

An Empirical Analysis of Pricing Determinants in China's Green Bond Market: A Study on Risk Mitigation Effects Through Certification Signals, Rating Analysis, and Disclosure Quality

Ruohan Wang

School of Public Finance and Taxation, Central University of Finance and Economics, Beijing, China

ABSTRACT

Green bonds, as an innovative financial instrument, are characterized by the earmarking of funds for low-carbon environmental protection, climate adaptation, and other green projects, thereby integrating environmental benefits with economic returns. Compared to conventional bonds, the "green attribute" of green bonds enables investors to pay a premium for environmental value creation. However, existing academic research on green bond pricing primarily focuses on policy effect evaluations or market size measurements, lacking micro-level analyses of the mechanisms through which risk mitigation factors influence pricing. Prior studies have demonstrated that third-party green certification alleviates information asymmetry via signaling effects, corporate ESG ratings integrate environmental, social, and governance risks into dynamic risk assessment frameworks, and environmental information disclosure quality enhances market transparency. Nevertheless, the synergistic impact of these three dimensions on green bond pricing remains unexplored. Drawing on Asymmetric Information Theory, Credit Risk Theory, and Signaling Theory, this study innovatively constructs a multi-dimensional analytical framework to examine the risk mitigation mechanisms in green bond pricing. Specifically, it investigates the sequential roles of compliance-driven assurance (third-party green certification), comprehensive risk quantification (corporate ESG ratings), and transparency enhancement (environmental information disclosure quality Score). Considering 2017 as the pivotal year marking the deepening of China's green financial system construction, the research employs a multiple linear regression model using green bond data from Wind Database (2017–2024) to conduct empirical tests across three dimensions. Results indicate that third-party certification significantly reduces financing costs by mitigating information asymmetry, with its credibility effects particularly pronounced in publicly offered bonds and non-listed enterprises. Corporate ESG ratings demonstrate superior explanatory power by integrating ESG risks into a dynamic pricing benchmark, outperforming single-dimensional certifications. Environmental information disclosure quality emerges as a critical determinant, directly lowering investor risk premiums through enhanced transparency. Furthermore, the study reveals the moderating effects of issuance methods and issuer characteristics on risk mitigation efficacy, offering theoretical insights for optimizing green financial policies and corporate financing strategies.

KEYWORDS

Green bond pricing; Third-party green certification; Corporate ESG ratings; Environmental information disclosure quality

1. RESEARCH BACKGROUND

Looking back at the course of global economic and social development over the past few centuries, economic growth and environmental protection have always exhibited a complex dynamic. Since the Industrial Revolution, the rapid advancement of industrialization and urbanization has created enormous material wealth, but it has also brought about environmental crises such as drastic deforestation, species extinction, and global warming. This development model, which sacrifices the ecological environment, also manifested itself during China's period of rapid economic growth following reform and opening up. From the late 20th century to the early 21st century, China experienced an average annual economic growth rate of nearly 10%, but this was accompanied by prominent problems such as deteriorating air quality, increasing water pollution in river basins, and expanding desertification. Frequent smog in the Beijing-Tianjin-Hebei region and heavy metal pollution incidents in the Yangtze River basin not only threaten public health but also hinder sustainable economic development. A deteriorating ecological environment ultimately impacts the economic system, manifesting itself in a chain reaction of rising governance costs, declining resource utilization efficiency, and increased green trade barriers, forcing society to re-evaluate its development path.

Against this backdrop, China has incorporated the development of an ecological civilization into its national development strategy, embarking on a new exploration of the synergistic coexistence of economic development and environmental protection. Through policy innovations such as improving the Environmental Protection Law, implementing the Ten Measures for Air Pollution Control, and establishing an ecological compensation mechanism, an institutional framework for environmental governance has gradually been established. At the same time, the capital market has become a key force driving green transformation, and green finance has emerged. Driven by the intensification of global climate change and the demand for sustainable development, green finance, as a key tool for achieving environmental goals and economic transformation, has become a focus of attention in the international capital market. This innovative financial instrument, by directing funds to environmental technology research and development, clean energy development, and ecological restoration, allocates environmental resources through market-based means. This not only alleviates financing bottlenecks for environmental projects, but also injects new momentum into the green upgrade of traditional industries and internalizes the pricing of environmental externalities.

As the world's largest carbon-emitting economy, my country has actively promoted green development through top-level policy design in recent years. The 2015 "Overall Plan for Ecological Civilization System Reform" explicitly proposed the establishment of a green financial system. Subsequently, the People's Bank of China, the National Development and Reform Commission, and seven other departments jointly issued the "Guiding Opinions on Establishing a Green Financial System," marking the basic formation of my country's green financial institutional framework. Green bonds, with their targeted financing capabilities, have become a core financing channel to support corporate green technology innovation and low-carbon transformation. According to statistics, by the end of the third quarter of 2023, my country's cumulative green bond issuance exceeded 2.1 trillion RMB, accounting for 46.7% of the global green bond market, ranking first globally for six consecutive years. This includes both green financial bonds led by policy banks and carbon neutral bonds issued by listed companies, forming a multi-layered and multi-sector green debt financing system. From 2017 to 2024, my country's cumulative green bond issuance continued to expand, as shown in Figure 1 below. After exceeding 1.2 trillion RMB in 2021, the growth rate stabilized, reaching a cumulative total of 1,127.141 billion RMB in 2023, confirming its status as a core vehicle for green financial instruments. Year-on-year growth rates fluctuated significantly, with peaks in 2019 (+24%) and 2021 (+18%), reflecting the release of policy dividends and accelerated market expansion. The negative growth in 2020 (-17%) and 2023 (-4%) is closely related to regulatory adjustments. Despite a slowdown in growth in 2023, the market will still see an increase of 642.611 billion yuan throughout the year, demonstrating its resilience amidst regulatory oversight. This trend

reveals that my country's green bond development is shifting from scale expansion to quality improvement. While the refinement of regulatory policies will dampen issuance in the short term, it will benefit the market's health and internationalization in the long term. With the standardization of ESG disclosure standards, it is expected that green bonds will become more deeply integrated into the global sustainable investment ecosystem.

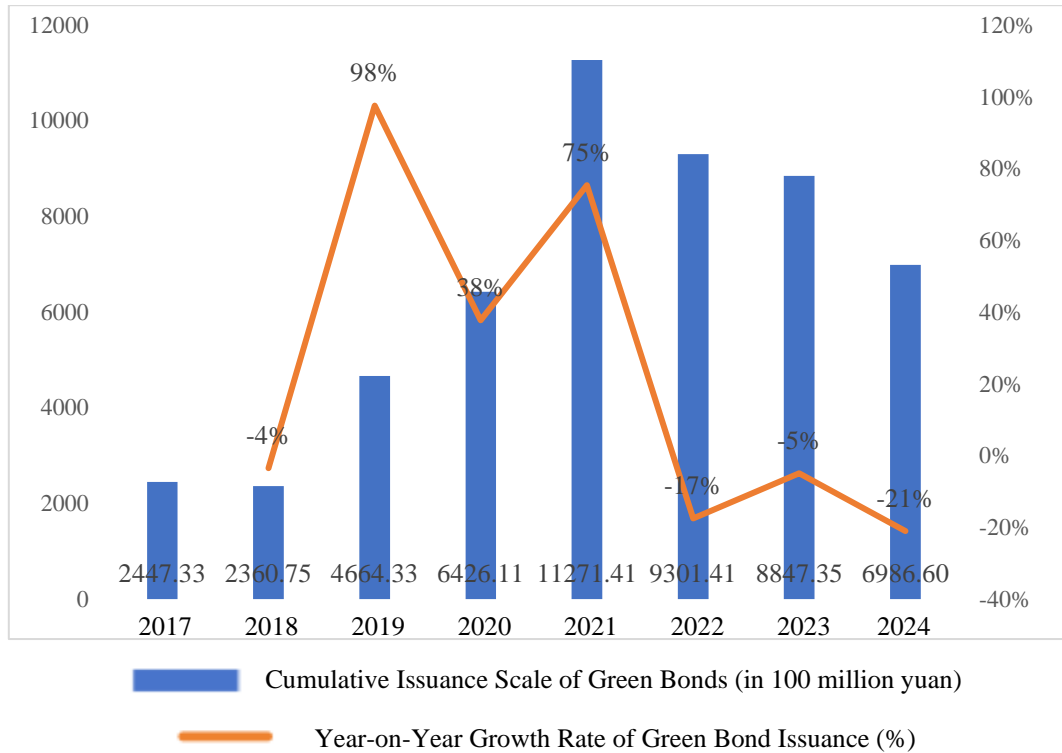


Figure 1. Green bond issuance from 2017 to 2024

The issuance of green bonds not only meets the funding needs of companies for green projects but also demonstrates their proactive commitment to environmental responsibility. Compared to traditional bonds, green bonds possess a unique value system through restrictions on fund use, third-party certification mechanisms, and information disclosure requirements. This uniqueness is reflected in pricing as a dual premium: on the one hand, the positive externalities generated by green bonds' environmental benefits give them a "moral premium," for which investors are willing to pay a premium; on the other hand, the rigorous certification process and information disclosure increase issuers' compliance costs, resulting in an "institutional premium" on the coupon rate. The pricing of green bonds in my country may also be significantly influenced by policy incentives. Policy instruments directly influence bond pricing by altering the risk-return ratio. However, existing research has largely focused on the policy effects or market development status of green bonds, lacking a systematic exploration of the micro-mechanisms underlying their pricing. In particular, the impact of risk dilution on coupon rates remains underdeveloped, hindering the precise implementation of green finance policies and improving corporate financing efficiency.

2. LITERATURE REVIEW

2.1. Literature Review on Bond Pricing

After decades of development, the research system of bond pricing mechanism has formed a systematic framework. Early studies focused on basic pricing factors. John et al. (2002) [11] first verified that the collateral attribute had a significant positive impact on the issuance premium based on a sample of fixed-rate bonds from 1993 to 1995. With the improvement of the credit rating system, Ziebart and Reiter (2010) conducted an empirical study on industrial bonds from 1981 to 1985 and

found that the S&P and Moody's rating results and corporate financial indicators together constituted the core elements of pricing. Chinese scholar Xu Qiang (2007) [1]'s study on short-term financing bonds revealed the nonlinear effect of maturity structure and issuance scale on pricing, while Fang Hongxing's team (2013) [2] quantified the weight of the impact of corporate property rights on pricing efficiency for the first time based on the decomposition analysis of corporate bond data from 2007 to 2011. These studies jointly constructed the theoretical foundation of traditional bond pricing, but have not yet touched on the emerging variable of green attributes. Later, with the rise of green bonds, domestic and foreign scholars showed significant theoretical differences in their research on the pricing mechanism of green bonds. Cross-national data from Kapraun and Scheins (2019) [13] show that green bonds have an issuance spread advantage of about 20-30bp, and this negative premium effect shows structural differences between different currencies. However, a localized study by Chinese scholars Jiang Feifan and Fan Longzhen (2020) [3] reached the opposite conclusion, and their sample regression from 2016 to 2019 did not find statistically significant differences. This cognitive divergence may be due to differences in market maturity: after years of development, the European and American markets have formed a stable premium mechanism, while emerging markets are still in the institutional exploration stage, resulting in a pricing mechanism with phased characteristics.

In terms of determining the pricing elements of green bonds, international research shows multi-dimensional characteristics. The CBI certification index system constructed by Hyun et al. (2019) [12] confirmed that the issuance cost of internationally certified green bonds is reduced by about 15%, and short-term (3-5 years) and large-scale (more than 1 billion yuan) bonds are more likely to obtain pricing advantages. Chinese scholars Zheng Lanxiang and Hu Xiaoyu (2021) [4] used a regression model based on 221 sample bonds from 2016 to 2019 and showed that third-party certification improved pricing efficiency by 23%, significantly higher than bond ratings and scale effects.

2.2. Literature Review on the Current Status Of Green Bond Development in My Country

2.2.1. Market expansion driven by policy

my country's green bond market started in 2016 and has shown a leapfrog development guided by policy. As one of the first pilot institutions (Ma Wenfang, 2019) [5], Industrial Bank's innovative practice reveals the dialectical relationship between regulatory arbitrage space and market norm construction. The intensive introduction of policy tools has pushed the market size from 230 billion yuan in 2016 to 800 billion yuan in 2022. However, the problem of "focusing on issuance and neglecting management" pointed out by Ma Wenfang (2019) [5] remains prominent, specifically manifested in institutional defects such as the lack of supervision on the use of funds and the formal disclosure of environmental benefits.

2.2.2. Market characteristics and pricing efficiency

The cross-cycle study by Zhang Xiaoqian et al. (2023) [6] shows that the issuance rate of my country's green bonds is 18bp lower than the benchmark yield on average, but this premium advantage tends to decline over time. The DSGE model they constructed confirmed that for every 1 standard deviation increase in the government's environmental governance efforts, the financing cost of corporate green bonds decreased by 23-35bp. This policy transmission effect is particularly significant in heavily polluting industries. However, market segmentation still exists, with the interest rate spread between the interbank market and the exchange market reaching 8-12bp, reflecting the urgency of building a unified market mechanism.

2.2.3. Existing Problems and Optimization Paths

There are three major structural contradictions in the current market: First, the fragmentation of the certification system leads to information asymmetry, with the proportion of third-party certification

less than 40% and inconsistent standards; second, the problem of capital mismatch is prominent, with about 35% of the raised funds not invested in green projects as agreed; third, the pricing mechanism is highly administrative, and the benchmark interest rate curve has not yet formed a market-based pricing basis. In this regard, Liu Chuanqi et al. (2021) [7] proposed a "three-in-one" reform framework: establishing a penetrating capital supervision system, building an environmental risk stress testing model, and cultivating localized ESG rating agencies. Ma Wenfang (2019) [5] emphasized that we should learn from the EU's Sustainable Finance Taxonomy to build a hierarchical certification system and a dynamic information disclosure mechanism.

2.3. Research Focus and Innovations of This Paper

2.3.1. Research Focus

This paper attempts to focus on the progressive screening logic of third-party green certification, corporate ESG ratings, and environmental information disclosure quality, revealing the progressive relationship between these three factors, from "compliance endorsement" to "comprehensive risk quantification" to "transparency enhancement," and systematically analyzing the hierarchical characteristics of the risk mitigation mechanism in green bond pricing.

This paper specifically examines the impact of third-party green institutions on green bond pricing. It argues that green certification, through the credit endorsement of green bonds by intermediaries, can largely address information asymmetry and reduce investors' demands for compensation for potential risks. Furthermore, given that third-party green certification focuses solely on project environmental benefits, this paper attempts to incorporate corporate ESG ratings, breaking through the static limitations of traditional certification and achieving dynamic risk coverage from a multidimensional perspective integrating environmental compliance, social risk, and governance risk. Finally, this paper focuses on environmental information disclosure quality, emphasizing its unique value in systematically quantifying the completeness and compliance of corporate environmental information disclosure, highlighting the theoretical mechanism by which "information quality directly affects the cost of capital."

2.3.2. Research Innovations

Theoretical Framework

This paper breaks away from the traditional understanding of green certification as a single function and constructs a progressive analytical chain of "compliance certification - comprehensive rating - transparency disclosure," revealing a comprehensive risk mitigation path from "ex-ante screening" to "ex-post supervision."

Variable Relationship Innovation

This paper innovatively introduces corporate ESG ratings as a core explanatory variable. This multi-dimensional information disclosure perspective addresses the limited environmental benefits of third-party green certifications. By integrating real-time environmental information tracking and social risk disclosure, it fills regulatory gaps. When information disclosure is incomplete, ESG ratings provide a supplementary pricing basis by integrating non-financial information.

Localized Practical Innovation

Considering the current development of my country's green bond market, which prioritizes issuance over management, this paper introduces environmental information disclosure quality as a core explanatory variable. By strengthening disclosure completeness and compliance, this paper aims to enhance market transparency, reduce hidden risks in green projects, and ultimately lower bond financing costs, highlighting the pricing transmission efficiency of information disclosure.

3. THEORETICAL BASIS AND RESEARCH HYPOTHESIS

3.1. Theoretical Basis

3.1.1. Information Asymmetry Theory

Information asymmetry theory is one of the core cornerstones of modern finance. Its ideological roots can be traced back to the "lemon market" model proposed by Akerlof (1970) [15]. This theory reveals the phenomenon that the asymmetry of information acquisition ability of market trading entities leads to distorted resource allocation efficiency. In the financial field, Stiglitz and Weiss (1981) further explained that information asymmetry in the credit market will lead to moral hazard and incentive distortion, that is, borrowers are more aware of project risks than lenders, resulting in capital allocation deviating from Pareto optimality. Due to its particularity, the green bond market presents a dual complexity of information asymmetry. On the one hand, there is "uncertainty" in environmental benefits. Issuers have private information such as carbon footprint accounting and technical feasibility, while external investors find it difficult to accurately assess the true value of the project; on the other hand, compliance costs are "hidden". Issuers may lower the threshold for green bond issuance through selective disclosure, creating "institutional arbitrage" space. This double dilemma exposes investors to the dual risks of authenticity of environmental benefits and opportunistic behavior of issuers. As an important carrier of signal transmission, the third-party certification mechanism is essentially an information screening system arrangement formed spontaneously by the market. According to the signal model of Flammer (2021) [14], authoritative certification agencies transform the implicit characteristics of green projects into verifiable standardized signals through independent assessment. When the environmental information disclosure standards have not yet been unified, third-party certification is equivalent to providing investors with a "risk diagnosis book", and the verifiable information provided by authoritative certification agencies can reduce investors' risk premium. Based on the above discussion, the information asymmetry theory provides an important analytical perspective for understanding the institutional dependence in green bond pricing, and also provides a theoretical basis for policymakers to optimize market infrastructure.

3.1.2. Credit risk theory

Credit risk theory points out that credit risk stems from the uncertainty of the debtor's default probability and default loss rate, and its pricing mechanism depends on the quantitative assessment of risk exposure. In the traditional bond market, credit risk is mainly measured by credit rating, financial leverage ratio and debt repayment ability indicators. However, due to the unique nature of green bonds' funding and environmental benefits, the connotation and scope of credit risk have significantly expanded. First, the realization of environmental benefits carries the risk of uncertainty. The technological maturity, policy dependence, and market risks of green projects may result in actual environmental benefits falling short of expectations, weakening the stability of project cash flow. Second, governance risk has a transmission effect. Issuers' ESG governance deficiencies may trigger related-party risk contagion. This risk structure significantly limits the application of traditional credit rating models in green bond pricing.

Credit risk theory provides a new analytical dimension for green bond pricing. Under conditions of information asymmetry, third-party certification can reduce the expected probability of default by providing technical compliance endorsements, and the strength of this effect is positively correlated with the asset specificity of the issuer. ESG ratings, on the other hand, integrate environmental, social, and governance risk factors to construct a dynamic credit risk assessment framework.

3.1.3. Signaling Theory

The core logic of signaling theory is that when information asymmetry exists in the market, one party with private information can transmit intrinsic quality signals to the other party through observable behavior, thereby influencing transaction pricing. In financial markets, signaling mechanisms can be

applied to corporate financing, primarily as high-credit-rated companies tend to choose equity financing to signal positive behavior, while low-credit-rated companies rely on debt financing to mitigate adverse selection risk.

In the green bond market, signaling mechanisms can operate through three channels: First, green attribute signals: issuers convey their commitment to environmental compliance to the market by obtaining third-party certification; second, governance signals: ESG rating systems integrate environmental, social, and governance indicators to reveal an issuer's sustainable development capabilities; and third, information disclosure signals: mandatory disclosure requirements compel issuers to release environmental performance data, reducing information ambiguity. These three signals form a complementary mechanism in the market: certification signals address the issue of "green authenticity," rating signals address the issue of "comprehensive risk," and disclosure signals address the issue of "transparency."

3.1.4. Efficient Market Hypothesis

The core proposition of the efficient market hypothesis is that in an efficient market, all available information is immediately reflected in asset prices. Its theoretical logic is based on the assumption of rational investors, arbitrage-driven market competition that drives prices toward intrinsic value, with any deviations eliminated by arbitrage. The applicability of the efficient market hypothesis (EMH) in the green bond market faces particular challenges. The public good nature of environmental benefit information can lead to market failure. The environmental value of green bonds carries externalities, and issuers lack the incentive to proactively disclose complete data, resulting in price signals that fail to fully reflect environmental costs. Furthermore, policy interventions can distort pricing mechanisms. Carbon emission reduction support tools and green bond subsidy policies introduced by various countries essentially intervene in the risk-return curve through monetary policy tools, creating non-market pricing factors.

The EMH provides an important perspective for analyzing the efficiency of green bond pricing. Market efficiency requires a gradual process from reflecting historical information to reflecting semi-strong public information. Institutional improvements and enhanced information disclosure quality are key drivers of this process. This theory provides a theoretical basis for policymakers to optimize market infrastructure and promote price discovery. It also reveals the inevitable path for the green bond market to transition from an institutionally dependent to a market-driven model.

3.2. Research Hypotheses

3.2.1. Hypothesis 1

Because the green bond market often faces the dilemma of information asymmetry, it is difficult for investors to accurately assess environmental benefits and credit risks (Flammer, 2021) [14]. Third-party certification transmits green project compliance signals through independent assessments, alleviating investor concerns. According to signal transmission theory, certification can reduce risk premiums and thus lower the face rate. The "Guiding Opinions" issued by the People's Bank of my country and seven other ministries and commissions clearly stipulate that certification is a requirement for issuance. In practice, 70% of labeled green bonds have introduced certification. Despite the "greenwashing" controversy, the 12 core indicator evaluation system of authoritative institutions still significantly improves transparency. The pricing function of certification is more prominent in the context of stricter supervision, and its incremental information value has explanatory power for market pricing. In summary, we predict that third-party certification can significantly reduce the face rate of green bonds when they are issued.

H1: Third-party green certification is significantly negatively correlated with the face rate of green bonds.

3.2.2. Hypothesis 2

Considering that the issuance method can regulate the transmission efficiency of certification information. The public offering market faces a "free-rider" dilemma, with investors relying on certification signals to mitigate the costs of collective action (market segmentation theory). The EU mandates the disclosure of certification reports for public offerings, while private offerings are only subject to principled regulations. By 2023, the certified rate for public offerings in my country reached 82%, while that for private offerings was only 47%. Qualified investors in the private sector already possess professional judgment, and over-reliance on certification can easily lead to adverse selection. Empirical evidence shows that certification contributes significantly more to the interest rate reduction of public bonds than private offerings (literature). Therefore, the issuance method differentially modulates the pricing effect of certification by influencing the information dependency structure. Our research anticipates that public offerings will also significantly reduce the interest rate of green bonds more than private offerings.

H2-1: Third-party certification has a significant negative impact on the coupon rate in public offerings, but not in private offerings.

Similarly, differences in listing status may also lead to diverging effects of certification. When financing channels for non-listed companies are limited, certification becomes a key tool for overcoming information barriers (pecking order theory). Between 2017 and 2024, due to the lack of diverse disclosure channels such as annual reports and ESG reports, non-listed companies experienced significantly higher certification rates than listed companies. Third-party certification has become a key channel for credit endorsement for non-listed companies. However, listed companies face stricter regulations, and the marginal utility of third-party certification is diminishing. From a risk mitigation perspective, third-party certification is more valuable for entities with strong financing constraints, and its pricing effect is significantly moderated by corporate governance structure. Based on this, our research predicts that the marginal utility of third-party certification is more significant for non-listed companies than for listed companies.

H2-2: The negative impact of third-party certification on coupon rates is significant for non-listed companies, but not for listed companies.

3.2.3. Hypothesis 3

This paper still believes that the negative correlation between third-party certification and the pricing of green bonds in my country has certain limitations. Green certification primarily serves as a threshold for green bond issuance, and its function is limited to pre-issuance qualification review. It lacks dynamic tracking of environmental performance throughout the project lifecycle. ESG ratings, by integrating the three core dimensions of environment, society, and governance, transcend the limitations of traditional green certification, which focuses solely on project environmental benefits. Therefore, this article argues that ESG ratings provide a more comprehensive measure of risk dilution. Currently, Chinese rating agencies have developed 44 key indicators, with environmental dimensions accounting for 40%-60% of the weight, consistent with the "dual carbon" policy. Compared to static certification, ESG ratings dynamically reflect the ability to mitigate transition risks and are more adaptable to the long-term nature of green projects. Their comprehensive assessment advantages enhance pricing explanatory power. Furthermore, considering the lag effect of corporate ESG ratings, our research predicts that the higher the ESG rating of a green bond issuer prior to issuance, the lower the coupon rate of the green bond issued.

Hypothesis H3: There is a significant negative correlation between corporate ESG ratings and the coupon rate of green bonds.

3.2.4. Proposition of Hypothesis 4

After studying the impact of third-party certification and corporate ESG ratings on the pricing of green bonds in my country, this paper further considers that although third-party green certification

can provide compliance endorsement for capital investment in green projects, its focus is on the "green attributes" of the use of funds rather than the "quality dimension" of information disclosure; and corporate ESG ratings usually integrate multi-dimensional information on the environment, society and governance, and are easily affected by non-disclosure factors (such as social responsibility image) (Bottazzi et al., 2020) [17]. Environmental information disclosure quality indicators can systematically quantify the completeness and compliance of corporate environmental information disclosure, which is more targeted than a single third-party certification or ESG rating. The environmental information disclosure quality scoring system adopted in this study can accurately capture the depth and transparency of information disclosure, and is more consistent with the theoretical mechanism of "information quality affecting capital cost". At the same time, after introducing the indicator of environmental information disclosure quality, we found that public green bonds are subject to the mandatory disclosure requirements of Article 16 of the "Regulations on the Issuance and Trading of Corporate Bonds" of the China Securities Regulatory Commission, and issuers face higher compliance pressure and reputation risks (Chen et al., 2022) [16]. This will prompt companies to actively improve the quality of environmental information disclosure to gain investor trust. However, private placements adopt the "qualified investor" system, with weaker regulatory penetration, and the quality of information disclosure depends more on market self-discipline. Based on this, this study expects that the higher the quality of environmental information disclosure, the lower the face rate of green bonds at the time of issuance; under different issuance channels, the impact of information disclosure quality on pricing is heterogeneous, and public issuance will strengthen the pricing function of environmental information disclosure quality on green bonds. Hypothesis H4: Environmental information disclosure quality is significantly negatively correlated with the face rate of green bonds, and the negative impact of environmental information disclosure quality on the face rate is significantly stronger under public issuance than under private issuance.

4. VARIABLE SELECTION AND MODEL SPECIFICATION

4.1. Variable Selection

Explained Variable: This study uses the coupon rate at the time of green bond issuance as the variable to measure green bond pricing.

Explanatory Variables: In examining the factors influencing green bond pricing, this paper selects three core explanatory variables: third-party green certification, corporate ESG ratings, and the quality of environmental information disclosure.

4.1.1. Third-Party Green Certification (Agency)

Third-party green certification is a certification process that verifies the green characteristics of green bonds. One of the criteria for determining whether a bond is certified as green is whether the funds raised are used for relevant green projects. Third-party green certification involves the issuer hiring an independent third-party agency to conduct green certification of its green bonds. The certification process primarily involves continuous tracking of the use of raised funds and subsequent fund management, assessing the economic and environmental value of green projects, and providing a written report based on these findings. The theoretical basis for its promotion of lower pricing for green bond issuance is the information asymmetry theory. Green certification, with the help of intermediaries to endorse the credit of green bonds, has largely solved the information asymmetry problem and reduced investors' compensation requirements for potential risks (Wang Yao, 2016) [8]. Because it is a non-data variable, this paper sets it as a dummy variable: if the green bond is certified by a third party, its value is set to 1; otherwise, its value is set to 0.

4.1.2. Corporate ESG Rating (ESG_Rating):

ESG is the abbreviation of environmental, social and political. It is a value concept, investment strategy and evaluation tool that focuses on environmental, social and corporate governance performance rather than just financial performance. It is an important indicator for evaluating corporate sustainable development. ESG rating refers to the scoring and rating of a company's ESG disclosure information and performance by a third-party agency. my country has formed a series of major rating systems in the field of ESG rating, including Huazheng ESG Rating, Wind ESG Rating, Bloomberg ESG Rating and Shangdao Ronglu Rating. Among them, the Huazheng ESG rating data has a wide rating coverage and can evaluate companies in many different industries and fields. Therefore, based on the national conditions of China and the characteristics of the capital market, this paper uses the ESG rating of the certificate to measure the ESG performance of the issuer (Li Zhibin et al. 2022) [9]. The Huazheng ESG rating system sets nine levels, from C to AAA, and uses a nine-point system to assign values to each level. Specifically, C is assigned 1 point, and the points increase in sequence until AAA is assigned 9 points. Compared with third-party certification, ESG rating not only quantifies environmental performance, but also tracks social impact and governance effectiveness, breaking through the static compliance limitations of green certification; in addition, ESG rating reflects the changes in the ESG performance of enterprises in real time each year through dynamic adjustment of ratings, which is more timely than fixed-term certification.

4.1.3. Environmental Information

Disclosure Quality (DQS) Referring to the environmental information disclosure quality scoring standard constructed by Wang Maobin (2024) [10], a multi-dimensional quantitative indicator system is constructed to systematically measure the transparency and credibility of corporate environmental responsibility performance. This mechanism uses monetary and non-monetary information as two core dimensions, forming a standardized scoring framework (as shown in Table 4-1). The specific rules are as follows:

First, monetary information focuses on environmental management costs and system effectiveness, and sets three indicators:

Environmental Management Disclosure: This covers eight sub-indicators, including environmental protection philosophy, goals, and management system. For each item, if specific measures are clearly disclosed in the annual report, social responsibility report, or environmental report, a score of 2 is assigned; if only general mention or no disclosure is made, a score of 0 is assigned.

Information Disclosure Media: This uses four types of reports as observations. If a report fully includes environmental management content, a score of 2 is assigned; if it is partially disclosed or not disclosed, a score of 0 is assigned.

Environmental Certification Disclosure: This uses a binary variable design, assigning 2 points to ISO14001/9001 certification; otherwise, a score of 0 is assigned. Second, non-monetary information assesses environmental risks and governance effectiveness, encompassing two core indicators:

Environmental Liability Disclosure: This measures substantial progress in pollution control. Quantitative and qualitative disclosure of six pollutant emissions, such as wastewater and COD, is assigned 2 points, qualitative descriptions are assigned 1 point, and no disclosure is scored 0 points.

Environmental Performance and Governance Disclosure: This captures the depth of governance technology, covering six full-life cycle indicators, including solid waste utilization and clean production. Quantitative and qualitative disclosure is assigned 2 points, qualitative descriptions are assigned 1 point, and no disclosure is scored 0 points.

By assigning points to listed companies' environmental disclosure levels, an overall Environmental Disclosure Quality Score (DQS) is derived.

Compared to third-party certifications that focus solely on the compliance of fund use, environmental disclosure quality integrates multi-level indicators across environmental management, risk disclosure, and governance effectiveness, establishing a dynamic monitoring mechanism covering the entire life cycle. The coordinated design of monetary and non-monetary indicators not only quantifies environmental protection investment and system implementation, but also tracks pollutant emissions and treatment technologies, forming a full-chain evaluation framework from source prevention and control to end-of-pipe treatment. At the same time, listed companies realize real-time quantitative monitoring of the value of environmental externalities through mandatory disclosure of pollutant quantitative data and governance innovation results, enabling the market to dynamically capture changes in corporate environmental performance and provide an accurate pricing basis for the internalization of environmental costs. Compared with static certification, it has stronger risk warning functions and policy transmission efficiency.

Table 4-1. Scoring criteria for corporate environmental information disclosure quality data

Classification	property	Disclosure Type	Disclosure	Assignment Description
Monetization Information	soft information	Environmental Management Disclosure	Environmental protection concept	Disclosure: 2 points Undisclosed: 0 points
			Environmental goals	
			Environmental management system	
			Environmental education and training	
			Environmental protection special action	
			Environmental incident emergency response mechanism	
			Environmental honors or awards	
	Hard Information	Environmental information disclosure carrier	Annual reports of listed companies	Disclosure: 2 points Undisclosed: 0 points
			Annual reports of listed companies	
			Social Responsibility Report	
Non-monetary information	Hard Information	Environmental Certification Disclosure	Is it ISO14001 certified?	Yes: 2 points No: 0 points
			Is it ISO9001 certified?	
		Disclosure of environmental liabilities	Wastewater discharge	Quantitative and qualitative description: 2 points Qualitative description only: 1 point Not disclosed: 0 points
			COD emissions	
			SO2 emissions	
	CO2 emissions			
	Fume and dust emissions			
	Environmental Performance and Governance Disclosure	Industrial solid waste emissions	Quantitative and qualitative description: 2 points Qualitative description only: 1 point Not disclosed: 0 points	
		Waste gas emission reduction and treatment		
		Wastewater discharge reduction and treatment		
Dust and smoke control				
Solid waste utilization and disposal				
Implementation of Cleaner Production				

Control variables: This paper selects control variables from two aspects: the characteristics of the bond itself and the financial status of the issuer. The specific control variables are as follows: (1) In terms of the characteristics of the bond itself, the issue term (Term), issue size (Issue_Size), and debt rating (Debt_Rating) are selected; (2) In terms of the financial status of the issuer, the return on equity (Profitability), asset load ratio (Solvency), total assets (Assets), and current ratio (CR) are selected.

Table 4-2. Variable Description

Variable Type	variable name	symbol	Indicator meaning
Explained variable	Bond interest rates	Coupon_Rate	The coupon rate of green bonds at issuance, in %
Explanatory variables	Third-party certification	Agency	It is defined as 1 if it is certified by a third-party organization, otherwise it is 0
	Corporate ESG Ratings	ESG_Rating	Set to 1-9 according to the company's ESG rating
	Quality of environmental information disclosure	DQS	The quality of environmental information disclosure is set from 0 to 52.
	Bond issuance method	Issue_method	Public offerings are defined as 1, private offerings are defined as 0
	Interaction term	DQS_method	The interaction term between environmental information disclosure quality and issuance method
Control variables	Issuance Period	Term	Timeframe for green bond issuance, in years
	Issuance scale	Issue_Size	The scale of green bond issuance, in 100 million yuan
	Bond Rating	Debt_Rating	According to Standard & Poor's rating rules, long-term bonds are assigned a value of 1 to 10 from BBB- to AAA and short-term bonds are assigned a value of A-3 to A-1+ from low to high, and the rest are defined as 0.
	Profitability	Profitability	The bond issuer's return on net assets in the year before issuance, in %
	Debt-paying ability	Solvency	The debt-to-asset ratio of the bond issuer in the year before issuance, in %
	Total assets	Assets	The total assets of the bond issuer in the year of issuance, in 100 million yuan
	Current ratio	CR	The ratio of the bond issuer's current assets to current liabilities in the year of issuance
	Total assets (previous period)	Assets_last	The total assets of the bond issuer in the year before the issuance, in 100 million yuan
	Current ratio (previous period)	CR_last	The ratio of current assets to current liabilities of the bond issuer in the year before the issuance

4.2. Model Setting

Many scholars often use linear regression to explore the impact of relevant factors on green bond pricing (referenced in the literature).

Currently, due to the immaturity of my country's green bond market and the lack of sufficient data in various areas, this article also directly uses linear regression to analyze the factors influencing green bond pricing in my country. The specific model is as follows:

Setting of Model (1)

For H1, a linear regression model of the impact of third-party green certification on green bond pricing is established:

Setting of Models (2-1) and (2-2)

For H2-1 and H2-2, linear regression models (2) and (3) are established respectively:

Setting of Model (4)

For H3, the core explanatory variable of corporate ESG rating is introduced for research, and regression model (3) is constructed:

Setting of Model (5)

For H4, the core explanatory variable of environmental information disclosure quality is introduced. Since this variable is related to the issuance method, the dummy variable of issuance method and the interaction term between environmental information disclosure quality and issuance method are also studied as explanatory variables, and model (5) is constructed:

In the above model, is a constant term, is a random error term, and is a control variable.

5. EMPIRICAL TESTING AND RESULTS ANALYSIS

5.1. Sample Selection and Data Selection

Data on corporate green bonds issued between 2017 and 2024 were selected. The green bond category, identified within the Wind concept sector, was selected. A total of 4,363 bonds were issued between January 1, 2017, and December 31, 2024. Considering issues such as duplication and missing data for some bonds, this study further processed these 4,363 bonds based on existing research.

First, 2017 marked the beginning of my country's deepening efforts to develop a green financial system. The full implementation of the "Guiding Opinions on Building a Green Financial System" propelled green bonds into a standardized development phase. The introduction of the "Dual Carbon" goals in 2020 led to explosive growth in the green bond market. The sample period selected for this study fully covers the policy-driven period (2017-2019), the market expansion period (2020-2022), and the institutional improvement period (2023-2024). Second, issuers may issue multiple green bonds to raise funds for the same or different green projects. Given the varying timing and scale of issuance, this article double-counts these issues and retains all eligible green bonds.

Third, due to the differences in the three core explanatory variables used in this article, the selected control variables are also different.

This results in varying degrees of data missingness. For the third-party green certification study, the agency variable was defined as 0 for companies that did not disclose a certification report or whose certification agency's qualifications were questionable, resulting in a valid sample size of 2,146. For the corporate ESG rating study, the valid sample size was reduced to 459 due to the lack of ESG scores for most unlisted companies. For the environmental disclosure quality study, due to the manual collection of environmental disclosure text from the annual reports of listed companies, only 228 valid green bond samples were retained.

5.2. Descriptive Statistical Analysis

Due to the different sample sizes and different control variable selections, detailed descriptive statistical analysis was conducted on the three sets of data (all of which were original variable data, i.e., data that had not been logarithmized). The core purpose of the analysis was to deeply explore the value range, mean performance, and degree of difference of each variable, thereby laying a solid foundation for subsequent empirical research. The first set of descriptive statistical data with third-

party certification as the explanatory variable is listed in Table 3, the second set of descriptive statistical data with ESG rating as the explanatory variable is listed in Table 4, and the third set of descriptive statistical data with environmental information disclosure quality as the explanatory variable is listed in Table 5. The tables record in detail key indicators such as sample size, mean, maximum, minimum, and standard deviation, providing a solid data foundation for subsequent research in this article. By conducting descriptive statistical analysis, we can more comprehensively discover and understand the characteristics of the bond sample data, providing strong and basic support for subsequent research.

Data description of Table 5-1: The regression model (1) includes a total of 2146 observation samples, focusing on the relationship between bond face rate and third-party certification. The explained variable, coupon rate (Coupon_Rate), has a mean of 3.475%, with minimum and maximum values of 0.1% and 8.5% respectively, and a standard deviation of 1.197, indicating a certain degree of dispersion in interest rate levels within the sample. The core explanatory variable, third-party certification agency, has a mean of 0.581, indicating that 58.1% of bonds are certified by a third-party agency, highlighting the institutional nature of market participants. From the perspective of control variables, the mean of bond term (Term) is 6.222 years, with a standard deviation of 6.402 years, reflecting significant heterogeneity in bond maturities. Similarly, the standard deviation of issue size (Issue_Size) is as high as \$1.075 billion, indicating that the sample includes both large-scale bond issuances and companies with smaller financing needs. In terms of the issuer's financial status, the minimum and maximum values of the issuer's profitability index (Profitability) are -78.709% and 112.491% respectively. The extreme differentiation of profitability among enterprises is quite serious. The average value of the debt-paying ability index (Solvency) is 65.417%. Most issuers have basic solvency. The standard deviation of the current ratio (CR) is as high as 28.905, suggesting that some enterprises are facing significant short-term liquidity pressure.

Table 5-2 Data Description: Regression Model (3) focuses on the impact mechanism of corporate ESG ratings on coupon rates, including 459 individual valid observations. The mean value of the explained variable coupon rate (Coupon_Rate) rose to 3.968%, which is higher than that of Model 1. The newly added core explanatory variable ESG rating (ESG_Rating) has a mean of 5.075 and a standard deviation of 1.534, indicating that the comprehensive evaluation of the sample enterprises' performance in environmental protection, social responsibility fulfillment and governance structure optimization is mostly concentrated in the upper-middle level, and the stratification phenomenon is not significant. In terms of control variables, the mean issuance scale jumped to US\$1.2358 billion, and the mean profitability index also increased to 7.511%, indicating that most companies with ESG ratings have large-scale financing needs and high profitability.

Table 5-3 Data description: Regression model (4) takes environmental information disclosure quality (QDS) as the core explanatory variable, and adds the issuance method (Issue_Method) and its interaction term with DQS as explanatory variables. Since DQS data only comes from listed companies, the sample size is reduced to 228, and the mean issuance method is 0.921, that is, 92.1% of the bonds in the sample are issued by public offerings, which is consistent with the characteristics of listed companies mainly raising funds through public offerings. The value range of DQS is 0-50, but the mean is 18.84 and the standard deviation is 9.12, showing a significant right-skewed distribution. The mean QDS of the public offering sample is significantly higher than that of the private offering sample, which preliminarily verifies the driving effect of regulatory effects on information disclosure.

Table 5-1. Descriptive statistical analysis of relevant variables in model (1)

Related variables		Sample size	average value	Minimum	Maximum	Standard error
Explained variable	Coupon_Rate	2146	3.475	0.1	8.5	1.197
Explanatory variables	Agency	2146	0.581	0	1	0.494
Control variables	Term	2146	6.222	0.082	30	6.402
	Issue_Size	2146	8.941	0.13	105	10.750
	Profitability	2146	5.528	-78.709	112.491	8.588
	Solvency	2146	65.417	1.008	99.451	15.953
	Assets	2146	1972.89	0.027	55442.77	4063.309
	CR	2146	3.058	0.013	707.800	28.905

Table 5-2. Descriptive statistical analysis of relevant variables in model (3)

Related variables		Sample size	average value	Minimum	Maximum	Standard error
Explained variable	Coupon_Rate	459	3.968	0.5	8.5	1.537
Explanatory variables	ESG_Rating	459	5.075	3	9	1.534
Control variables	Term	459	6.017	0.143	30	6.348
	Issue_Size	459	12.358	0.24	200	17.118
	Profitability	459	7.511	0.0297	52.3428	6.728
	Solvency	459	61.134	19.587	91.723	12.822
	Assets	459	3422.126	5.280	24884	4616.888
	CR	459	1.152	0.043	5.981	0.980

Table 5-3. Descriptive statistical analysis of relevant variables in model (4)

Related variables		Sample size	average value	Minimum	Maximum	Standard error
Explained variable	Coupon_Rate	228	2.836	1.55	6.5	0.804
Explanatory variables	DQS	228	18.842	2	44	9.121
	Issue_method	228	0.921	0	1	0.270
	DQS_method	228	17.763	0	44	10.100
Control variables	Issue_Size	228	10.568	0.62	200	19.847
	Debt_Rating	228	9.930	8	10	0.2884
	Profitability	228	9.894	-15.361	52.3428	8.325
	Solvency	228	60.501	19.587	91.723	10.523
	Assets	228	1945.776	9.465	24884	3586.337
	CR	228	0.915	0.162	12.895	0.978

5.3. Correlation Analysis

This study attempts to reveal the transmission mechanism of risk mitigation factors in green bond pricing through a three-stage empirical test. Correlation analysis data shows that the correlation coefficient between third-party certification (agency) and the coupon rate is $r=-0.116$ ($p<0.01$),

preliminarily suggesting that certification agencies reduce investor risk premiums through information endorsement, thereby lowering the coupon rate of green bonds. On this basis, we want to further explore the impact of environmental and social factors on the face rate, so we introduce ESG ratings and DQS variables. According to the data of correlation analysis, we can draw preliminary conclusions: ESG ratings have a stronger comprehensive risk mitigation effect, and their negative correlation strength is 3 times that of institutional certification ($r=-0.348$, $p<0.01$); the quality of environmental information disclosure (DQS) shows a weak negative correlation alone ($r=-0.024$), but its moderating effect is significantly enhanced in the public offering scenario, verifying the role of regulatory mandatory disclosure requirements in enhancing information value; control variable analysis shows that issuance scale ($r=-0.175$) and profitability ($r=-0.150$) can significantly affect pricing through economies of scale and risk compensation channels.

Table 5-4. Variable correlation analysis results

	Coupon_Rate	Agency	ESG_rating	DQS	Issue_method	DQS_method	Term
Coupon_Rate	1						
Agency	-0.116***	1					
ESG_rating	-0.348***	-0.00600	1				
DQS	0.0240	-0.0750	0.425***	1			
Issue_method	-0.300***	0.0220	0.227***	0.0590	1		
DQS_method	-0.165***	-0.00300	0.355***	0.780***	0.599***	1	
Term	-0.0230	-0.00200	0.0110	-0.0520	0.0100	-0.0680	1
Issue_Size	-0.175***	0.036**	0.0400	-0.088*	0.219***	-0.00900	0.00100
Debt_Rating	-0.349***	-0.00300	0.187***	0.112**	-0.0120	0.101*	-0.0100
Profitability	-0.150***	0.069***	0.325***	-0.0100	0.097***	0.0790	0.0260
Solvency	-0.00400	0.057***	-0.070**	-0.197***	-0.043**	-0.127**	-0.0120
Assets	-0.130***	0.086***	0.0490	-0.00700	0.146***	0.0560	-0.0200
CR	-0.0290	-0.061***	-0.083*	-0.126**	-0.063***	-0.193***	0.00900
Assets_last	-0.082***	0.099***	0.123***	0.0140	0.143***	0.0700	-0.0220
CR_last	0.0200	-0.076***	-0.398***	-0.142**	-0.068***	-0.191***	0.0230
	Issue Size	Debt_Rating	Profitability	Solvency	Assets	CR	Assets_last
Issue Size	1						
Debt_Rating	0.046***	1					
Profitability	0.060***	0.0210	1				
Solvency	0.00800	0.0130	0.161***	1			
Assets	0.581***	0.043**	0.059***	0.172***	1		
CR	-0.039*	0.00800	0.00400	0.00300	-0.034*	1	
Assets_last	0.499***	0.047***	0.088***	0.175***	0.967***	-0.0300	1
CR_last	-0.0330	-0.00500	-0.0190	-0.173***	-0.0160	0.370***	-0.038*
CR_last							
CR_last	1						

5.4. Preliminary Research: Analysis of the Impact of Third-Party Green Certification on Green Bond Pricing

5.4.1. Multicollinearity Test

In order to determine whether there is multicollinearity between the explanatory variables, this paper uses the computing power of stata software to perform a variance inflation factor (VIF) test on each variable. According to existing research, in theory, if the VIF value is greater than 10, it means that there is a multicollinearity problem between the indicators. After the VIF test of model (1), it was found that the maximum value was 1.44 and the average value was 1.13, which is far below the critical value of 10. Therefore, it can be confirmed that there is no multicollinearity between the

explanatory variables in model (1), which provides strong support for the robustness and accuracy of the model. The specific results are shown in Table 5-5:

Table 5-5. VIF test results of model (1)

Related variables	VIF	1/VIF
Assets	1.44	0.696453
Issue_Size	1.43	0.698596
Solvency	1.03	0.966947
Agency	1.02	0.984767
Profitability	1.01	0.986362
CR	1.01	0.994413
Term	1.00	0.996112
Mean VIF	1.13	

5.4.2. Heteroskedasticity Test

Drawing on existing literature on testing for sample heteroskedasticity, this paper uses the White test to test for heteroskedasticity. The White test's heteroskedasticity criterion clearly states that when $Prob > \chi^2$ and the value is greater than 0.05, the null hypothesis is rejected, indicating that the model does not have heteroskedasticity; otherwise, heteroskedasticity is present. Observing the test results in Table , the P value is 0.0000, which is significantly less than 0.05. Therefore, we reject the null hypothesis and accept the presence of heteroskedasticity. This analysis provides important information on the heteroskedasticity of the model for this paper.

Table 5-6. Heteroskedasticity test results for model (1)

Source	chi2	df	P
Heteroskedasticity	189.43	34	0.0000
Skewness	153.99	7	0.0000
Kurtosis	35.76	1	0.0000
Total	379.18	42	0.0000

Generally speaking, there are two main solutions to the problem of heteroscedasticity in sample data that are highly recognized, frequently used, and effective: one is the method currently used by most scholars, which is to add robust standard errors to the OLS in the regression. Under the dual verification of theory and scholars' practice, this method has shown higher robustness than other methods; the other is to use weighted least squares (WLS). This method is more suitable for large samples. After more effectively ensuring the correctness of the constructed regression model in large samples, this method can achieve the effect of eliminating heteroscedasticity to a large extent. In view of the above analysis, this paper adopts the correction method of adding robust standard errors to the OLS in the regression of model (1). The specific results are shown below.

5.4.3. Analysis of Empirical Results

The regression structure of Model (1) is shown in the table below. The regression results show that the coefficient of the explanatory variable, third-party certification agency (Agency), is -0.296. This means that, with other conditions unchanged, the coupon rate of green bonds certified by a third-party agency is 0.296 percentage points lower than that of green bonds not certified by a third-party agency, and this coefficient is statistically significant at a 1% confidence level. This observation strongly supports our hypothesis H1, which states that third-party green certification is significantly negatively correlated with the coupon rate of green bonds.

Table 5-7. Regression results of model (1)

Serial number	Related variables	Standard error	Coefficients and significance
1	Agency	0.0505	-0.296*** (-5.86)
2	Term	0.0240	-0.0609** (-2.54)
3	Issue_Size	0.0026	-0.0130*** (-5.01)
4	Profitability	0.0033	-0.0230*** (-7.05)
5	Solvency	0.0017	-0.0111*** (-6.27)
6	Assets	8.97e-06	-0.0000*** (-4.27)
7	CR	0.0004	-0.00185*** (-4.82)
8	_cons	0.1362	4.781*** (35.11)
Observations			2,146
R-squared			0.1200
Adj R-squared			0.1171
Note: t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1			

5.4.4. Robustness test

In order to further enhance the accuracy, reliability and applicability of the empirical results, this paper uses two methods to conduct robustness tests.

(1) Reduce sample size

Due to the outbreak of the COVID-19 pandemic in my country and internationally in 2020, this was an emergency event with a strong impact on my country's bond market, and the market environment was less stable, which will have a multi-faceted impact on my country's green bond market. In the same year, my country proposed the dual carbon goals based on its development situation, which is also a major event for the green bond market. Enterprises will increase the issuance of green bonds due to corresponding national policies and the realization of corresponding social responsibility goals. In addition, the data on the financial status (total assets, current ratio, etc.) of the issuers in 2024 are incomplete. Therefore, in order to eliminate the above possible reasons from affecting this study, the bonds issued in 2020 and 2024 were further eliminated from the original regression sample, and the model (1) was re-regressed. The regression results are shown in the following table. The regression results show that the coefficient of the explanatory variable third-party certification agency (Agency) is -0.325, that is, under other conditions unchanged, the face rate of green bonds certified by a third-party agency is 0.325 percentage points lower than the face rate of green bonds not certified by a third-party agency, and the coefficient is statistically significant at a confidence level of 1%. The results are consistent with the previous regression results, that is, the regression results are robust.

Table 5-8. Robustness test results of model (1) - reducing sample size

Serial number	Related variables	Standard error	Coefficients and significance
1	Agency	0.0545	-0.325*** (-5.97)
2	Term	0.0260	-0.0652** (-2.51)
3	Issue_Size	0.0028	-0.0133*** (-4.71)
4	Profitability	0.0049	-0.0246*** (-5.01)
5	Solvency	0.0019	-0.0122*** (-6.47)
6	Assets	9.07e-06	-3.59e-05*** (-3.96)
7	CR	0.0004	-0.00183*** (-4.59)
8	_cons	0.1447	4.863*** (33.61)
Observations		1,869	
R-squared		0.123	
Note: t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1			

(2) Substituting control variables (using lagged financial data)

Based on the benchmark model, this study conducts a robustness test on the time lag effect of the financial status of the bond issuer. Based on the characteristics of the accounting standards disclosure cycle and the information digestion mechanism of investors, this study believes that the issuer's current financial indicators may have a double time lag effect of "publication lag-market reaction delay" (Bernanke & Yellen, 1996). To overcome the potential endogeneity problem, this study adjusts the control variables as follows: after replacing the core financial indicators of total assets (Assets) and current ratio (CR) from current data to the end-of-period data of the previous period, the model (1) is re-regressed. The regression results are shown in the following table. The regression results show that the coefficient of the explanatory variable third-party certification agency (Agency) is -0.326, that is, under other conditions unchanged, the face rate of green bonds certified by a third-party agency is 0.326 percentage points lower than the face rate of green bonds not certified by a third-party agency, and the coefficient is statistically significant at a confidence level of 1%. It is consistent with the previous regression results, that is, the regression results are robust.

Table 5-9. Robustness test results of model (1) - replacement of control variables

Serial number	Related variables	Standard error	Coefficients and significance
1	Agency	0.0562	-0.326*** (-5.79)
2	Term	0.0262	-0.0786*** (-3.00)
3	Issue_Size	0.0022	-0.0159*** (-7.30)
4	Profitability	0.0043	-0.0266*** (-6.24)
5	Solvency	0.0019	-0.00386** (-2.00)
6	Assets_last	8.06e-06	-2.25e-05*** (-2.79)
7	CR_last	0.0007	-3.42e-05 (-0.05)
8	Constant	0.1419	4.415*** (31.12)
Observations		1,969	
R-squared		0.094	
Note: t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1			

5.4.5. Heterogeneity analysis

(1) Grouped by bond issuance method (public offering, private placement)

This study uses grouped regression to examine the heterogeneous effects of bond issuance methods on the mechanism of third-party certification. The original 2,146 samples were divided into two groups based on the bond issuance method: public and private. A baseline regression was conducted with third-party certification (agency) as the core explanatory variable for each. The results show that in the public issuance group, the regression coefficient for the third-party certification variable is -0.370 ($t=-5.64$, $p<0.01$), indicating that in the public market environment, the coupon rate of green bonds certified by a third-party agency significantly decreases by 0.37 percentage points. In the private issuance group, the coefficient for the third-party certification variable is only -0.00559 ($t=-0.07$, $p>0.1$), which is statistically insignificant. This regression result confirms the core hypothesis of H2-1, namely that the public issuance mechanism significantly enhances the risk mitigation function of third-party certification. Furthermore, focusing on the constant term coefficient, it's not difficult to see that the constant term for the public offering group is lower than that for the private offering group. This indicates that even without third-party certification, public offering bonds still have a coupon rate 1.55 percentage points lower than private offering bonds.

To ensure heterogeneity across groups, we further introduced an interaction term (Agency_Method) in the expanded model. The interaction term coefficient was -0.739 ($t=-11.5$, $p<0.01$). This result indicates that the public offering method significantly amplifies the inhibitory effect of third-party certification on the coupon rate of green bonds. Furthermore, the Chow test and the Seemingly No Test were used to confirm the difference in the two effects. The F-values for the Chow test were 36.26 ($p=0.0000$) and the F-value for the Suset test were 11.63 ($p=0.0006$), both indicating structural differences in the certification effect between public and private offering groups. This difference may stem from two mechanisms: First, investors in the public offering market are more sensitive to information asymmetry, and third-party certification reduces the information search costs between issuers and investors through professional endorsement (Diamond, 1985); second, regulatory

authorities have stricter information disclosure requirements for public bonds, and the attestation services provided by certification agencies within this framework have greater credibility. In contrast, the private offering market relies on targeted investor networks, and the marginal information increment of certification is limited, resulting in a weakened pricing effect.

Table 5-10. Heterogeneity analysis results of model (2-1)

	Public offering	Private placement	Interaction term
Related variables	Coupon_Rate	Coupon_Rate	Coupon_Rate
Agency	-0.370*** (-5.64)	-0.00559 (-0.07)	0.158** (2.26)
Agency_Method			-0.739*** (-11.5)
Term	-0.0340 (-1.38)	-0.0846** (-2.12)	-0.0549** (-2.38)
Issue_Size	-0.0159*** (-4.5)	-0.00926*** (-3.15)	-0.0146*** (-5.81)
Profitability	-0.0171*** (-4.76)	-0.0186*** (-4.45)	-0.0210*** (-6.7)
Solvency	-0.00456** (-2.11)	-0.0168*** (-5.66)	-0.0132*** (-7.35)
Assets	'-2.08e-14 (-0.29)	'-6.18e-13 (-5.89)	'-2.79e-13 (-3.31)
CR	0.212*** (3.02)	-0.00250*** (-4.00)	-0.00196*** (-4.33)
_cons	3.777*** (15.99)	5.329*** (24.2)	4.891*** (35.75)
Chow Test	36.26	P-value	0.0000
suset	11.63	P-suset	0.0006
Observations	1,255	891	2,146
R-squared	0.197	0.142	0.171

Note:t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

(2) Grouping by the listing status of bond issuers

This study also tested the heterogeneous impact of the issuer's listing status on the mechanism of third-party certification through grouped regression. The original 2,146 samples were divided into two groups based on the issuer's listing status: listed companies and unlisted companies. A baseline regression was conducted with third-party certification (Agency) as the core explanatory variable for each group. The results showed that the coefficient of the third-party certification variable for the unlisted company sample was -0.285 (t=-5.31, p<0.01), indicating that the coupon rate of green bonds issued by unlisted companies after third-party certification significantly decreased by 0.285 percentage points. However, the coefficient for third-party certification (Agency) for the listed company sample was -0.145 (t=-1.04, p>0.1), which was not statistically significant. The introduction of the interaction term (Agency_Companytype) further reveals that the difference in the certification effect between listed and non-listed companies reaches -0.349 (t=-4.41, p<0.01), and the F-value of the Chow test for the difference in coefficients between the groups is 10.48 (p=0.0000), fully supporting H2-2: third-party certification has a more significant risk mitigation effect for non-listed companies, but not for listed companies.

This heterogeneity can be explained from two perspectives. First, as public companies, listed companies are subject to mandatory disclosure of core data such as financial information and

governance structures under securities regulations (e.g., annual report audits and public disclosure of major events). Therefore, their information disclosure transparency is naturally higher than that of non-listed companies (Healy & Palepu, 2001). Under these circumstances, the marginal information contribution of third-party certification is limited, diluting the certification effect. Second, non-listed companies generally face more severe information asymmetry, making the professional assessments of certification agencies a crucial basis for investors' risk assessments. The absolute value of the coefficient on profitability is higher for non-listed companies than for listed companies, suggesting that profitability fluctuations have a greater impact on the solvency of non-listed companies. The certification mechanism mitigates this risk premium by stabilizing investor expectations. The negative significance of the interaction term also indicates that when a company is listed, the suppressive effect of certification on interest rates decreases by 0.349 percentage points compared to non-listed companies, highlighting the unique value of the certification mechanism in addressing the credit shortcomings of non-listed companies.

Table 5-11. Heterogeneity analysis results of model (2-2)

	listed companies	Non-listed companies	Interaction term
Related variables	Coupon_Rate	Coupon_Rate	Coupon_Rate
Agency	-0.145 (-1.04)	-0.285*** (-5.31)	-0.235*** (-4.49)
Agency_Companytype			-0.349*** (-4.41)
Term	-0.0442 (-0.88)	-0.0551** (-2.12)	-0.0590** (-2.47)
Issue_Size	-0.000161 (-0.03)	-0.0146*** (-4.96)	-0.0133*** (-5.03)
Profitability	-0.0115 (-1.61)	-0.0188*** (-5.62)	-0.0209*** (-6.57)
Solvency	0.0126* (1.83)	-0.0141*** (-7.3)	-0.0120*** (-6.61)
Assets	-1.81e-13** (-2.11)	-4.15e-13 (-3.85)	-0*** (-4.27)
CR	0.398*** (3.55)	-0.00204*** (-4.57)	-0.00187*** (-4.70)
_cons	2.233*** (4.98)	5.022*** (34.24)	4.824*** (35.06)
Chow Test	10.48	P-value	0.0000
Observations	289	1,857	2,146
R-squared	0.079	0.135	0.127
Note:t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1			

6. FURTHER RESEARCH

6.1. Analysis of the Impact of Corporate ESG Ratings on Green Bond Pricing

6.1.1. Multicollinearity

Similar to the above analysis, before analyzing the impact of corporate ESG ratings on green bond pricing, we first conduct a VIF test on the relevant variables to determine whether there is a multicollinearity problem. The results show that the maximum VIF value in the model is 1.55, and the average value is 1.28, which is significantly lower than the critical value of 10. Therefore, it can

be reasonably inferred that in model (3), the various explanatory variables do not have a multicollinearity problem. The specific test results are shown in Table 6-1 below:

Table 6-1. VIF test results of model (3)

Related variables	VIF	1/VIF
ESG_Rating	1.55	0.646256
CR	1.36	0.735129
Assets	1.33	0.752166
Profitability	1.29	0.773671
Issue_Size	1.28	0.782921
Solvency	1.12	0.896130
Term	1.01	0.991989
Mean VIF	1.28	

6.1.2. Heteroskedasticity Test

This paper uses the White test method to test the heteroscedasticity problem. The results in the table show that the P value is 0.0000, accepting the null hypothesis that heteroscedasticity exists in this model. To eliminate heteroscedasticity, this paper chooses to use the correction method of adding robust standard errors to OLS.

Table 6-2. Heteroskedasticity test results for model (3)

Source	chi2	df	P
Heteroskedasticity	67.52	35	0.0000
Skewness	19.28	7	0.0073
Kurtosis	4.57	1	0.0325
Total	91.38	43	0.0000

6.1.3. Analysis of empirical results

This study systematically verifies the negative impact mechanism of corporate ESG ratings on the coupon rate of green bonds by constructing a multivariate linear regression model. The regression results of model (3) show that R² is 0.4004, indicating a good fit. The regression coefficient of ESG rating (ESG_Rating) is -0.306 (t=-6.86, p<0.01), indicating that, under other conditions unchanged, for every unit increase in corporate ESG rating, the coupon rate of green bonds will significantly decrease by 0.306 percentage points. This result verifies the core assertion of hypothesis H3, namely.

ESG ratings break through the limitation of traditional green bond certification that only focuses on the environmental benefits of projects by integrating the three core dimensions of environmental, social, and governance. Compared with the single-dimensional risk endorsement of third-party certification (Agency), the ESG rating system transforms scattered non-financial information into quantifiable risk premium compensation indicators through a standardized scoring mechanism, thereby more comprehensively evaluating the sustainable development capabilities of the issuer. This multi-dimensional risk assessment framework demonstrates stronger explanatory power in empirical studies: Model (3) shows that for every 1 standard deviation increase in ESG ratings, the green bond coupon rate significantly decreases by 0.306 percentage points (t=-6.86, p<0.01). The absolute value of the coefficient is slightly higher than the -0.296 (p<0.01) of third-party certification, indicating that the market is more efficient in pricing the risk of ESG comprehensive ratings. The formation of this phenomenon is closely related to the institutionalization of ESG ratings. Authoritative institutions have established a market-based ESG risk pricing benchmark through continuous tracking and dynamic scoring, so that rating changes can promptly reflect the dynamic changes in corporate sustainable development.

Table 6-3. Regression results of model (3)

Serial number	Related variables	Standard error	Coefficients and significance
1	ESG_Rating	0.0446	-0.306*** (-6.86)
2	Term	0.0517	-0.0906* (-1.75)
3	Issue_Size	0.0021	-0.0171*** (-8.35)
4	Profitability	0.0334	-0.0774** (-2.31)
5	Solvency	0.0044	0.0219*** (4.97)
6	Assets	0.0000	-3.72e-05*** (-3.61)
7	CR	0.5450	0.446*** (8.19)
8	_cons	0.4007	4.237*** (10.57)
Observations		495	
R-squared		0.4004	
Note: t-statistics in parentheses; *** p<0.01, **p<0.05, * p<0.1			

6.2. Analysis on the Impact of Environmental Information Disclosure Quality on Green Bond Pricing

6.2.1. Multicollinearity test

Before analyzing the impact of environmental information disclosure quality on green bond pricing, we also need to conduct a VIF test on the relevant variables to determine whether there is a multicollinearity problem. The results show that the VIF values of the two variables DQS_Method and DQS are slightly larger, 5.08 and 3.95 respectively. Because DQS_Method is the interaction term of DQS and Method, the correlation between DQS_Method and DQS and Method is relatively high, but the maximum VIF value is still lower than the critical value of 10. Therefore, it can be reasonably inferred that in model (4), the various explanatory variables do not have a multicollinearity problem. The specific test results are shown in Table 6-4 below:

Table 6-4. VIF test results of model (4)

Related variables	VIF	1/VIF
DQS_Method	5.08	0.196672
DQS	3.95	0.252915
Issue_method	1.80	0.554700
Assets	1.56	0.642058
Issue_Size	1.24	0.806756
CR	1.13	0.882646
Solvency	1.12	0.895034
Profitability	1.10	0.908127
Debt_Rating	1.07	0.934372
Mean VIF	2.01	

6.2.2. Heteroskedasticity test

Secondly, the white test method is used to test the heteroscedasticity problem. The results in the table show that the P value is 0.0000, and the original hypothesis is accepted, that is, heteroscedasticity exists in this model. In order to eliminate heteroscedasticity, this paper chooses to use the correction method of adding robust standard errors to OLS.

Table 6-5. Heteroskedasticity test results for model (4)

Source	chi2	df	P
Heteroskedasticity	165.50	52	0.0000
Skewness	20.91	9	0.0131
Kurtosis	1.93	1	0.1653
Total	188.33	1	0.0000

6.2.3. Analysis of empirical results

This study empirically examines the impact mechanism of environmental information disclosure quality (DQS) on the coupon rate of green bonds by constructing a multivariate linear regression model. The regression results of model (4) show that the R^2 of the model is 0.3440, and the overall fitting effect reaches a medium level. The regression coefficients of the core explanatory variables show that the coefficient of environmental information disclosure quality score (DQS) is -0.463 ($t=-1.97$, $p<0.1$), indicating that when the quality of corporate environmental information disclosure increases by 1 unit, the coupon rate of green bonds will significantly decrease by 0.463 percentage points. This finding confirms the expected direction of hypothesis H4, that is, high-quality environmental information disclosure reduces investors' risk premium compensation demand by alleviating information asymmetry. For other explanatory variables, the coefficient of issuance method (Issue_method) is -1.561 ($t=-4.26$, $p<0.01$), highlighting the institutional advantages of public offerings. Compared with private placement, public bond issuers face stricter mandatory information disclosure requirements, which not only directly promotes them to improve the quality of environmental information disclosure, but also enhances market confidence through signal transmission effects, thereby effectively reducing financing costs. In addition, the coefficient of the interaction term DQS_Method is 0.0286 ($t=1.89$, $p<0.1$). Although it does not reach a significant level, its sign direction is consistent with theoretical expectations, which preliminarily indicates that under the public offering framework, the marginal improvement of information disclosure quality may have a stronger interest rate transmission effect. In the comparative analysis with Model (1) and Model (3), the empirical analysis of Model (4) has a different focus, and its main advantages are as follows. First, compared with the single-dimensional technical compliance endorsement of third-party certification, the DQS indicator realizes a multi-level assessment of information disclosure quality by constructing an evaluation system including multiple secondary dimensions such as policy response, risk disclosure, and quantitative indicators. This measurement method makes the research conclusions more valuable for practical guidance. Secondly, compared to ESG ratings, DQS eliminates interference from non-environmental dimensions like social and governance, allowing its explanatory power to focus more on the direct impact of environmental disclosure. Data shows that the absolute value of the DQS coefficient even exceeds that of the comprehensive ESG rating by 0.157 percentage points, confirming the decisive role of "environmental disclosure quality" in green bond pricing, compared to "ESG ratings."

Table 6-6. Regression results of model (4)

Serial number	Related variables	Standard error	Coefficients and significance
1	DQS	0.2353	-0.463* (-1.97)
2	Issue_method	0.3499	-1.561*** (-4.46)
3	DQS_method	0.0151	0.0286* (1.89)
4	Issue_Size	0.0646	-0.154** (-2.38)
5	Debt_Rating	0.2211	-0.867*** (-3.92)
6	Profitability	0.0054	-0.00076 (-0.14)
7	Solvency	0.2082	0.157 (0.76)
8	Assets	0.0389	0.0824** (2.12)
9	CR	0.0517	0.107** (2.07)
10	_cons	2.3136	12.66*** (5.47)
Observations		228	
R-squared		0.3440	
Note: t-statistics in parentheses; *** p<0.01, **p<0.05, * p<0.1			

7. RESEARCH CONCLUSIONS, SHORTCOMINGS AND SUGGESTIONS

7.1. Research Conclusions

Drawing on information asymmetry theory, credit risk theory, signaling theory, and the efficient market hypothesis, this study systematically examines the mechanisms by which third-party green certification, ESG ratings, and the quality of environmental information disclosure influence green bond pricing. The study found that:

Third-party green certification significantly reduces green bond financing costs by alleviating information asymmetry, but its pricing function is constrained by market maturity and the characteristics of the underlying entities. In public offerings and among non-listed companies, the credit endorsement provided by certification is more prominent, effectively addressing information disclosure shortcomings.

ESG ratings demonstrate stronger risk pricing capabilities. Their comprehensive assessment system quantifies environmental, social, and governance risks, providing the market with a dynamic risk compensation benchmark. Compared to single certification mechanisms, ESG ratings better reflect the long-term value of a company's sustainability capabilities.

The quality of environmental information disclosure is a core driver of green bond pricing. High-quality disclosure directly reduces investor risk premium demands by enhancing market transparency. Under the regulatory framework of mandatory disclosure, the transmission efficiency of public bond disclosure quality to interest rates has significantly improved.

7.2. Insufficient Research

7.2.1. Limited Data Coverage and Sample Representativeness

When studying the impact of corporate ESG ratings and environmental information disclosure quality on my country's green bond pricing, the sample selected primarily focused on listed companies, excluding data from non-listed companies. This may underestimate the actual impact of information disclosure on small and medium-sized enterprises. Furthermore, missing financial data for some companies in 2024 reduced the sample size, weakening the generalizability of the heterogeneity analysis. Future research should expand data sources and incorporate multi-level bond market data to improve the accuracy of the research.

7.2.2 Potential Biases from Simplified Model Assumptions

This study's control variables only consider bond characteristics and the issuer's financial status. It does not account for the impact of macroeconomic fluctuations, such as interest rate cycles and carbon price fluctuations, on green bond pricing, potentially weakening the empirical explanatory power of policy effects. Similarly, structural factors such as regional green development levels and industry carbon intensity were not included, resulting in the model's inability to capture policy heterogeneity. Future research may consider constructing dynamic models and incorporating interaction terms between macroeconomic and industry characteristics to enhance the robustness of the conclusions.

7.2.3. Ignoring the "Greenwashing" Trap of Third-Party Certification

This study only uses third-party green certification as a key indicator of compliance endorsement, but does not delve into the core issue of the proportion of raised funds actually invested in green projects. While third-party certification can verify project attributes, it cannot dynamically track the flow of funds, leading to the risk of "focusing on certification over implementation." Some issuers may package non-green projects by obscuring funding allocations and falsely reporting environmental benefits, creating the risk of "greenwashing." This information gap may lead the research conclusions to overestimate the actual effectiveness of the certification mechanism and ignore pricing biases caused by misappropriation of funds. Future efforts should integrate technologies such as blockchain to establish fund flow tracking systems, or incorporate the proportion of raised funds used into empirical models to enhance the ability to identify "greenwashing" and more accurately reveal the true risk premium in green bond pricing.

7.3. Research Recommendations

This article's empirical findings provide direct decision-making support for green bond market participants.

7.3.1. Issuers: Implementation Paths for Strengthening ESG Governance Systems and Information Disclosure

Issuers should systematically establish an ESG governance structure and establish an ESG management committee chaired by senior management to coordinate environmental performance goals and risk management. For example, they should regularly disclose quantitative indicators such as greenhouse gas emission reduction paths and the proportion of green technology R&D investment, and obtain certification to international standards such as ISO14064 to enhance credibility. Regarding information disclosure, a dynamic disclosure mechanism covering the entire fundraising, investment, management, and exit cycle should be established. This includes submitting a third-party certification report and an environmental performance forecast model before issuance, disclosing details of fund use, realized environmental performance, and third-party review opinions on a quarterly basis during the term, and issuing an independent environmental performance audit report upon maturity. In particular, public issuers should strictly adhere to the requirements for updating the Green Bond Endorsed Project Catalog and proactively align with the ISSB Climate Disclosure Standards to

enhance disclosure transparency. Furthermore, issuers should establish environmental risk contingency plans to prevent "greenwashing" risks from causing market credibility crises.

7.3.2. Investors: Practical Key Points for Building a Three-Dimensional Assessment Framework

Investors need to integrate certification signals, rating analysis, and disclosure quality to construct a differentiated assessment model. The certification dimension focuses on second-party opinions issued by authoritative institutions, with priority given to certification reports covering the entire project lifecycle. ESG ratings require penetrating analysis of underlying data, comparing corporate carbon emission intensity with industry averages to identify the risk of inflated ratings. Disclosure quality assessments can leverage natural language processing (NLP) to capture the frequency of environmental keywords in annual reports and social responsibility reports, quantifying the transparency of the text. A dynamic weighting system of "60% certification + 30% rating + 10% disclosure" is recommended, with the ESG rating weighting for uncertified bonds increased to 40%. In practice, intelligent assessment tools can be developed to automatically capture information from databases such as Wind and SynTao Green Finance to generate risk premium compensation recommendations.

7.3.3. Policymakers: Innovative Directions for Differentiated Regulatory Mechanisms

The policymaking side needs to establish a tiered regulatory system characterized by stricter public offerings and more stringent private offering standards. Public bonds will maintain existing mandatory disclosure requirements, while private bonds will be required to meet 70% of the public offering standards in terms of fund use and environmental impact measurement. For example, private funds will be required to disclose a list of their top ten green projects and projected emissions reductions. A "regulatory sandbox" mechanism could be introduced, piloting mandatory ESG rating disclosure for private green bonds in pilot free trade zones, with the experience gradually replicated. Supporting incentive and penalty measures include providing green credit interest subsidies to companies with ESG ratings of AA or above, and waiving registration fees for private bonds that meet disclosure quality standards. At the same time, regulatory arbitrage must be prevented by establishing a cross-departmental data sharing platform to compare certification reports, tax data, and environmental administrative penalty records, and crack down on false disclosures. In the medium and long term, legislation on green bond information disclosure is needed to clarify the legal responsibilities of issuers and intermediaries, and include environmental information disclosure violations in the negative list of corporate credit ratings, thereby establishing hard market constraints.

REFERENCES

- [1] Xu Qiang. Analysis of the spread structure of short-term financing bonds [J]. Securities Market Herald, 2007(03):31-34.
- [2] Fang Hongxing, Shi Jikun, Zhang Guangbao. Property rights, information quality and corporate bond pricing - empirical evidence from China's capital market [J]. Financial Research, 2013(4):13.
- [3] Jiang Feifan, Fan Longzhen. Green premium or green discount? - A study based on the credit spread of China's green bonds [J]. Finance and Finance, 2020(4):11-15.
- [4] Zheng Lanxiang, Hu Xiaoyu. Analysis of the main factors affecting the issuance rate of green bonds in my country [J]. Journal of Huainan Normal University, 2021, 23(01):24-30.
- [5] Ma Wenfang. Case study of the issuance of green bonds by Industrial Bank [D]. Hunan: Xiangtan University, 2019:1-48.
- [6] Zhang Xiaoqian, Wang Zhiwei. Are green bonds conducive to reducing corporate financing costs? From the perspective of government supervision and environmental governance [J]. Financial Research, 2023, (09):94-111.
- [7] Liu Chuanqi, Li Xinpeng. The current status of my country's green bond development and international comparison [J]. Green Finance, 2021(1):25-29.
- [8] Wang Yao, Cao Chang. Current status and prospects of third-party certification of green bonds in China [J]. Environmental Protection, 2016, 44(19):22-26.

- [9] Li Zhibin, Shao Yumeng, Li Zongze, et al. ESG information disclosure, media supervision and corporate financing constraints [J]. *Scientific Decision-making*, 2022, (07):1-26.
- [10] Wang Maobin, Ye Tao, Kong Dongmin. Green manufacturing and corporate environmental information disclosure - a policy experiment based on the creation of green factories in China [J]. *Economic Research*, 2024, 59(02):116-134.
- [11] John K, Lynch A W, Puri M. Credit Ratings, Collateral and Loan Characteristics: Implications for Yield [J]. *SSRN Electronic Journal*, 2002
- [12] Hyun S, Park D, Tian S. The Price of Going Green: the Role of Greenness in Green Bond Markets [J]. *Accounting & Finance*, 2019.
- [13] Kapraun J, Latino C, Scheins C, et al. (In)-credibly green: Which Bonds Trade at a Green Bond Premium? [J]. *Social Science Electronic Publishing*, 2019.
- [14] Caroline Flammer. Corporate green bonds [J]. *Journal of Financial Economics*, 2021.
- [15] George Akerlof. The Market for Lemons: Quality Uncertainty and the Market Mechanism [J]. *The Quarterly Journal of Economics*, 1970.
- [16] Chen et al. Environmental Regulation, ESG Performance, and Corporate Bond Financing Costs: Evidence from China [J]. *Journal of Sustainable Finance & Investment*, 2022.
- [17] Leora F. Bottazzi. ESG Ratings and the Rise of 'Social Washing' in Corporate Bond Markets [J]. *Journal of Corporate Finance*, 2020.