tighter credit spread when compared to similar corporate bond issues[31]. Similarly, Wang et al. (2020) documented that corporate green bonds have a lower yield spread than corresponding conventional bonds in the Chinese green bond market[36]. In addition, some evidence of the opposite phenomenon (positive yield spread between green and non-green bonds) was found. Larcker and Watts (2020) analyzed a sample of 640 US municipal green bonds and found that a small positive premium (0.5 bps) determined that green bonds are slightly more expensive than non-green bonds for the issuer[25].

Around 2020, scholars' research directions began to become broader, with most research focusing on the relationship between green bonds and other financial instruments, green bonds and stock reaction, and the supply-side analysis of green bonds. Reboredo et al. (2020) found that green bonds have a strong price connectedness with treasury and corporate bonds in the short and long run in the EU and US but are weakly price correlated with the high-yield corporate bond, stock, and energy stock markets in different time horizons[32]. Huynh (2020) demonstrated the co-movement effect between the green bonds and a selection of AAA-rated government bonds[20]. In the stock reaction field, Zhou and Cui (2019) confirmed the positive relation between the green bond issuance and stock price reaction, by focusing on 144 green bonds issued by 70 Chinese listed firms[39]. Flammer (2021) found that the stock market responds positively to the announcement of green bond issuance[15]. The response is stronger for green bonds that are certified by independent third parties and first-time issuers. From the supply-side analysis for green bonds, Russo et al. (2021) found that the nature of the project which is financed by a green bond could influence its performance[34]. For instance, sustainable management of natural resources, water management, and terrestrial and aquatic biodiversity conservation projects seem to affect green bond performance positively while clean transportation and climate change adaption have a negative effect.

After 2020, a large number of scholars began to study the greenwashing in the green bond market. Based on information asymmetry, greenwashing had been regarded as an important factor disrupting the green bond market. Bachelet, Becchetti and Manfredonia (2019) argued that green bonds may enjoy a negative premium, but the premium requires either the established reputation of the (institutional) issuers or a green verification in order to reduce asymmetric information and provide guarantees to investors against bond greenwashing[2]. Schmittmann and Gao (2022) showed that green bonds have a price premium over conventional bonds when there is information asymmetry, and it is costly to engage in greenwashing[35]. Baldi and Pandimiglio (2022) argued that the diffusion of greenwashing practices may apply to both public and corporate GB issuers[3]. In the public sector, SNATs and States are more prone to engaging in greenwashing practices as they are less close to their constituencies and thus less easily subject to investors' controls. In the corporate sector, firms operating in the manufacturing sector are more inclined to pursue greenwashing strategies as eluding investors' controls requires less effort compared to what can be carried out in services' operations. Xu, Lu and Tong (2022) found that the greenwashing risk leads to higher credit spread in the Chinese green bond market, but voluntary third-party certification helps reduce greenwashing concern[37]. Hussain et al. (2023) found a positive relationship between greenwashing and the cost of bonds and a more pronounced relation between greenwashing and the cost of bonds for firms whose credit rating is adjacent to the investment borderline, firms within environmentally sensitive industries, and firms with opaque information environments[19].

The sample size of most literature researching on green bonds is around 800. In this paper, I increased the sample size to nearly 2,000, evenly split between green bonds and traditional bonds. As greenwashing is gradually recognized by investors, the reliability of ESG score as an important reference indicator for investment has decreased, and investors have realized the underlying risks. I delve into the relationship between ESG scores and corporate bond yield spreads and explore the heterogeneity across industries and countries between green bonds and conventional bonds.

CHAPTER 3

RESEARCH DESIGN AND VARIABLES

To study this issue, there are two main approaches. First, we can use panel data and regression analysis to examine causal effects. Second, we can utilize cross-sectional data, controlling for the same economic conditions by collecting data at a given day, to explore the relationship between ESG scores and bond yields and to analyze the differences between green bonds and conventional bonds.

In this paper, I create a cross-sectional dataset and conduct Ordinary Least Square (OLS) regressions using the G-spread and ESG score as the dependent variable and independent variable respectively. Both are logarithmically transformed for analysis. I regressed the G-Spread on the ESG score, controlling for ROA, ROE, beta, market capital, market-to-book ratio, interest coverage ratio, cash and equivalents, coupon, redemption date, issue price and green bond dummy variable (Table 3.1). Year and industry fixed effects are added. The country fixed effect is added in the robustness check. The regression formula is as follows:

$$\begin{aligned} ln(GSpread) &= \alpha + \beta_1 \ln(ESGScore) + \beta_2 GreenDummies \\ &+ \beta_3 \ln(ESGScore) \times Green + \beta_4 ROE + \beta_5 ROA \\ &+ \beta_6 Beta + \beta_7 \ln(MTB) + \beta_8 \ln(ICR) + \beta_9 \ln(Cash) \\ &+ \beta_{10} \ln(Coupon) + \beta_{11} \ln(Duration) + \beta_{12} \ln(IP) \\ &+ IndustryFE + YearFE + CountryFE + \epsilon \end{aligned}$$

Table 3.1: Variable Description

Variable Name	Description
G-Spread	Dependent variable, equals the difference or spread between corporate (including green) bonds and treasury bonds of the same maturity, measured in basis points (bps)
ESG Score	Independent variable, companies' ESG Score.
Green	Dummy variable, Green = 1 or 0 refers to green and conventional bonds respectively.
Coupon	The annual interest paid on a bond, expressed as a percentage of the face value.
ROE	Return on Equity
ROA	Return on Asset
Beta	a measure of the volatility of the company's stock compared to the market.
Cash	Cash and equivalents
Market Capital	Total market capitalization of the company
MTB	Market to Book Ratio
ICR	Interest Coverage Ratio
Duration	The time between the bond data acquisition date and the maturity date.
IP	Issue Price, the price at which the bond is issued
Amount Issued	Total bond issuance
Industry FE	Industry fixed effect
Year FE	Issued year fixed effect
Country FE	Issued country fixed effect

where *MTB* denotes the market-to-book ratio; *ICR* is the interest coverage ratio; *Cash* represents cash and equivalents; *Duration* is residual maturity; ϵ is the error term; βs are the coefficients. The logarithmic form is not used for *ROE*, *ROA* and *Beta* because these three variables contain negative values.

CHAPTER 4

SAMPLE CONSTRUCTION AND DESCRIPTIVE STATISTICS

I constructed a cross-sectional dataset of global public corporate green bonds from Refinitiv Workspace Database. Refinitiv offers one of the most comprehensive ESG databases and is widely used in academic studies (Pulino et al., 2022)[8].

The Refinitiv Workspace Database, formerly known as ASSET4, has comprehensive ESG and financial data on global listed companies. For corporate bonds, Refinitiv provides data on the issuers' full name, issue date, maturity, issuance amount, issued price, currency, yield to maturity, and listed exchanges. It also includes issuers' financial data in the bonds panel. I have retrieved data from Refinitiv using the Green Bond Indicator Function to identify green bonds issued by public corporations and additionally controlled for year fixed effects and industry fixed effects according to Thomson Reuters industry categories. For comparison, I selected conventional bonds issued by green bond issuers to analyze the impact that green labels will have on various bond indicators.

My sample collects bonds issued from January 2014 to November 2023. The choice of the 2014-2023 interval for public corporate green bonds is based on the combination of two reasons: (1) After the release of GBP in 2014, the green bond market is booming; (2) The issuances of green bonds were observed between 2014 and 2023. My final sample contains 1817 public corporate bonds including 1094 green bonds and 723 conventional bonds from 459 public corporations in 30 countries.

Table 4.1 shows the descriptive statistics of all observed objects. Table 4.2 contains the descriptive statistics of the regression variable categorized by green bonds and conventional bonds. As can be seen from Table 4.2, the average G-spread of traditional bonds is 142.58 bps, and the average G-spread of green bonds is 742.91 bps. In other words, conventional bonds have a risk premium on average about 1.4258% above treasuries, while green bonds have yields 7.4291% above treasuries. Although these measures reflect a cross section on a single data (Nov 3, 2023), the comparative yields suggest that no greenium exists at all, and that green bonds, for whatever reason, are heavily discounted relative to conventional bonds. In the regressions that follow, the objective is to determine whether these yield differentials are related to ESG or other factors in the economy. Since the cross section is taken on a specific data the contemporaneous macro economic conditions were common to all bond issuing entities, so it is more likely that differences are attributable to the issuing entities, the localized economic conditions, the structure of the bonds, and the market's faith in the integrity of the bonds (e.g. greenwashing) or riskiness of the bonds (e.g. low and volatile carbon offset markets).

Table 4.1: Descriptive Statistics

	Mean	Min	Q1	Median	Q3	Max	S.D.
G-Spread	504.04	6.02	61.31	118.38	192.63	564763.27	13263.03
ESG Score	68.57	16.80	59.07	71.75	79.95	93.03	15.48
Coupon	3.18	0.001	1.8	3.12	4.38	11.75	1.83
ROE	9.41	-533.88	5.32	9.87	14.51	133.81	23.39
ROA	2.80	-45.32	0.65	1.85	4.30	36.16	4.79
Beta	0.99	-0.14	0.62	1.04	1.27	2.87	0.47
Cash	35221.73	0.001	539	2074.81	16253	540434	92596.35
Market Capital	57921.61	79.44	5400.16	14741.44	38365.55	765509.08	139813.56
MTB	115.94	5.33	54.93	84.05	149.9	629.17	98.78
ICR	7.70	0.06	0.90	2.89	5.75	326.03	21.73
Duration	4258.42	366	1818	2555	3653	365242	19234.10
IP	99.80	95.19	99.70	100	100	103.24	0.43
Amount Issued	4.81e+08	10000	1.13e+08	4.00e+08	6.00e+08	1.50e+10	6.68e+08

Table 4.2: Descriptive Statistics by Green Dummy Variable

Conventional Bonds	N	Mean	SD	Min	Max
G-Spread	723	142.58	453.90	6.40	9994.21
ESG Score	723	70.01	13.36	26.74	93.03
Market capital	723	3.14	1.72	0.001	11.56
ROE	723	10.86	26.17	-533.88	133.80
ROA	723	3.36	4.96	-45.32	36.16
Beta	723	0.98	0.43	-0.063	2.87
Market-to-Book	723	13512.88	50683.27	4.83	458054.86
Interest Coverage	723	35233.09	68788.56	386.39	765509.08
Cash	723	89.65	60.37	5.33	329.12
Coupon	723	7.20	15.84	0.06	313.52
Duration	723	3843.30	3591.21	546	36523
Issue price	723	99.76	0.46	95.49	101.67
Amount	723	5.12e+08	9.11+e08	972191	1.50e+10
Green Bonds	**N**	**Mean**	**SD**	**Min**	**Max**
G-Spread	1094	742.91	17087.67	6.02	564763.27
ESG Score	1094	67.62	16.68	16.80	93.03
Market capital	1094	3.20	1.90	0.01	11.75
ROE	1094	8.45	21.31	-533.88	133.80
ROA	1094	2.42	4.63	-45.32	36.16
Beta	1094	1.00	0.50	-0.14	2.87
Market-to-Book	1094	49568.61	109686.22	0.001	540434
Interest Coverage	1094	72915.94	169667.65	79.44	765509.08
Cash	1094	133.31	114.21	5.33	629.17
Coupon	1094	8.03	24.87	0.06	326.03
Duration	1094	4532.76	24616.21	366	365242
Issue price	1094	99.82	0.41	95.19	103.24
Amount	1094	4.60e+08	4.37+e08	10000	4.11e+09

CHAPTER 5

EMPIRICAL RESULTS

5.1 Main Result

Table 5.1 presents the results of the Robust OLS regressions with G-Spread as the dependent variable. A positive coefficient indicates that an increase in the independent variable widens the spread between bond yields and t-bond yields, while a negative coefficient indicates a narrowing of the spread. A widening of the spread indicates a lower market price of bonds, while a narrowing of the spread indicates an increase in bond prices. Except for variables that have negative values (e.g. ROA, ROE, and Beta), and the dummy variables, all other variables are in natural logarithmic form. The regression results are mixed and provide ambiguous signals between the effect of ESG Score on bond yields generally, and green bonds particularly. The industry, year and country fixed effects have significant influence on the average ESG response. Only one model, column (4), which includes only country fixed effect shows statistical significance on ESG and the green bond premium, or in this case discounts.

In column (4), the coefficients of ESG Score, Green and the interact term are -0.262, -1.163 and 0.331 respectively, all significant at the 10% level. The G-Spread of the bonds decreases with higher ESG Scores of the issuer. In column (2)˜(3) and (5), with only the industry or year fixed effects or both included. The coefficients of ESG Score are significant at 1%, 5% and 1% level respectively, higher than column (4) at 10%. In column (8), including all the fixed effects, the coefficients of ESG Score, Green and the interact term are 0.172, 0.099 and -0.010 respectively but not significant.

Compared with column (4), columns (2), (3), and (5) increase the significance level on the coefficient of ESG score from 10% to 5% and even 1%. After adding country fixed effects in column (8), the significance of the three key variables (ESG Score, Green, ESG×Green) disappears. This result indicates that the industry and year fixed effects are highly correlated with ESG Scores (the independent variable), which lead to multicollinearity. Due to the existence of multicollinearity, I will use column (4) as the basic model to explain the impact of ESG Score on G-Spread and divide country and industry fixed effects into two dimensions for analysis. Industry fixed effect analysis will present in the heterogeneity analysis part.

The null hypothesis that ESG scores have no effect on G-spread is rejected at 10% significance level. In column (4), the main parts of regression formula are as following:

$$\ln(GSpread) = -0.262 \times \ln(ESGScore) - 1.163 \times Green + 0.331 \times \ln(ESGScore) \times Green + CountryFE$$

The coefficient of ESG Score can be interpreted as 1% increase in ESG Score decreases G-Spread by 0.262%. The sample mean of G-Spread is 504.04 bps, 1% increase in ESG Score decreases G-Spread by 1.32 bps or 0.0132%.

By transforming the model, I found that H2 is rejected. The model can be transformed as follows:

$$\ln(GSpread) = Green[0.331 \times \ln(ESGScore) - 1.163] - 0.262 \ln(ESGScore)$$

Replace the ESG Score with its mean value of 68.57 in Table 1, we can get the formula as follows:

$$\ln \frac{Spread_G}{Spread_C} = \ln Spread_G - \ln Spread_C = [0.331 \times \ln(68.57) - 1.163] = 0.24$$

$$Spread_G = e^{0.24} \times Spread_C = 1.267 \times Spread_C$$

G-Spread of green bonds is 1.267 times of that of conventional bonds, green bonds have a yield premium over conventional bonds. According to the negative relationship between bond yields and coupons, this result suggests that investors pay less for green bonds than conventional bonds. This may be due to greenwashing or instability in the linked-asset market, which makes investors attach more risk premium to green bonds.

To explore which component of the ESG score predominantly influences the relationships identified in Table 5.2, I further disaggregated the ESG score into its E, S, and G components and conducted separate regressions, as shown in Table 5.2. Only the coefficient of G-score, which is -0.229, is significant at 1% level. Combined with the results in Table 4, the ESG score has a negative relationship with G-Spread and the G-score dominates the relationship. G-score consists of three aspects: management, shareholders and CSR strategy. Based on the findings, investors may prioritize the social responsibility undertaken by companies, as well as the rationality of company management and shareholder structure. Iliev, Kalodimos and Lowry (2021) found that investors concentrate their attention on firms and shareholder meetings where the expected effects on portfolio value are greatest[21]. For example, they devote less attention to firms with lower quality governance environments, highlighting the extent to which management entrenchment can prevent value-increasing changes. Investors prefer companies with good management performance. A high G-score can reduce the risk premium on corporate bonds' yield.

Table 5.1: Effect of ESG Scores on G-Spread (OLS)

G-Spread	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ESG Score	0.156	0.490***	0.298**	-0.262*	0.574***	0.033	-0.109	0.172
	(1.10)	(2.95)	(1.99)	(-1.88)	(3.37)	(0.22)	(-0.80)	(1.16)
Green	-0.465	0.066	0.051	-1.163*	0.330	-0.454	-0.507	0.099
	(-0.69)	(0.09)	(0.07)	(-1.88)	(0.46)	(-0.81)	(-0.83)	(0.18)
ESG×Green	0.232	0.074	0.093	0.331**	-0.006	0.155	0.144	-0.010
	(1.46)	(0.46)	(0.56)	(2.29)	(-0.03)	(1.19)	(1.01)	(-0.08)
Coupon	0.258***	0.198***	0.280***	0.167***	0.215***	0.160***	0.208***	0.191***
	(11.93)	(8.39)	(11.71)	(7.15)	(7.71)	(7.02)	(7.41)	(6.87)
ROE	0.001	-0.017***	0.001	0.001	-0.015***	-0.012***	0.001	-0.010***
	(1.02)	(-4.40)	(0.99)	(0.59)	(-3.96)	(-3.80)	(0.52)	(-3.20)
ROA	-0.024***	0.045***	-0.024***	-0.015**	0.038***	0.031***	-0.016***	0.025**
	(-3.38)	(3.38)	(-3.64)	(-2.37)	(2.95)	(2.73)	(-2.92)	(2.30)
Beta	0.531***	0.323***	0.489***	0.291***	0.316***	0.067	0.277***	0.058
	(12.06)	(5.47)	(10.56)	(8.56)	(5.32)	(1.56)	(7.82)	(1.36)
Cash	-0.013	0.002	-0.013	0.053***	-0.001	0.070***	0.048***	0.067***
	(-1.34)	(0.17)	(-1.34)	(5.58)	(-0.09)	(6.56)	(5.27)	(6.46)
Market Capital	-0.070***	-0.121***	-0.078***	-0.172***	-0.114***	-0.216***	-0.158***	-0.204***
	(-4.11)	(-5.79)	(-4.36)	(-11.65)	(-5.40)	(-12.28)	(-10.59)	(-12.22)
MTB	-0.033	-0.082**	0.014	-0.031	-0.053	-0.156***	-0.004	-0.147***
	(-1.39)	(-2.41)	(0.59)	(-1.36)	(-1.52)	(-5.77)	(-0.19)	(-5.17)
ICR	-0.027	-0.088**	-0.028	0.068***	-0.087**	-0.050	0.063***	-0.057*
	(-1.31)	(-2.50)	(-1.39)	(3.60)	(-2.52)	(-1.58)	(3.49)	(-1.91)
Duration	0.307***	0.320***	0.312***	0.162***	0.346***	0.177***	0.201***	0.221***
	(8.86)	(8.34)	(8.20)	(5.54)	(8.30)	(5.18)	(6.29)	(6.09)
Price	-8.928	-2.992	-8.747	-1.736	-3.565	-1.059	-4.400	-3.480
	(-1.09)	(-0.37)	(-1.05)	(-0.47)	(-0.42)	(-0.31)	(-1.19)	(-1.07)
Amount	-0.026	-0.001	-0.004	-0.124***	0.004	-0.076***	-0.128***	-0.086***
	(-1.45)	(-0.02)	(-0.22)	(-9.55)	(0.20)	(-5.15)	(-8.14)	(-5.48)
Constant	43.232	15.159	41.052	16.041	16.761	12.212	26.922	22.133
	(1.14)	(0.40)	(1.07)	(0.93)	(0.43)	(0.78)	(1.57)	(1.48)
Industry FE	NO	YES	NO	NO	YES	YES	NO	YES
Year FE	NO	NO	YES	NO	YES	NO	YES	YES
Country FE	NO	NO	NO	YES	NO	YES	YES	YES
N	1817	1817	1817	1817	1817	1817	1817	1817
R^2	0.331	0.477	0.362	0.581	0.498	0.668	0.610	0.696

t statistics in parentheses

*p<0.1, **p<0.05, ***p<0.01

Table 5.2: Effect of ESG Components on G-Spread

G-Spread	(1)	(2)	(3)
E Score	0.027		
	(0.31)		
S Score		-0.006	
		(-0.07)	
G Score			-0.229***
			(-3.49)
E×Green	0.091		
	(0.96)		
S×Green		0.100	
		(1.06)	
G×Green			0.189**
			(2.43)
Green	-0.142	-0.178	-0.554*
	(-0.35)	(-0.44)	(-1.70)
Industry FE	NO	NO	NO
Year FE	NO	NO	NO
Country FE	YES	YES	YES
N	1814	1817	1815
R^2	0.581	0.581	0.583

Note: Independent variables in three columns are E-Score, S-Score, G-Score respectively.

t statistics in parentheses

*p<0.1, **p<0.05, ***p<0.01

5.2 Heterogeneity Analysis

5.2.1 Green vs. Conventional in G-Spread

In the main results, I found there exists multicollinearity in the basic model. In order to better present the different effects between green and conventional bonds, I conduct group regression on the samples by dividing the sample into two groups ("Green" and "Conventional"). The regression model is as follow:

$$\begin{aligned} ln(GSpread) = {} & \alpha + \beta_1 \ln(ESGScore) + \beta_2 ROE + \beta_3 ROA + \beta_4 Beta \\ & + \beta_5 \ln(MTB) + \beta_6 \ln(ICR) + \beta_7 \ln(Cash) + \beta_8 \ln(IP) \\ & + \beta_9 \ln(Duration) + \beta_{10} \ln(Coupon) + IndustryFE \\ & + YearFE + CountryFE + \epsilon \end{aligned}$$

where β s are the coefficients; ϵ is the error term.

Table 5.3 shows the result of group regressions. In the green bonds group, 1% increase in ESG score increases G-Spread by 0.179% (1.33 bps) at 5% significance level. In the conventional bonds group, 1% increase in ESG score leads to a 0.014% (0.02 bps) decrease in G-Spread without significance. Hence, green bonds exhibit a significant but modest yield spread premium in response to an increase in ESG scores, whereas ESG scores do not yield a significant effect on conventional bonds. Compared to conventional bonds, these results suggest that green bonds, on average, have a lower market price (i.e. are sold at a discount) than conventional bonds, which in turn suggests that the concept of a green bond 'greemium' cannot be supported by this data.

Table 5.4 presents the grouped regression results after splitting the ESG scores. The results indicate that the relationship between green bond yield spreads and ESG scores is mainly influenced by E-score, showing a positive significant relationship at 1% level. In conventional bonds, this relationship is primarily affected by E-score and G-score, with a positive association between conventional bonds and E-score, but a negative association with G-score. The coefficient for E-score is 0.362, significant at the 1% level, while the coefficient for G-score is -0.216, significant at the 10% level.

Table 5.3: Effect of ESG Scores on G-Spread by Green Classification

G-Spread	Green Bonds	Conventional Bonds
ESG Score	0.179**	-0.014
	(2.31)	(-0.06)
ROE	-0.007**	-0.010
	(-2.06)	(-1.28)
ROA	0.016	0.026
	(1.20)	(1.14)
Beta	0.179***	-0.205***
	(3.28)	(-2.61)
Cash	0.051***	0.093***
	(3.86)	(3.97)
Market Capital	-0.198***	-0.193***
	(-8.94)	(-6.88)
MTB	-0.124***	-0.110
	(-3.24)	(-1.24)
ICR	-0.020	-0.117***
	(-0.59)	(-3.01)
Coupon	0.214***	0.143**
	(6.59)	(2.47)
Duration	0.149***	0.352***
	(3.50)	(7.40)
Price	-2.986	-1.512
	(-0.56)	(-0.35)
Amount	-0.062***	-0.009
	(-3.19)	(-0.29)
Constant	18.913	10.659
	(0.76)	(0.54)
Industry FE	YES	YES
Year FE	YES	YES
Country FE	YES	YES
N	1094	723
R^2	0.713	0.713

t statistics in parentheses
*p<0.1, **p<0.05, ***p<0.01

Table 5.4: Effect of ESG Scores Components on G-Spread by Green Classification

G-Spread	(1)	(2)	(3)	(4)	(5)	(6)
E Score	0.154***			0.362***		
	(3.41)			(2.76)		
S Score		0.061			0.056	
		(1.21)			(0.55)	
G Score			0.081			-0.216*
			(1.15)			(-1.93)
ROE	-0.007*	-0.007*	-0.007*	-0.009	-0.011	-0.009
	(-1.90)	(-1.91)	(-1.95)	(-1.08)	(-1.29)	(-1.17)
ROA	0.015	0.013	0.014	0.024	0.027	0.023
	(1.13)	(1.02)	(1.05)	(1.00)	(1.14)	(1.04)
Beta	0.190***	0.196***	0.194***	-0.207***	-0.209***	-0.202***
	(3.55)	(3.63)	(3.54)	(-2.75)	(-2.70)	(-2.61)
Cash	0.050***	0.052***	0.053***	0.074***	0.091***	0.091***
	(3.77)	(3.94)	(4.01)	(3.25)	(4.02)	(4.02)
Market Capital	-0.198***	-0.194***	-0.192***	-0.198***	-0.197***	-0.193***
	(-9.24)	(-8.81)	(-8.86)	(-7.34)	(-7.12)	(-7.12)
MTB	-0.127***	-0.125***	-0.128***	-0.136	-0.114	-0.091
	(-3.33)	(-3.25)	(-3.31)	(-1.47)	(-1.18)	(-1.00)
ICR	-0.024	-0.019	-0.020	-0.129***	-0.117***	-0.119***
	(-0.70)	(-0.56)	(-0.58)	(-3.46)	(-3.01)	(-3.07)
Coupon	0.214***	0.216***	0.214***	0.153**	0.147**	0.130**
	(6.60)	(6.63)	(6.62)	(2.52)	(2.40)	(2.28)
Duration	0.150***	0.150***	0.149***	0.360***	0.352***	0.355***
	(3.53)	(3.54)	(3.48)	(7.64)	(7.63)	(7.75)
Price	-3.537	-3.586	-3.634	-2.154	-1.515	-0.598
	(-0.65)	(-0.66)	(-0.68)	(-0.50)	(-0.36)	(-0.14)
Amount	-0.062***	-0.061***	-0.058***	-0.015	-0.012	-0.016
	(-3.23)	(-3.13)	(-2.95)	(-0.47)	(-0.39)	(-0.51)
Constant	21.571	22.075	22.194	12.518	10.505	7.376
	(0.85)	(0.88)	(0.90)	(0.63)	(0.53)	(0.37)
Industry FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Country FE	YES	YES	YES	YES	YES	YES
N	1091	1094	1094	723	723	721
R^2	0.714	0.712	0.712	0.717	0.713	0.716

Note: Columns (1)~(3) refer to green bonds, column (4)~(6) refer to conventional bonds.
t statistics in parentheses
$*p<0.1$, $**p<0.05$, $***p<0.01$

5.2.2 Heterogeneity Across Industries

Due to different industry attributes, the impact of ESG Score on bond yield may be different across industries. To explore the industry heterogeneity, I choose top 5 industries with the largest number of companies in the sample and conduct group regression. The main part of the model is as follows:

$$\begin{aligned} ln(GSpread) = &\beta_1 \ln(ESGScore) + \beta_2 GreenDummies \\ &+ \beta_3 \ln(ESGScore) \times Green + CountryFE \end{aligned}$$

Table 5.5 shows that in the electric utilities industry, ESG score has a positive and significant relationship with bond yield spread. The G-Spread difference between green bonds and conventional bonds can be calculated as follows:

$$\ln \frac{Spread_G}{Spread_C} = \ln Spread_G - \ln Spread_C = \beta_2 Green + \beta_3 \ln(ESGScore) \times Green = \gamma$$

$$Spread_G = e^{\gamma} \times Spread_C$$

In bank and electric utilities industries, the coefficients of green dummy variable are significant at 5% and 10% respectively, e^{γ}_{Bank}=1.41 and e^{γ}_{EU}=1.29. Green bonds in these two industries have a yield spread premium over conventional bonds, which represents that investors notice that there are underlying risks in green bonds. According to Table 5.6, the relationship between ESG score and bond yield is dominated by environmental and governance pillars in the electric utilities industry while it is dominated by E-Score in the banking industry.

In the banking industry, according to a Thomson Reuters report in 2023, the number of instances of greenwashing by banks and financial services companies around the world rose 70% in the past 12 months from the previous 12 months. European financial institutions accounted for most of those instances, and much of the greenwashing involved claims about fossil fuels. For example, German police conducted raids on Deutsche Bank (DB) and its asset management subsidiary (DWS) over suspected greenwashing. In this case, the accusation was leveled against the asset manager for exaggerating the scale of its ESG investments. Some of its investment products were labeled as sustainable on sales prospectuses, despite ESG criteria not being clearly considered for most of these products.

In electric utilities industry, instead of transitioning quickly to clean energy, according to the report published by environmental group Sierra Club and University of California in 2022, many utilities in the US are propping up aging coal plants and expanding polluting gas infrastructure. This indicates a significant risk of greenwashing in the industry, leading investors to maintain a skeptical attitude towards the flow of funds into green bonds within the sector. Funds earmarked for green projects may be diverted elsewhere, leading to failure in meeting the promised green objectives by companies, which highlights significant risks in environmental commitment and management strategies at the corporate level. For example, one of "greenwashing's worst offenders" is the Tennessee Valley Authority (TVA). The utility has only committed to retiring 3 percent of its coal generation this decade. It also has plans to build up more gas infrastructure this decade than all but one of the other parent companies in the assessment.

Table 5.5: Effect of ESG Scores on G-Spread by Top 5 Industry

G-Spread	Bank	EU	Real Estate Rental	MU	C-REITs
ESG Score	-0.463	0.788***	0.676	0.188	0.857
	(-1.65)	(3.10)	(1.27)	(0.19)	(0.86)
Green	-2.863**	1.964*	0.253	1.737	3.383
	(-2.45)	(1.85)	(0.12)	(0.44)	(0.70)
ESG×Green	0.756***	-0.401	-0.063	-0.354	-0.728
	(2.70)	(-1.56)	(-0.12)	(-0.38)	(-0.65)
Country FE	YES	YES	YES	YES	YES
N	432	221	126	71	70
R^2	0.777	0.729	0.891	0.480	0.808

Note: EU referes to Electric Utilities, MU refers to Multiline Utilities, C-REITS refers to Commercial REITs.
t statistics in parentheses
$*p<0.1$, $**p<0.05$, $***p<0.01$

Table 5.6: Effect of ESG Components on G-Spread by Top 5 Industry

G-Spread	Banks	Banks	Banks	Electric Utilites	Electric Utilites	Electric Utilites
E Score	-0.402*			0.387*		
	(-1.83)			(1.89)		
S Score		-0.140			0.232	
		(-0.58)			(1.13)	
G Score			-0.223			0.658**
			(-1.16)			(2.60)
E×Green	0.589***			-0.308		
	(2.64)			(-1.37)		
S×Green		0.525**			-0.107	
		(2.28)			(-0.56)	
G×Green			0.334*			-0.408*
			(1.70)			(-1.78)
Green	-2.198**	-1.911**	-1.038	1.584*	0.723	1.982**
	(-2.29)	(-1.98)	(-1.31)	(1.71)	(0.95)	(2.02)
Country FE	YES	YES	YES	YES	YES	YES
N	432	432	430	221	221	221
R^2	0.778	0.777	0.778	0.724	0.721	0.728

t statistics in parentheses
$*p<0.1$, $**p<0.05$, $***p<0.01$

5.2.3 Heterogeneity Across Countries/Regions

Table 5.7 shows the heterogeneity effect in the top 3 countries and regions. In the Eurobonds market, ESG score has a negative relationship with bond yield spreads while it holds a positive relationship in the US bonds market. After separating the ESG score into E, S, G pillars in Table 5.8, I found that the S-Score has a positive and significant relationship with bond yield spreads in the US. In China, E-Score has the positive relationship with bond yield spreads at 5% significance level while governance score has the negative relationship with bond yield spreads at 10% significance level.

In 2020, the European Union, known for its leading role in green finance globally, passed the EU Taxonomy Regulation ((EU)2020/852). This regulation establishes a set of unified standards within the EU to determine the environmental sustainability of an economic activity. Its aim is to provide a ”common language” framework for businesses and investors. This framework assists investors and other financial market participants in assessing the level of environmental sustainability of an investment, thus reducing greenwashing risks. Therefore, in the Eurobonds market, ESG score has a negative relationship with corporate bonds yield spread. Moreover, compared to carbon trading markets in other countries, the EU’s carbon market experiences low volatility. In 2019, the EU carbon market introduced the Market Stability Reserve (MSR), which automatically adjusts the annual carbon quota auction volume based on certain rules and objectives to prevent an oversupply issue, effectively regulating and stabilizing carbon trading prices. As a result, carbon-linked bonds in Europe offer relatively stable coupons, and the premium for green bonds is lower compared to other countries. The yield spread of green bonds in Europe is 1.02 times of conventional bonds, which is much lower than in the US (1.15) and China (1.13).

In 2022, there was a backlash against ESG initiatives in the United States. Some state governments believed that the rise of ESG could harm the oil and gas industry, a cornerstone of the American economy. For example, Florida lawmakers enacted a law to require the state’s Chief Financial Officer to make investment decisions based solely on pecuniary factors and disallow the consideration of any social, political, or ideological interests when making investment decisions. Vanguard Group Inc. also withdrew from one of the largest financial alliances focused on climate issues. Research indicates that this anti-ESG sentiment has also influenced investment decisions made by fund managers, leading to a decrease in the importance placed on sustainability within their evaluation criteria. This backlash may lead to a yield spread premium in the US bond market, which indicates that a significant portion of investors are skeptical about green bonds, which leads to a premium on the yield spread of green bonds and the positive relationship between ESG score and corporate bonds yield spread.

In China, the green bond market has been regulated with a focus on environmental concerns, especially under the guidance of ”carbon neutrality” and ”peak carbon” goals. In 2021, the People's Bank of China issued the Financial Industry Standard ”Guidelines for Environmental Information Disclosure by Financial Institutions,” which sets forth principled requirements for financial institutions to disclose environmental information in terms of content and format. The China Securities Regulatory Commission has also imposed mandatory requirements for the disclosure of green corporate bonds, such as the disclosure of information regarding green projects funded, capital raising plans, environmental benefit goals, etc. However, China lacks a tailored ESG scoring system that aligns with its unique characteristics currently. Moreover, legislation regarding greenwashing is still imperfect, leading to a prevalent issue of greenwashing in the country. For instance, the Southern Daily publishes an annual list of companies engaged in greenwashing. Many well-known enterprises, such as China Shenhua and its subsidiaries, were fined over 20 million yuan for environmental penalties, ranking first in the coal industry in terms of total fines. Aside from breaching environmental assessment laws, the company faced penalties for unauthorized dumping and accumulation of hazardous waste, as well as neglecting inspections of hazardous waste warehouses. Zhejiang Huatong Meat Products, which won the prize of "Green Enterprise" and claimed to have established a "green industrial chain" across feed processing, livestock and poultry breeding, slaughtering, and meat processing, was found to have repeatedly discharged excessive pollutants. Therefore, greenwashing raises doubts among people about companies with high E-scores. Meanwhile, companies with high E-scores usually invest more funds in green production, which puts them at a cost disadvantage. Consequently, according to bond pricing models, green bonds issued by companies with high E-scores may experience a price discount and a premium on yield spread.

Table 5.7: Effect of ESG Scores on G-Spread by Top 3 Countries

G-Spread	Eurobonds	US	China
ESG Score	-0.954*	0.626*	-0.031
	(-1.83)	(1.83)	(-0.13)
Green	-4.144*	0.460	0.817
	(-1.89)	(0.59)	(0.87)
ESG×Green	0.974*	-0.076	-0.173
	(1.92)	(-0.42)	(-0.75)
Industry FE	YES	YES	YES
Year FE	YES	YES	YES
N	574	455	299
R^2	0.639	0.780	0.684

t statistics in parentheses
$*p<0.1$, $**p<0.05$, $***p<0.01$

Table 5.8: Effect of ESG Scores Components on G-Spread by Top 3 Countries

G-Spread	EU	EU	EU	US	US	US	China	China	China
E Score	-0.352			0.269			0.439**		
	(-0.98)			(1.56)			(2.37)		
S Score		-0.338			0.509**			-0.135	
		(-1.28)			(2.34)			(-0.93)	
G Score			-0.260			-0.063			-0.305*
			(-1.46)			(-0.34)			(-1.79)
E×Green	0.445			-0.169			-0.294*		
	(1.25)			(-1.00)			(-1.76)		
S×Green		0.341			-0.111			0.006	
		(1.32)			(-0.78)			(0.04)	
G×Green			0.268			0.203			-0.007
			(1.44)			(1.63)			(-0.05)
Green	-1.905	-1.438	-1.097	0.859	0.607	-0.701	1.329*	0.094	0.164
	(-1.22)	(-1.28)	(-1.39)	(1.16)	(0.99)	(-1.36)	(1.92)	(0.15)	(0.29)
Industry FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
N	571	574	574	455	455	455	299	299	297
R^2	0.634	0.633	0.634	0.777	0.781	0.777	0.691	0.685	0.704

Note: EU refers to European Union.
t statistics in parentheses
*p<0.1, **p<0.05, ***p<0.01

5.2.4 Heterogeneity Across Grade Groups

A final set of results evaluates bond yields on grouped ESG scores. These groupings are based on ranked/ordered ESG scores across companies. According to the order of ESG score from high to low, Reuters Workspace ranks ESG scores for each bond issuing company from high to low: A, B, C and D. If a 'greenium' exists for high quality ESG scores, then bond yields would be lower (bond prices higher) for A-grade companies relative to D-grade companies. Table 5.9 shows regression results of (binary) grades A, B and C relative to the D grade group. In model 1, results show that the A grade group and C grade group have lower yield spreads than the D grade group at 10% and 5% significance level respectively, while B-grade firms are not statistically different. As the ESG-grades would be highly correlated with ESG score, significance for ESG Score and its interaction with green bonds disappears. When I disaggregated the ESG Score into three components (Model 2), I find that E-Score has a positive relationship with corporate bond yield spreads and A, B, C grade groups all have lower bond spreads than D grade group at 5% significance level. These results suggest that D-grade green bonds have lower market prices than higher grade bonds. However, the yield coefficients -0.594, -0.498, and -0.637 for grades A, B and C respectively are not consistently ordered as one would expect if higher ESG scores carried a bond premium. For example, all other things being equal, C-grade firms have higher bond prices, on average, than A-grade bonds, while B-grade bonds, as a group, have lower bond prices than A and C. Additionally, when the ESG-grade is used there is no statistical difference between the yields on green bonds and conventional bonds, which again brings into question the general assumption of a ‘greenium’ on green bonds.

Table 5.9: Effect of ESG Scores on G-Spread in Grade Groups

G-Spread	(1)	(2)	(3)	(4)
ESG Score	0.161			
	(0.83)			
ESG×Green	0.033			
	(0.26)			
E Score		0.380***		
		(3.58)		
E×Green		-0.127		
		(-1.27)		
S Score			0.036	
			(0.42)	
S×Green			0.020	
			(0.26)	
G Score				-0.101
				(-1.23)
G×Green				0.079
				(1.02)
Green	-0.076	0.600	-0.027	-0.273
	(-0.14)	(1.42)	(-0.08)	(-0.84)
A	-0.387*	-0.594***	-0.274	-0.161
	(-1.95)	(-3.28)	(-1.65)	(-1.13)
B	-0.295	-0.498***	-0.209	-0.117
	(-1.64)	(-2.88)	(-1.32)	(-0.85)
C	-0.472***	-0.637***	-0.432***	-0.372***
	(-3.06)	(-3.95)	(-2.88)	(-2.69)
Industry FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
N	1817	1814	1817	1815
R^2	0.701	0.705	0.701	0.701

Note: Columns (1)~(4) uses ESG Score, E-Score, S-Score, G-Score for independent variables and explore the different effect on G-Spread between four grade groups.

t statistics in parentheses

*p<0.1, **p<0.05, ***p<0.01

CHAPTER 6

DISCUSSION

In the regression analysis, my findings indicate that ESG Score has a negative relationship with G-spread of corporate bonds generally, the effect of ESG score is significant but small. Moreover, green bonds have a much higher yield premium compared to conventional bonds. This suggests that investors perceive corporate green bonds from companies as high-risk, leading to an elevated risk premium for the bonds, even better performance in ESG Score cannot offset the premium effect. There are two factors that contribute to this conclusion: "Greenwashing" driven by information asymmetry and heightened volatility in the underlying asset market to which the bonds are linked.

6.1 Greenwashing

Greenwashing refers to the practice of persuading the public that a company's products are eco-friendly or have a greater positive environmental impact than they actually do by selectively publishing information or providing false and misleading information, creating a deceptive perception of the product's environmental impacts. In the green bond market, the essence of greenwashing is to create information asymmetry between bond issuers and investors to raise capital, but the capital is not used for green projects, sometimes it will even finally flow to heavy-pollution industries like mining.

Rothchild and Stiglitz (1976) used the imperfect information model to analyze the insurance market and conclude that even a small amount of imperfect information could have a significant effect on competitive insurance markets[33]. Grossman and Stiglitz (1980) also argued that the extent to which investors react to new information depends on the efforts that investors devote to search and analyze data[16]. This information asymmetry model laid a solid foundation for the research on greenwashing and was later widely cited in research. Information asymmetry is highly maneuverable in the disclosure and readability of ESG reports and then influences investors' actions. Bond issuers, as the proactive party holding more information, tend to engage in greenwashing practices.

Based on comprehensive research, greenwashing affects bond yield spreads through two potential channels: litigation risks and rating disagreement.

6.1.1 Greenwashing and Litigation Risks

The incremental cost of debt associated with greenwashing may reflect public bond investors' concern regarding greenwashers' subsequent environmental litigation costs. Firms with inferior environmental performance are more likely to engage in greenwashing (Hussain et al., 2023)[19]. Once detected, these firms will be associated with litigation costs that have a considerable impact on the firm's value and profitability, which may influence the bond price. For example, in February 2017, Walmart paid USD 1 million to settle greenwashing claims that misleadingly claimed to sell “biodegradable” or “compostable” plastic.

Some issuers will use more information they have to whitewash ESG disclosure reports and bond issuance documents, making investors think that the company’s ESG performance is better than it is. Greenwashing companies that may seek to gain an advantage from the legitimacy associated with disclosing CSR information, while putting in minimal effort to address CSR issues, might adopt more difficult-to-understand language to write fuzzy reports (Courtis, 2004)[11]. Issuers engaging in CSR practices are more likely to provide transparent disclosures with higher readability because this reflects socially responsible behavior and a firm’s commitment to high ethical standards (Bacha and Ajina, 2020)[1].

For investors, they might not fully consider information when it is too costly to extract (Bloomfield, 2008)[4]. Information readability could affect the cost of analyzing data and, consequently, influence investors’ reactions toward corporate narrative disclosures (Lehavy et al., 2011; You and Zhang, 2009)[26, 38]. Consequently, the readability of corporate disclosures becomes an important issue, especially with concerns about information sharing and asymmetry.

As a result, bondholders are likely to consider environmental litigation risk while creating the debt issue, especially for greenwashing firms. Therefore, debt holders may demand a higher interest rate to counteract the anticipated environmental litigation risk, which leads to a higher yield spread of green bonds (e.g., Bradley and Chen 2011; Karpoff et al. 2008)[6, 24].

6.1.2 Greenwashing and Rating Disagreement

The presence of numerous ESG rating agencies in the market, such as Bloomberg, Morningstar, MSCI and Moody's, among others, introduces heterogeneity in rating systems. This heterogeneity leads to variations in the ratings assigned to the same company by different agencies, indicating differing perspectives on the ESG risks associated with the company. Prior studies show that rating splits at the time of the bond issue raise the information uncertainty surrounding the issuer and bond spreads (Bonsall Miller 2017; Livingston, Naranjo, and Zhou 2007; Livingston and Zhou 2010)[5, 27, 28]. In recent studies, researchers argue that ESG rating disagreement not only perplexes investors but also incentivizes firms and their managers to wrap corporate greenwashing in the disguise of rating divergence (Christensen et al., 2022; Hu et al., 2023)[9, 18].

When investors recognize that rating discrepancies may increase the risk of greenwashing by companies, their confidence in firms with strong ESG performance diminishes. They begin to question whether companies are artificially boosting their ESG ratings through greenwashing tactics. This phenomenon will lead to a higher yield spread for green bonds issued by companies with high ESG performance.

6.2 Bond Pricing model and Volatility of Underlying Assets

The price of green bonds typically fluctuates in line with underlying asset prices. As was presented in section 1.4 for, project-backed bonds, asset-backed bonds and "Use of Proceed" bonds in which bond prices and yields were contingent on the underlying price of carbon or carbon offsets, the relationship between green and conventional bonds was characterized by $B_G - B_C = \sum -\frac{ck \times \frac{\max(z-f,0)}{z}}{(1+r)^t} \leq 0$
In words, such bonds include an imbedded risk transfer from the issuing entity to investments equal to a put option on the price of carbon (offsets) with a strike price equivalent to the breakeven carbon price. Thus it was argued,

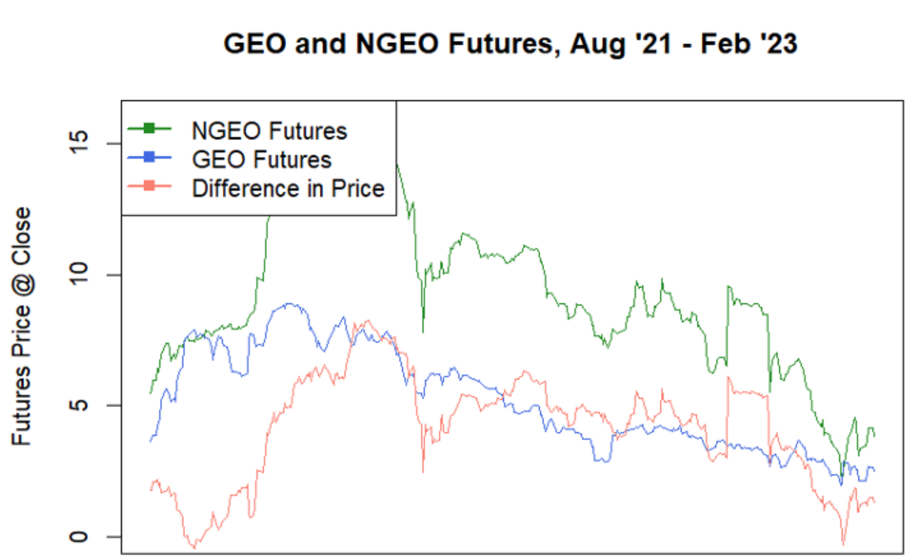
$$B_G \leq B_C$$

$$Yield_G \leq Yield_C$$

and that for positive option value, and in the absence of 'green glow', the yield spread of green bonds is higher than or equal to conventional bonds and that green bonds will have a yield greater than or equal to that of conventional bonds.

This model explains, at least in part, the yield spread premium in green bonds. Essentially, it is because of the underlying assets of green bonds, such as the most representative carbon assets, and the instability of profits from green projects. As shown in Figure 6.1, the carbon futures appear to have high volatility in one year and a half, which attached a risk premium to carbon-linked green bonds. The price volatility of carbon futures within one year is greater than that of treasury, the coupon of carbon-linked bonds also fluctuates significantly within a short time.

Figure 6.1: Carbon Futures Price Trend



CHAPTER 7

CONCLUSION

Conventional wisdom asserts that green bonds, bonds issued in support of sustainability, climate and/or the environment, are rewarded with a lower bond yield relative to conventional corporate bonds. The lower yield results in a higher market price for the green bond often referred to as a 'greenium'. The economic argument is that green bonds are viewed favorably by the investing public because of the 'green glow' about corporate responsibility. In recent years several organizations (including Reuters which is used in this study) have developed ESG (environment, sustainability and governance) scores for corporations, with higher scores reflecting greater corporate efforts towards sustainability and environmental responsibility. It follows that bonds issued by high ESG scoring firms would be viewed more favorably in the market by green-conscience investors. Whether a 'greenium' exists is an empirical question and at least one industry report has recently indicated that while there was previously a greenium attached to green bonds, the glow has diminished and that by 2024 green bond premiums were not substantially higher than conventional bonds.

Based on raw statistics (Table 4.2) the G-Spread (bond yields minus treasury yields of same maturity) on 723 conventional bonds was 142.58 basis points while the average yield on 1094 green bonds was 742.91 basis points, This suggests, on average that green bonds are valued at a discount to conventional bonds. Furthermore, the mean ESG score attached to firms issuing green bonds was higher on average than ESG scores on firms issuing green bonds (70.01 vs 67.62). On the surface this suggests that the 'greenium' may be more myth than reality and that ESG scores as a metric of social/corporate responsibility, may not , unto themselves, indicate a 'greenium' effect. This thesis addresses to broad questions. First is whether there is a relationship between ESG scores and the yields on bonds generally, and green bonds specifically, and second whether green bonds in fact have a greenium over conventional bonds. To these ends, this thesis examined the relationship between ESG scores and bond yield spreads, as well as the difference in yield spreads between green bonds and conventional bonds, The study examines a cross-section of yields across 1,817 bonds, comprised of 1,094 green bonds and 723 conventional bonds, on a specific data, 11/03/2024. It also investigates heterogeneity across industries and countries. After conducting OLS regression for the whole sample and group regression in green bonds, conventional bonds, top 5 industries and top 3 countries (regions) respectively, I conclude the following:

First, Implementing the OLS regression, I found that ESG Score has a negative relationship with bonds' yield spread. A 1% increase in ESG score decreases bonds' yield spread by 0.262% (1.32 bps) at 10% significance level. While this suggests a significant yield premium on green bonds the effect is not "material". Moreover, green bonds offer a yield premium compared to traditional bonds. The yield spreads on green bonds are 1.267 times of yield spreads on conventional bonds.

Secondly, due to the multicollinearity in the basic model, I conducted heterogeneity analysis to explore the different effects brought by ESG score between green bonds and conventional bonds. Results show that in green bonds samples, 1% increase in ESG score increases G-spread by 0.179% at 5% significance level. Therefore, green bonds have a significant but small yield spread premium when the ESG score increases while ESG score has no effect on conventional bonds. This finding further underscores the higher yield spread potential of green bonds compared to conventional bonds.

Additionally, I explored the industry heterogeneity for the impact of the ESG score. After conducting group regression in top 5 industries, I found that green bonds in bank and electric utilities industries have a significant yield spread premium. ESG score has a positive relationship with bond yield spread in the electric utilities industry, which mainly accounts for greenwashing.

In different countries or regions, I found that in the Eurobonds market, ESG score has a negative relationship with bond yield spreads while it holds a positive relationship in the US bonds market. In the US bond market, social pillar score has a positive and significant relationship with bond yield spreads, which dominates the relationship between ESG score and bond yields. In China, the environmental pillar score has a positive relationship with bond yield spreads at a 5% significance level.

In conclusion, in this cross-sectional dataset, there is a negative correlation between ESG score and bond yield, with the governance pillar score being the dominant factor in this relationship. Secondly, green bonds have a yield spread premium compared to conventional bonds. These findings are also validated in industry and country heterogeneity studies, albeit with slight variations. In the electric utilities industry, ESG and bond yield spread exhibit a significant positive correlation, primarily driven by the environmental pillar score. Both the banking and electric utilities industries show a higher yield premium for green bonds compared to their respective conventional bonds. In Europe, there is a negative correlation between ESG score and bond yield, while in the United States, it's positive, driven by the social pillar score. In China, although there isn't a significant relationship between overall ESG score and bond yield, there are significant positive correlations at the 5% significance level for the environmental pillar score. The reasons behind these findings can be attributed to greenwashing and the pricing models of green bonds. In the future, scholars can delve deeper into ESG ratings, exploring how the components of Environmental/Social/Governance pillars score affect the returns of green bonds.

Finally, to the broader question of whether a 'greenium' exists on green bonds, the results of this study provides, at best, weak evidence that any 'greenium' is related to ESG. That green bond yields are, on average substantially greater than yields on conventional bonds, suggest that the market is adding a substantial risk premium to green bonds. Evidence that there is a statistical relationship between ESG and green bond yields is weak, which suggests that the valuation of ESG scores and the pricing of green bonds likely follow different channels of assessment. When firms were 'graded' by group on ESG scores, the differences in bond yields across (from high to low) A, B and C grades were mixed and unordered.

However, with some confidence we can conclude that bonds issued by the A, B, and C-graded firms had significantly lower bond yields (higher bond prices) than the lowest ESG D-grade. However, even when controlling for ESG scores and the E, S and G elements the regressions failed to conclude that green bond yields were significantly different than conventional bond yields. We end by concluding that green bond yields are, at best, not materially different from conventional bond yields, and that, at best, the relationship between ESG scores and green bond yields is weak to immaterial.

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