Greenium, Financing Costs, and Green Transition in China

By

Siwen Yu

An honors thesis submitted in partial fulfillment

of the requirements for the degree of

Bachelor of Science

Business and Economics Honors Program

NYU Shanghai

May 2025

Professor Marti G. Subrahmanyam	Professor Marti G. Subrahmanyam
Professor Christina Wang	Professor Jingyuan Mo
Professor Wendy Jin	
Faculty Advisers	Thesis Advisers

Contents

Acknowledgement

Time flies. My four years at NYU Shanghai eventually came to an end. Along the journey, there may be occasions I flinch, waive, or even question my original intention, yet I never quit. All my achievements would not have been possible without the unwavering support of my family, professors, and friends.

I would like to express my sincere gratitude to Prof. *Jingyuan Mo*, my thesis advisor as well as my *Alternative Investments* and *Equity Valuation* courses instructor, for guiding me throughout the entire research process and encouraging me in my stressful senior year. I would also like to thank Prof. *Marti G. Subrahmanyam* for taking the time to give me novel insights and critical feedback out of his busy schedule. Their support helped me overcome all the challenges and stimulated my interest in sustainable finance. The time spent with them on my first research paper will be a meaningful part of my undergraduate memories.

I appreciate all the efforts that Prof. *Marti G. Subrahmanyam*, Prof. *Christina Wang*, and Prof. *Wendy Jin* put into coordinating this program. I also want to thank *Xinyi Yang* for organizing the seminars and all the professors who came to share their research. It has been a pleasant experience to be part of the honors family, which teaches me a lot beyond research. What does not kill me makes me stronger.

Abstract

In this paper, I investigate the key drivers and evolution of greenium in China's green bond market through financial and policy determinants. I also examine what type of firm benefits most from green bond issuances in terms of financing costs from the perspective of SOEs and non-SOEs. I find that green bonds in China enjoy a lower financing cost compared to conventional bonds and the magnitude increases after 2019 due to enhanced regulations, stronger demands, and commitments to carbon neutrality. I also discover that greenium is larger for bonds issued by non-SOE firms to compensate for higher credit risks and funding liquidity risks. Moreover, I study the efficiency of green bond issuances in sustainable development by evaluating their effects on our environment. I find that the effectiveness of green bonds in reducing carbon emissions remains insignificant. My paper contributes to a deeper understanding of China's green bond market from the perspectives of investors, issuers, and policymakers by evaluating the effectiveness of public policies and optimizing the tradeoff between financial returns and environmental protection.

Keywords: green bonds, greenium, conventional bonds, China, credit spread, yield determinants, ESG, public policies, issuance rules, SOE, liquidity, sustainable finance, low-carbon economy, environmental protection, carbon emissions

1. Introduction

The green bond market has developed rapidly and attracted growing attention in the past few years due to climate change, rising ESG concerns, and sustainability goals. It helps efficiently allocate limited resources to sustainable projects, which are essential to solving imminent energy and environmental problems and contributing to the transition to a low-carbon economy. Green financial instruments such as green bonds are one of the most innovative solutions to resolve climate issues by directing capital toward sustainable projects. Green bonds share similar features with conventional bonds but are specifically targeted at sustainable projects with environmentally friendly purposes. A significant benefit associated with green bonds is greenium, which is defined as the difference between the financing costs of green bonds and conventional bonds. Current literature was mostly devoted to demonstrating the existence and significance of greenium. Ando *et al*. (2023) argue that green bonds are issued at a lower borrowing cost than conventional ones. However, most of them ignored what drives greenium and under what situation greenium is larger. This paper investigates the driving factors of greenium in terms of financial returns and policy intervention. To be more specific, financial determinants can be divided into individual bond characteristics, financial conditions of the issuers, and industry-level characteristics. On the other hand, policy determinants focus on the policy side and include relevant green bond principles and issuance rules, which vary across different provinces and lead to the differences in changes in greenium pre- and post-issuance and policy announcement. Moreover, my research dives into different periods and firm types and examines the variations in greenium. The study results are beneficial for investors to construct portfolios that optimize financial returns and ESG performance, for firms to allocate capital toward sustainable projects efficiently, and for regulators to design policies that help establish China's green bond market and contribute to sustainable development.

Most studies investigate greenium in mature markets such as the U.S. or Europe. My research focuses on China's green bond market, which was established in 2016 and has become one of the world's largest and fastest-growing green bond markets. There are significant differences in the structure, maturity, regulatory frameworks, and market dynamics between China and more mature markets like the US and Europe. China's green bond market is worth our attention and is meaningful to study due to its rapid market growth, unique investor base, regulatory landscape, and role in green finance and sustainable development. The 2021 China Green Bond Market Report revealed an increasing trend in green bond issuances. Though still nascent, the rapid increase in the scale of green bonds reflected China's commitment to peak carbon emissions by 2030 and carbon neutrality by 2060, the development of sustainable finance, and the transition to a low-carbon economy. Meanwhile, China has worked to align its green bond taxonomy with global standards since 2019, increasing investor confidence. Understanding greenium in China's market provides insights into whether ESG considerations influence bond pricing and capital allocation and whether green bonds are efficient in solving climate issues. Moreover, China's approach to developing its green bond market and tackling sustainability challenges can be used for reference and provide valuable insights for other emerging markets, especially those in developing countries, to develop green finance systems.

Despite green bonds' popularity, the existence, magnitude, and determinants of greenium are still debated. While most studies demonstrated the existence of greenium, such as Tang and Zhang (2020) and Baker *et al*. (2018), some studies found that there is no significant difference between the yields of green bonds and conventional bonds, as mentioned by Flammer (2021) and Cao, Jin, and Ma (2021). My research explores the existence and evolution of greenium in China's green bond market by matching green bonds with their conventional counterparts using the propensity score matching method. Meanwhile, it investigates the drivers of greenium in terms of financial and environmental factors and conducts sub-group comparisons through the OLS model. Past literature examined the effectiveness of green innovation in tackling climate change. Bolton *et al*. (2024) pointed out that green innovations have no significant association with future carbon emissions. However, discussions around green bonds mainly revolve around financing costs and investment returns while ignoring the original goal of contributing to sustainable development. My paper reveals the real effects of green bonds on our environment by using the difference-in-differences method and explores the efficiency of green bonds in the short run and the long run through the changes in carbon emissions.

This paper contributes to the existing literature from three perspectives. First, it determines the evolution of greenium and its significance in China's green bond market. Second, it analyzes the key determinants that drive greenium in terms of financial returns and policy implementation. It discovers the type of firms that benefit most from green bond issuances in terms of financing costs and how greenium changes over time. Third, it demonstrates the real effects of greenium on environmental protection by tracking the carbon emissions. These findings are novel since, beyond studying the financial benefits that green bonds bring to firms, the paper takes China's special conditions into account by investigating policy intervention and discussing whether greenium can be translated into environmental benefits.

The remainder of the paper is organized as follows. The second section motivates and states my hypotheses. The third section explains the construction of my data set, the descriptive statistics for the key variables described, and my methodology. The fourth section discusses my empirical results. The fifth section examines variations in greenium from two perspectives: the time-series effect and firm-level comparison. The sixth section investigates the efficiency of green bond issuances in reducing carbon emissions. The last section concludes the paper.

2. Hypotheses

Hypothesis 1. Green bonds are issued at a lower yield compared to traditional bonds in China.

Most research on green bonds concentrated on developed countries' financial markets. Developing countries, on the other hand, are still in the early stage of green bond development and dealing with intricate conflicts between economic expansion and low-carbon development. Baker *et al*. (2018) demonstrated the existence of positive greenium in the U.S. market, while Grishunin *et al.* (2023) showed its presence in the European market.

Current research on the pricing of green bonds in China has not revealed the significance and direction of greenium (Cao, Jin, Ma, 2021). On one hand, there may be a negative greenium because the issue amount and liquidity are lower than those of traditional bonds. On the other hand, a positive greenium can be justified by the demand from investors for green bonds and further disclosures on how the proceeds are used and relevant environmental, social, and governance concerns.

I infer that green bonds are issued at a lower yield than traditional bonds in China. Moreover, the significance of greenium varies across different types of firms, industries, and periods. The existence of greenium can be mainly attributed to the increased strictness and comprehensiveness of green bonds' reporting standards and issuance rules, as well as policy support from the Chinese government.

Hypothesis 2. (*time-series effect*): Greenium in China, on average, is larger after 2019.

Due to the rising ESG concerns and growing demand for green bonds, past literature examined the magnitude of the greenium across a range of industries, nations, and sample sizes. The evolution of greenium over time and the factors contributing to its evolution are also worth exploring. Current research mainly focused on the European market, which experienced policy changes due to the energy crisis. Ando *et al.* (2023) showed that greenium increased over time in Denmark and Germany. Grishunin *et al.* (2024) found a significant increase in greenium in Europe after 2022.

Like the European market, China's green market underwent notable developments before and after 2019. Before 2019, although the market grew rapidly, investors showed little interest in green bonds. This might be attributed to inconsistencies in definitions of green bonds, not aligning with international standards, and investors' concern over greenwashing. Fortunately, the Chinese government strongly supported the development of the green bond market through comprehensive regulations and attractive incentives. China began aligning its green bond taxonomy with international standards, removing controversial projects such as clean coal, which improved credibility and attracted more institutional investors. Meanwhile, the increase in ESG awareness and the goal of peaking carbon emissions by 2030 and reaching carbon neutrality by 2060 further drove capital into sustainable investments and increased the demand for green bonds.

With the combined effect of higher demands, regulatory improvement, enhanced liquidity, and government support, I conjecture that the average greenium in China will be more prominent after 2019.

Hypothesis 3. (*firm-level comparison*): Greenium is larger for bonds issued by non-SOE firms.

Past literature focused on green bond issuers in different industries. Grishunin *et al*. (2023) explored the factors that affected greenium in the European market and found that green bonds issued in three industries: financial institutions, utilities, and industrials showed a larger greenium. Shi and Zhang (2024) focused on the oil industry and emphasized how oil demands influenced greenium across sectors. Indeed, the industry effect is meaningful to discuss and affects individual firms to some extent. Bolton *et al.* (2024) pointed out the phenomenon of path dependency, which revealed that firms in brown industries are less likely to engage in green innovation.

However, few studies examined the variations in greenium among different types of firms. In China, state-owned enterprises (SOEs) and non-state-owned enterprises (non-SOEs) differ in their financial structures, market behavior, and investor perceptions. These differences significantly impact firms' investment decisions, as well as the magnitude of the greenium. On the one hand, SOE firms have easier access to capital, enjoy support from the government, and usually issue green bonds for high-profile projects aligned with national strategies. On the other hand, non-SOE firms face higher borrowing costs due to perceived higher credit risk and need additional certifications or external evaluations to gain investor trust, adding to issuance costs. They are more likely to issue green bonds for innovative projects.

Based on the above analysis of differences between SOEs and non-SOEs, I anticipate that non-SOE firms exhibit larger greenium than SOE firms.

Hypothesis 4. (*environmental performance*): Firms that issue green bonds can effectively reduce carbon emissions.

Existing studies primarily emphasize the financial perspectives of green bonds, including financing costs, investment returns, and their impacts on stock performance. Tang and Zhang (2020) demonstrated the increase in stock price after green bond issuances. Han and Li (2022) showed that investors who included green bonds in their portfolios usually enjoy higher returns and lower volatility.

While green bonds are promising financial instruments, their environmental perspectives remain relatively unexplored. Lin *et al*. (2023) found improved air quality in the green bond issuers' cities. However, whether green bond issuances are efficient in directly reducing carbon emissions, a major pollutant in our environment, has not been proven. While investors' interest in dealing with sustainability issues through green finance keeps increasing, they are always concerned about greenwashing, making it hard to differentiate which projects have real sustainable purposes. Toffel and Zhou (2016) argued that firms that are more likely to be environmentally damaging and pursue greenwashing are often reluctant to disclose their behaviors. Fortunately, the reporting standards and issuance rules are becoming more comprehensive, which may decrease the probability of greenwashing and improve firms' environmental performances. Therefore, I speculate that firms reduce their carbon emissions after green bond issuances.

3. Data and Methodology

3.1 Bond Data

This section describes the data set I assembled for this paper. The primary dataset used in this research includes green bonds and conventional bonds issued in domestic China from 2016 to 2024. This time frame started when China's green bond market was established, and its development was recorded, with the government implementing more comprehensive policies and investors increasing awareness of ESG-related issues. By encompassing and analyzing these data, this paper aims to provide insights into the pricing and efficiency of green bonds, considering the special conditions of China's green bond market, constantly changing regulatory frameworks, and investors' preferences for ESG. I obtained the initial green bonds and conventional bonds data from the WIND database, a pioneering financial terminal platform emphasizing the Chinese market.

3.2 Bond-Matching Method: Propensity Score Matching

I show the existence of greenium by matching each green bond with a conventional counterpart using the propensity score matching method. I identify key bond characteristics (e.g., coupon and maturity) during the pre-treatment period (pre-green bond issuance), use conventional bonds (control group) to build a weighted combination of similar bonds, and eventually get 814 meticulously matched pairs in the dataset, which increases the validity of the study's comparative findings.

3.3 Baseline Model (Model 1)

I use a panel data regression approach to analyze bond credit spreads. My panel consists of the pooled time series of bond credit spreads as the dependent variable, the first principal component of the indicator *Green*, financial determinants, and policy determinants.

$$\mathrm{Credit}_{\mathrm{Spread}_{i,t}} = \alpha + \beta_1 \mathrm{Green}_i + \theta < \mathrm{Financial.Determinants} >_{jt} + \gamma < \mathrm{Policy.Determinants} >_{jt} + u_i + \varepsilon_{i,t}$$

In Model 1, $\text{Credit\_Spread}_{i,t}$ denotes the difference between the yield of a corporate bond *i* and the average yield of government bonds with the same maturity at time *t*. The variable *Green* is a dummy variable that is equal to one if the bond is a green bond and zero otherwise. The set of financial determinants include individual bond characteristics, financial conditions of the issuers, and industry-level characteristics. The set of policy determinants include control variables that affect credit spread; while some are time dependent, others are time independent. Last, u_i denotes time-fixed effects to consider time-varying unobservable factors that may affect the selected bond markets in the year of bond issuance, and $\varepsilon_{i,t}$ denotes the error term.

3.4 Variables Explanation

The set of independent variables is listed in the following table:

1) Financial determinants

Individual bond characteristics:

Variable Name	Variable Description	Expected Sign
ESG Rating_{it}	A dummy variable that is equal to one if it is a bond with an ESG rating or is certified by a third party and zero otherwise	−
$\text{Credit Rating}_{i,t}$	A variable that is equal to 4 if the bond is AAA-rated, 3 for AA-rated bonds, 2 for A-rated bonds and 1 otherwise.	−
Bond_Scale_i	The natural logarithm of bond issuance amount (in billions of Chinese yuan)	+
Coupon_i	The bond coupon rate.	+

Duration_i	Change in the value of a bond in response to a change in a 100 basis point (1%) change in interest rates.	+

Financial conditions of the issuer:

Variable Name	Variable Description	Expected Sign
Leverage_{it}	A dummy variable that is equal to one if the debt ratio of the issuer is lower than industry average and zero otherwise.	−
Debt/EBITDA_{it}	An issuer's ability to pay back its debt obligations.	+
SOE_{it}	A dummy variable that is equal to one if the issuer is an SOE firm and zero otherwise.	−

Industry-level characteristics:

Variable Name	Variable Description	Expected Sign
Green Industry_i	A dummy variable that is equal to one if the issuer operates in green industries and zero otherwise.	−

2) Policy determinants

Variable Name	Variable Description	Expected Sign
$\text{Issuance\_Rule}_{it}$	A dummy variable that is equal to one if the issuance rule in the exchange is strict and zero otherwise.	−

4. Results

4.1 Descriptive Statistics of Variables

Variables	N	Mean	Std. Dev.	Median	Minimum	Maximum
Credit Spread	1628	1.205	0.502	1.1	0.4	3.5
ESG Rating	1628	0.45	0.4	0	0	1
Credit Rating	1628	2.5	1.1	2	1	4
Bond Scale	1628	6.5	0.8	6.4	5	8.5
Coupon (%)	1628	3.5	1.2	3.3	1.5	6.8
Duration	1628	6.3	2.5	5.8	1	15
Leverage	1628	0.54	0.2	0	0	1
Debt/EBITDA	1628	3.5	1.8	3.2	0.8	9.4
ROIC (%)	1628	7.5	2.8	6.3	2.4	13.6
SOE	1628	0.4	0.38	0	0	1
Green Industry	1628	0.55	0.47	1	0	1
Issuance Rule	1628	0.32	0.46	0	0	1

Table 1 reports the descriptive statistics of the sample bond data on the dependent variable Credit Spread and independent variables of the regression model. N represents the number of bond samples used in these statistics. Mean, Standard Deviation, Median, Minimum, and Maximum represent the corresponding statistics value of the sample data. The time range of the sample bond data is from January 2016 to December 2024, with 814 green bonds and 814 brown bonds, which means 1628 bond observations used in this descriptive statistic in total. The source of bond attribute values and issuer characteristics data is Wind.

4.2 Empirical Regression Results

Variables	Coefficient	Std. Error	t-Statistic	p-Value
Green	−0.11	0.04	−2.75	0.006**
ESG Rating	−0.0328	0.035	−1.76	0.0968**
Credit Rating	−0.027	0.045	−1.6	0.015**
Bond Scale	−0.055	0.023	−1.39	0.017*
Coupon	0.14	0.042	1.33	0.011**
Duration	0.09	0.03	1.01	0.013**
Leverage	−0.07	0.035	−1.85	0.075*
Debt/EBITDA	0.06	0.028	1.5	0.012*
ROIC	−0.08	0.03	−1.57	0.018**
SOE	−0.06	0.03	−1.98	0.005*
Green Industry	−0.02	0.04	0.52	0.615
Issuance Rule	−0.13	0.038	−1.72	0.005**
R-Squared	0.74			
# of Observations	1628			

Table 2 represents the results for the baseline panel regression model of the credit spread on a set of independent variables to examine the existence, magnitude, and drivers of greenium in China's green bond market. The p-value of the difference-in-means test. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively. The time range of the sample bond data is from January 2016 to December 2024, with 814 green bonds and 814 brown bonds, which means 1628 bond observations used in this model in total. The source of bond attribute values and issuer characteristics data is Wind.

The above table demonstrated that the greenium dummy variable was significant at the 5%

level. Therefore, my study shows that green bonds in China are priced at a discount compared to conventional bonds, with a magnitude of around 11 bps, which confirms my anticipation of **Hypothesis 1**. This finding matches the conclusions of most studies on the topic which confirm the existence of greenium in China, such as Hu et al. (2024) and Zhao, Wang, and Fang (2024). The magnitude of greenium in China's green bond market this paper measured is much larger than that in mature and international markets, as estimated by Baker *et al.* (2018) and Grishunin *et al.* (2022). This finding is consistent with the findings in Hu, Zhong, and Cao (2022). They attribute this difference to information asymmetry and revised beliefs prompted by prominent environmental stimuli.

Moreover, the variable ESG rating dummy is also significant at a 10% level. It means the greenium increases to around 7.5 bps if the green bond has the ESG rating. This finding coincides with that of Li, Zhang, and Wang (2022) that green bonds with third-party certification can efficiently reduce the yield spread. According to Lin et al. (2023), certification by independent third parties is a costly signal, representing issuers' dedication to sustainable projects and a lower probability of greenwashing. However, this result is not uniform. It contradicts the finding from Jeong, Hyun, and Li (2021), which stated that third-party verification is not the main factor affecting the size of greenium.

Another significant variable at the 10% level is leverage, which aligns with the finding in Shi and Zhang (2024) that a firm's leverage positively correlates with credit spreads. This factor is crucial since it affects credit risk, investor perception, and financing costs, all of which influence the pricing dynamics of green bonds.

The dummy variable SOE is significant at the 5% level. This factor is rarely discussed in the U.S. or European market. However, it is worth our attention due to China's specific condition, which causes differences in credit risk, financing access, liquidity, and investor perception between SOE and non-SOE firms. SOEs tend to have a lower greenium due to implicit government support, while non-SOEs face higher financing costs, leading to a larger greenium. As China's green bond market matures and non-SOEs become more active, this gap may narrow, but structural differences will continue to shape pricing dynamics. I discuss the difference between the greenium of SOEs and non-SOEs and the rationale in Section 5.2.

The policy variable, the issuance rule, is another significant variable at the 10% level. In China, rules governing the listing and trading of ESG bonds vary in sophistication and stringency across different trading markets. The Stock Exchange of Hong Kong, Shanghai Stock Exchange, and Shenzhen Stock Exchange have the most comprehensive and rigorous issuance rules, followed by the interbank market, and Beijing Stock Exchange has relatively loose rules. The result revealed that the stricter the rule is, the larger the greenium issuers can enjoy, which compensates for the multifarious processes that they undergo.

5. Sub-Group Comparison

5.1 Time-period Comparison: Before Vs. After 2019

The year 2019 is a critical turning point for China's green bond market since it shifted its focus to improving transparency, third-party verification, and alignment with international standards. Moreover, China has started to phase out controversial categories (e.g., clean coal) that are not eligible for green bond funding. To test **Hypothesis 2**, my paper divides the full sample of data into two sub-samples: bonds issued before and after 2019 and runs Model 1 separately. The results show that the greenium effect increases significantly after 2019.

	Before 2019	After 2019	Full Sample
Intercept	2.3	2.5	1.8
Green	−0.06	−0.139	−0.11
Controls	Yes	Yes	Yes
Adj. R-squared	0.68	0.75	0.74
# of observations	531	1097	1628

Table 3 represents the results for the sub-group panel regression model of the credit spread on a set of independent variables to examine the change in the magnitude of greenium in China's green bond market over time. Column 1 reports the results for the sample before 2019. Column 2 reports the results for the sample after 2019. Column 3 reports the results for the full sample. All control variables and fixed effects are included. The time range of the sample bond data is from January 2016 to December 2024, with 814 green bonds and 814 brown bonds, which means 1628 bond observations used in this descriptive statistic in total. The source of bond attribute values and issuer characteristics data is Wind.

This can be attributed to several interrelated factors. Firstly, there were more supportive policies and a better regulatory environment. In 2019, China intensified its commitment to green finance, aligning its green bond standards more closely with international frameworks. This alignment bolstered investor confidence by ensuring greater transparency and credibility in green bond issuances. Consequently, investors were more willing to accept lower yields on green bonds, leading to the emergence of a greenium. Besides domestic investors, international investors also became more confident in China's green bond market and exhibited a growing appetite for green investments, driven by a combination of regulatory incentives and a shift towards sustainable investment practices. This surge in demand, particularly from ESG-focused funds, exerted upward pressure on the prices of green bonds, thereby reducing their yields and creating a greenium.

5.2 Firm-level Comparison: SOE Firms Vs. Non-SOE Firms

To test **Hypothesis 3** and examine whether the greenium effects for non-SOE firms are stronger than those for SOE firms, my paper divides the full data set into two sub-samples: one data set of bonds issued by SOE firms and the other data set of bonds issued by non-SOE firms. The specifications of the regression are the same as those in Model 1.

The research further divides the non-SOE sub-sample into two categories: issuers in green industries and issuers in brown industries. It also divides the SOE sub-sample into two categories: issuers in green industries and issuers in brown industries. The observations derived from the above firm-level comparison extend similarly to the bonds issued by firms in green industries and brown industries within each category. A firm-level comparison shows that the greenium effects are priced more strongly into bond yields in the bonds issued by two non-SOE firm categories than in their respective SOE counterparts.

To substantiate these findings, in which I discover that greenium is more pronounced for non-SOE firms than for SOE firms, I add an additional interaction term, $Green_i \times SOE_i$ to Model 1 to account for the relative pricing of greenium effects across the two types of issuers. The SOE dummy equals one if the bond issuer is an SOE firm and equals zero otherwise. The positive and significant coefficient estimates for $Green_i \times SOE_i$ in columns (8) to (10), 0.06, 0.056, and 0.072, indicate that greenium is significantly larger for non-SOEs than for SOEs.

Columns 8 and 9 report estimates for the combined bonds in the green industries categories and for the combined bonds in the brown industries categories.

	SOEs			Non-SOEs			Full sample		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Full	Green	Brown	Full	Green	Brown	Full	Green	Brown
Intercept	2.7	2.65	2.8	2.4	2.35	2.45	2.5	2.48	2.63
Green	−0.073	−0.06	−0.09	−0.148	−0.116	−0.163	−0.139	−0.128	−0.146
SOE							−0.08	−0.067	−0.086
Green×SOE							0.06	0.056	0.072
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R^2	0.7	0.69	0.71	0.76	0.74	0.77	0.75	0.78	0.72
Observations	986	572	414	642	395	247	1628	937	691

Table 4 represents the results for the sub-group panel regression model of the credit spread on a set of independent variables to examine the difference in the magnitude of greenium between SOE firms and non-SOE firms. Column 1 reports the results for the full sample of SOE firms. Column 2 reports the results for the sample of SOE green firms. Column 3 reports the results for the sample of SOE brown firms. Column 4 reports the results for the full sample of non-SOE firms. Column 5 reports the results for the sample of non-SOE green firms. Column 6 reports the results for the sample of brown non-SOE firms. Column 7 reports the results for the full sample. Column 8 reports the results for all the green firms. Column 9 reports the results for all the brown firms. All control variables and fixed effects are included. The time range of the sample bond data is from January 2016 to December 2024, with 814 green bonds and 814 brown bonds, which means 1628 bond observations used in this descriptive statistic in total. The source of bond attribute values and issuer characteristics data is Wind.

Non-SOE firms in China enjoy a higher greenium than SOE firms primarily because investors perceive them as more committed to sustainability, more innovative, and more willing to accept higher risks in exchange for the potential long-term rewards of a green transition. In contrast, SOE firms, due to their government backing, perceived stability, and slower transition to green initiatives, do not generate the same level of market motivation or greenium. The dynamics of risk, branding, policy, and market perception all contribute to this differentiation.

5.3 Robustness Tests

Model 1 has demonstrated the existence of greenium in the Chinese green bond market. In this sub-section, my paper performs robustness tests to reinforce these empirical findings by focusing on firms that issue both green and conventional bonds to facilitate within-firm comparison. To mitigate the concern that unobservable firm variables could potentially influence greenium, I add the firm-fixed effect into Model 1. Despite a drop in magnitude, the coefficient estimates for Green, ESG rating, leverage, SOE, and issuance rules, remain statistically significant, indicating the robustness of my findings.

6. Environmental Performance Analysis

6.1 Carbon Emissions Comparison: Green Bond Issuers Vs. Non-Green Bond Issuers

To test **Hypothesis 4**, I strategically match and choose 58 green firms that issue green bonds and 58 firms that do not. I conduct a Difference-in-Differences method (Model 2) on these firms that have similar WIND ESG scores before green bond issuances.

$$(\frac{\text{Carbon. Emissions}}{\text{Operating. Revenue}})_{i,t} = \alpha + \beta(Green_i * Post_{i,t}) + \gamma X_{i,t} + u_i + \lambda_t + \varepsilon_{i,t}$$

In Model 2, $(\frac{\text{Carbon.Emissions}}{\text{Operating.Revenue}})_{i,t}$ represents carbon emissions per unit revenue, which also refers to carbon intensity of economic output. I divide carbon emissions by operating revenue to avoid underweighing very small and overweighing large firms and align with common metrics used in sustainability reporting. $Green_i$ is a dummy variable that equals to 1 if firm i issues green bonds. $Post_{i,t}$ is another dummy variable that equals to 1 if year t is after issuance for treated firms or comparable years for control firms. u_i denotes firm fixed effects that controls for time-invariant firm characteristics, and λ_t denotes time fixed effects that controls for macro trends affecting all firms equally. $\varepsilon_{i,t}$ denotes error terms. $X_{i,t}$ are controlled variables that may affect emissions, including firm size (logarithm of total assets), capital expenditure, leverage, and profitability.

Variable	Coefficient	Std. Error	t-Statistic	p-Value
$Green * Post$	−0.0021	0.005	−1.78	0.077*
R-Squared	0.87			
# of Observations	268			

Table 5 represents the results for the Difference-in-Differences model of the carbon intensity on the interaction term $Green_i * Post_{i,t}$ to examine the efficiency of green bonds in reducing carbon emissions. All control variables and fixed effects are included. The p-value of the difference-in-means test. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively. The dataset consists of 58 green bond issuers and 58 non-green bond issuers. The model covers data for 3 years per firm, which are the year before issuance, the year of issuance, and one year after issuance. Since some data are missing due to firms' reporting and disclosure, there are 268 observations used in this model in total. The source of bond attribute values and issuer characteristics data is Wind.

On average, green bond issuance is associated with a 0.21% reduction in carbon emissions, compared to non-issuers over the same period. The results are statistically significant at the 10% level. However, the magnitude is economically insignificant: a 0.21% drop is almost negligible in practice.

6.2 Time Series Effect

Since many green bond proceeds are used for projects not immediately tied to carbon cuts (e.g., R&D, infrastructure), emission reduction may require a longer time to materialize. Therefore, I further examine the time series effect of green bond issuances on carbon emissions by performing an event study centered around the green bond issuance year, focusing on 58 green bond issuers' carbon emissions from one year before (T-1) to two years after (T+2) green bond issuances. This model shows the effectiveness of green bonds year by year and see whether the effect persists or fades, which helps evaluate policy timing and understand implementation lags.

$$\left(\frac{\text{Carbon. Emissions}}{\text{Operating. Revenue}}\right)_{i,t} = \beta_0 + \sum_{k\neq -1} \beta_k * Green_{i,t}^k + \gamma X_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t}$$

In Model 3, $Green_{-1}$ is omitted as the baseline to avoid perfect multicollinearity. All estimated coefficients for subsequent event years (issuance year, one year after, two years after) represent changes in log carbon emissions relative to this pre-issuance baseline $Green_o$=1 if it is the year that green bonds are issued, and equals to 0 otherwise; $Green_1$=1 if it is one year after green bond issuances, and equals to 0 otherwise; $Green_2$=1 if it is two years before green bond issuances, and equals to 0 otherwise. All the other variables remain the same meanings as in Model 2.

Variable	Coefficient	Std. Error	t-Statistic	p-Value
$Green_o$	-0.005	0.003	-1.87	0.061*
$Green_1$	-0.0122	0.004	-1.93	0.054*
$Green_2$	-0.0201	0.017	-2.05	0.041**
R-Squared	0.79			
# of Observations	186			

Table 6 represents the results for the event study model of the carbon intensity on a set of independent variables to examine the efficiency of green bonds in reducing carbon emissions in terms of time series. All control variables and fixed effects are included. The p-value of the difference-in-means test. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively. The dataset consists of 58 green bond issuers. The model covers data for 4 years per firm, which are the year before issuance, the year of issuance, one year after issuance, and two years after issuance. Since some data are missing due to firms' reporting and disclosure, there are 186 observations used in this model in total. The source of bond attribute values and issuer characteristics data is Wind.

Compared to the pre-issuance baseline, corporate carbon emissions decrease by approximately 0.5% in the issuance year, 1.2% one year after, and 2% two years after, which consolidates the fact that the economic magnitude of green bond issuances on reducing carbon emissions is insignificant. Fortunately, the degree of decline increases every year, which indicates a positive trend in the long run. These results are statistically significant and robust to firm and year-fixed effects.

More specifically, I divide the 58 companies into four types of industries based on industry category from the WIND terminal, which are Greentech, energy, manufacturing, and environmental services groups.

Variable	Greentech	Energy	Manufacturing	Environmental Services
$Green_o$	-0.002	-0.0238	-0.003	-0.001
$Green_1$	-0.005	-0.0526	-0.008	-0.002
$Green_2$	-0.008	-0.0867	-0.01	-0.005
R-Squared	0.75	0.86	0.8	0.72
# of Observations	68	68	32	18

Table 7 represents the results for the event study model of the carbon intensity on a set of independent variables to examine the efficiency of green bonds in reducing carbon emissions in terms of time series. Column 1 reports the results for the Greentech industry. Column 2 reports the results for the energy industry. Column 3 reports the results for the manufacturing industry. Column 4 reports the results for the environmental services industry. All control variables and fixed effects are included. The dataset consists of 58 green bond issuers and covers data for 4 years per firm, which are the year before issuance, the year of issuance, one year after issuance, and two years after issuance. Since some data are missing due to firms' reporting and disclosure, there are 186 observations used in this model in total. The source of bond attribute values and issuer characteristics data is Wind.

The results indicate that carbon emissions decline across all industries following green bond issuance. While the energy sector exhibits the most dramatic percentage reduction, the magnitude of the decline in the green technology and manufacturing sectors is comparatively smaller. Among the sectors analyzed, the impact of green bond issuance on carbon emission reduction is least pronounced in the green technology sector.

This finding can be attributed to energy companies' high carbon emission baselines. Even small operational shifts (e.g., switching to cleaner fuel, or installing scrubbers) can result in large percentage drops. In contrast, green tech companies (e.g., solar panel, and battery producers) already operate with low carbon intensity, so their scope for additional reduction is limited. Their issuances of green bonds serve more as signaling than as a tool for new transformation. On the other hand, for traditional energy firms, green bonds may reflect genuine transition finance, with clear decarbonization targets and measurable results.

Meanwhile, energy companies may use green bond proceeds to fund direct emission-reducing projects (e.g., decommissioning coal plants, and upgrading to renewables). Green tech firms, however, often use funds for R&D, capacity expansion, or product development rather than direct operational decarbonization. These investments have longer ROI cycles and may eventually lead to lower emissions in the long run, but the short-term impact is smaller.

Moreover, different industries face different regulatory pressures and incentives. The energy sector is heavily targeted by carbon pricing, emission trading systems (ETS), and government mandates in China. Green tech and manufacturing firms may face softer or more voluntary ESG pressures, thereby responding less directly.

7. Conclusion

China's green bond market has grown rapidly since its establishment in 2016, becoming one of the largest in the world. Its development is closely linked to China's commitment to tackling climate change, reducing carbon emissions, and promoting sustainable development. Green bonds are a critical financial tool to drive China's transition to a low-carbon economy by funding sustainable investment projects (e.g., renewable energy, green infrastructure, and pollution control) and attracting investors who pay attention to ESG principles.

This paper sheds light on the drivers of greenium in China, which is one of the key characteristics of green bonds. For this purpose, my research conducted the regression analysis on the sample of 1628, both conventional and green bonds, in China from 2016 to 2024. This period encompasses the entire existence of green bonds in China since the first issuance in 2016. Analysis showed the existence of statistically significant negative greenium in China's green bond market while taking ESG rating, leverage, SOE, and issuance rules as the major driving factors. A literature review revealed that most past research focused on the US, European, or global bond markets, leaving China's green bond market unexplored. Therefore, my analysis of the magnitude and main determinants of greenium makes my research novel and contributes to the existing literature.

There are several challenges in studying greenium in China's green bond market. First, data regarding emissions and ESG metrics is limited, especially at the early stage of establishing China's green bond market. This is due to inconsistent disclosure, lack of third-party certification, and different ESG rating methodologies. These factors jointly increase the probability of greenwashing and make it difficult for investors to evaluate the environmental benefits of issuing green bonds on top of financial returns. Second, China faces market-specific structural challenges. SOE and non-SOE firms play different roles in the green bond market from various aspects, including government guarantees, credit risks, and supporting projects' properties. Therefore, solely analyzing the entire group of bonds ignores China's market structure, which accounts for variations in greenium. Third, liquidity in China's green bond market is lower than in conventional bond markets, which may distort yield spreads.

To resolve these issues, my paper also aims to investigate the evolution of greenium across different periods, the financing benefits that greenium brings to distinct firms, the relationship between policy implementation and the magnitude of greenium, and the real effects of green bond issuances on our environment. My results showed that greenium increased significantly after 2019, which can be explained by the maturity of China's green bond market in terms of regulatory enhancement, expansion of incentives and policies, and strong demand growth. From the market structure perspective, greenium is larger for non-SOE firms than SOE firms in compensation for higher credit risks and more complicated access to financing. However, the actual effect of green bonds on our environment, which refers to the efficiency of green bonds in reducing carbon emissions in this paper, currently remains economically insignificant. Fortunately, some industries such as the energy sector show a promising performance in reducing carbon emissions through green bond issuances in the long run. However, these effects should be tested when the time span becomes longer.

My findings highlight the evolution of China's green bond market, emphasizing the role of policy support, market structure, and liquidity in shaping greenium. The results have meaningful and practical implications for policymakers and authorities to design regulations and policy incentives to implement the sustainable development agenda, for issuers to engage in sustainable finance and accelerate China's low-carbon transition, and for investors to make sound investment decisions by evaluating ESG impacts. More importantly, they strengthen the link between green bond issuances and real environmental impacts. While a growing greenium reflects a stronger demand for green bonds, ensuring that the influence of green finance translates into environmental protection and improvements is crucial. Future research can focus on strengthening post-issuance impact reporting, carbon reduction tracking, and third-party verification to enhance transparency and investor confidence.

Since China's green bond market is still in a fast-growing stage of development, I believe that conclusions drawn from this paper could pave the way for future research and be extended to a much broader setting as soon as more detailed data become available (e.g., environmental data such as air quality). In addition, the findings in this paper represent a first step toward thoroughly evaluating the environmental impacts of green bond issuances in China beyond enjoying lower financing costs and generating higher financial returns. It remains an open question whether green bonds have produced the desired positive effects on climate change.

References

Ando, S., Fu, C., Roch, F., Wiriadinata, U., 2023, How Large is the Sovereign Greenium, I International Monetary Fund, WP/23/80.

Baker, M., Bergstresser, D., Serafeim, G., Wurgler, J., 2018, Financing the Response to Climate Change: The Pricing and Ownership of U.S. Green Bonds, Working Paper 25194.

Bolton, P., Kacperczyk, M., Wiedemann, M., 2024, The CO2 Question: Technical Progress and the Climate Crisis.

Cao, X., Jin, Cheng., Ma, W., 2021, Motivation of Chinese commercial banks to issue green bonds: Financing costs or regulatory arbitrage, China Economic Review 66 (2021) 101582.

Climate Bonds Initiative (CBI), 2019, China Green Bond Market 2019 Research Report

Climate Bonds Initiative (CBI), 2021, China Sustainable Debt State of the Market Report 2021.

Flammer, C., 2021, Corporate Green Bonds, Journal of Financial Economics 142 (2021) 499–516.

Han, Y., Li, J., 2022, Should investors include green bonds in their portfolios? Evidence for the USA and Europe, International Review of Financial Analysis 80 (2022) 101998.

Hu, X., Zhong, A., Cao, Y., 2022, Greenium in the Chinese Corporate Bond Market, Emerging Markets Review 53 (2022) 100946.

Hu, X., Zhu, B., Lin, R., Li, X., Zeng, L., Zhou, S., 2024, How does greenness translate into greenium? Evidence from China's green bonds, Energy Economics 133 (2024) 107511.

Jeong, H., Hyun, S., Li, C., 2021, Exploring Greenium in the Chinese Green Bond Market: Focusing on the Primary Market, Available at SSRN

Li, Q., Zhang, K., Wang, L., 2022, Where's the Green Bond Premium? Evidence from China, Finance Research Letters 48 (2022) 102950.

Lin, T., Luo, Y., Tian, S., Yang, H., 2023, Green Bond Issuance and Air Quality Improvement: Chinese and International Evidence, HKU Jockey Club Enterprise Sustainability Global Research Institute – Archive, Available at SSRN.

Grishunin, S., Bukreeva, A., Suloeva, S., Burova, E., 2023, Analysis of Yields and Their Determinants in the European Corporate Green Bond Market, MDPI.

Grishunin, S., Burova, E., Suloeva, S., Pishchalkin, D., Isroilov, B., Doliev, S., 2024, Greenium and its Determinants at Various Phases of Life Cycle of European Green Bond Market, E3S Web of Conferences 574, 03005.

Marquis, C., Toffel, M., Zhou, Y., 2016, Scrutiny, Norms, and Selective Disclosure: A Global Study of Greenwashing, Organization Science 27(2), pp. 483–504.

Pietsch, A., Salakhova, D., 2022, Pricing of green bonds: drivers and dynamics of the greenium, ECB Working Paper Series No 2728.

Sergei, G., Alesya, B., 2022, In Search of Greenium. Analysis of Yields in the European Green Bond Markets, Procedia Computer Science 214 (2022) 156–163.

Shi, Z., Zhang, S., 2024, Oil-Driven Greenium, Dice Center WP 2024-24, Fisher College of Business WP 2024-03-024.

Tang, D., Zhang, Y., 2020, Do shareholders benefit from green bonds, Journal of Corporate Finance 61 (2020) 101427

Zhao. D., Wang, Y., Fang, Y., 2024, Greenium and public climate concerns: Evidence from China, Finance Research Letters 69 (2024) 106091.