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Future Development Prospects of Green Bond Assessment

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ABSTRACT

Against the macro-background of China's efforts to promote a green and low-carbon economic and social transformation and implement the dual carbon goals, green finance has emerged as a core pathway to support low-carbon development. This paper reviews the current state of research on green bonds, analyzes the challenges in their value assessment work, and integrates domestic and international research findings with market practices. It explores optimized pathways for green bond valuation and provides an outlook on future development trends. The aim is to refine the theoretical framework for green bond assessment and promote the healthy and sustainable growth of China's green finance market.

KEYWORDS

Green Bonds; Green Finance; Sustainable Development; Value Assessment

1. INTRODUCTION

Green bonds are a debt financing instrument issued by financial or non-financial enterprises, with the purpose of providing financial support for projects that meet specific green standards and conditions. The issuance methods of green bonds include both public offerings and private placements, targeting unspecific or specific investors, while agreeing to pay interest and principal to investors within a specified timeframe. As a diversified financing tool, green bonds encompass various types, including corporate bonds, enterprise bonds, and asset-backed securities. Correspondingly, different types of green bonds are managed by different regulatory authorities and approval-issuance departments.

There are differing perspectives on the definition of green bonds internationally and domestically. Internationally, definitions of green bonds often refer to documents such as the Climate Bonds Standard and the Green Bond Principles. The issuance of the "Climate Awareness Bond" in 2007 ultimately established the definition of green bonds, namely: "A debt financing instrument where the issuer, in accordance with the Green Bond Principles or equivalent standards, exclusively allocates the raised funds or an equivalent amount to new or existing eligible green projects, and continuously discloses the project's environmental and financial performance." In China, green bonds are explicitly defined as bond instruments where the funds raised after issuance, or an equivalent monetary value, are used to provide partial or full financing for newly added or existing green projects that meet established standards. Furthermore, green bonds must adhere to the four core components of the Green Bond Principles: Use of Proceeds, Process for Project Evaluation and Selection, Management of Proceeds, and Reporting.

Compared to conventional bonds, green bonds possess unique characteristics. Firstly, the use of proceeds raised by green bonds has a clear environmental orientation, typically centered around green

projects that generate environmental benefits, such as wind power, nuclear power, solar power, low-carbon transportation, and low-carbon buildings. Secondly, the transparency requirements for disclosing green projects are high. Issuers need to clearly define the selection criteria and decision-making processes for green projects in the offering documents and provide detailed disclosures on the expected environmental benefits. Thirdly, issuers are required to publicly disclose the management mechanisms and usage of the raised funds, leading to more standardized management of the proceeds. Finally, issuers have a legal obligation for information disclosure during the bond's lifetime. During this period, issuers need to explain and publicize project progress and the utilization of funds.

Since China began issuing green bonds in 2016, the scale of the green bond market has expanded rapidly. However, it is noteworthy that although the scale of China's green bond market is already among the largest in the world, its proportion relative to the conventional bond market, which has a stock of over one hundred trillion yuan, remains at a relatively low level.

This review provides an in-depth exploration of green bonds and their valuation, examining the latest research and market developments, and analyzing the challenges associated with their valuation and market growth. The rapid development of green bonds is inseparable from the needs of the economic and social green and low-carbon transformation and the pursuit of the Dual Carbon Goals. Multiple studies have emphasized this connection, pointing out that green bonds are one of the core pathways for constructing a green finance system and facilitating the low-carbon economic transition [2, 32]. Integrating green bonds deeply into financial markets and the real economy requires a thorough understanding of their attributes and developmental limitations, prompting a comprehensive analysis of their market potential and current shortcomings.

This paper will explore the core characteristics and market-influencing factors of green bonds, assess the methods and limitations of quantifying their environmental benefits, and examine their multifaceted impacts on the financial market ecosystem and corporate development [7, 18]. Furthermore, this paper will delve into the significant role of various modeling approaches in optimizing the valuation of green bonds to better align with market realities and reflect their true value [57, 59]. This paper aims to provide a nuanced perspective on the current state of green bonds, acknowledging their notable achievements in the development of green finance while also identifying the challenges that need to be addressed to support further market expansion and sustainable development.

2. FACTORS INFLUENCING GREEN BONDS

As financial instruments with yield attributes, green bonds share commonalities with traditional bonds in their fundraising methods, both relying on issuing securities in the bond market to aggregate substantial capital. However, the capital raised through green bonds is specifically allocated to environmentally friendly green projects, such as those in nuclear power or photovoltaic energy [16]. In terms of characteristics, green bonds exhibit distinct green and clean traits, often have longer issuance cycles, and possess the advantage of relatively lower financing costs. Due to these unique features, green bonds can continuously provide robust financial support on China's journey towards a green and low-carbon economic transition, playing a significant role in the construction and improvement of China's green finance system [2].

However, compared to the more established green bond markets in foreign countries, China's green bond market started relatively late. Although Chinese green bonds are broadly consistent with their foreign counterparts in terms of issuers, issuance purposes, and operational mechanisms, notable differences exist in several aspects, including the breadth and depth of market participation, bond financing models, the variety of green products, and social benefits [3]. During the actual operation of the green bond market, certain external environmental factors play a crucial role in its development

trajectory. For instance, lower market inflation and interest rates, and a higher RMB exchange rate, have created favorable conditions for the growth of the green bond market [4].

Further analyzing the relationship between green bonds and financial markets, Xu and Jia suggest that traditional financial markets and the green bond market exert mutual influence, and the synergistic effects between them should be fully explored and leveraged to promote the healthy development of the entire financial ecosystem [7]. Green bonds also effectively mitigate the maturity mismatch between corporate investment and financing, thereby reducing corporate investment and financing risks, and exhibit significant environmental protection effects and industry spillover effects [8, 9]. From a macro perspective, complex and variable risk effects and spillover effects exist between the green bond market and various other financial markets [10-12]. Moreover, scholars have employed various quantitative analysis models to conduct more in-depth investigations into the effects of green bonds, with most studies focusing on the relationship between the green bond market and the stock market. For example, Qin et al. found through empirical research that after the official introduction of labeled green bonds, risk effects emerged between China's stock market and green bond market, with the direction of risk transmission running from the low-carbon stock market to the green bond market [13]. Zhou using the VEC-BEKK-GARCH model, verified that shock transmission effects do occur between the green bond market and the stock market, and that the price and volatility spillover effects between them exhibit unique asymmetric characteristics [14]. Yang employing event study methodology, further discovered that issuing green bonds has a negative effect on stock prices [15].

Furthermore, a significant correlation exists between green bonds and corporate development. In an effort to reduce carbon emissions, the European Union has actively promoted green bonds. Many astute automotive companies have seized this opportunity, leveraging green bonds to establish comprehensive green financing frameworks and effectively enhance their economic performance [17]. Further analysis of corporate data indicates that green bonds can effectively help improve corporate performance by influencing the degree of corporate financing constraints, promoting green innovation processes, and contributing to company growth across multiple dimensions [18]. Wu et al. through detailed comparison of the quantity of green innovation among companies in different operating environments and industries, found that green bonds play a more prominent role in promoting green innovation effectiveness for companies located in regions with a high-quality business environment and for those in non-heavy-polluting industries [19]. Conversely, Zhou et al. using a multi-period difference-in-differences model, discovered that the promoting effect of green bond issuance on green innovation is more significant in heavily polluting industries, enterprises with lower internal agency costs, and firms in their growth and maturity stages [20]. Other studies have noted the differential impact of green bonds on corporate green innovation. Research by Wang et al. revealed potential strategic innovation behavior by companies but found no significant promoting effect on corporate green project investment, R&D investment, corporate value, or environmental performance [21].

Alongside the vigorous development of the green bond market, the issuance volume of green bonds in China has shown a positive trend. However, during this developmental process, risks associated with green bonds have also become increasingly prominent. These risks primarily manifest in aspects such as liquidity risk, default risk, green project risk, and political risk [22]. Zhang et al. using a random effects model, focused on investigating the specific impact of liquidity risk on the yield spread of green bonds [23]. Wu employed different liquidity measures to delve into the relationship between liquidity risk and yield differentials for green bonds compared to traditional bonds [24]. Hu took a unique perspective from the standpoint of green finance, conducting heterogeneity tests and finding that, to some extent, green bond issuance can effectively alleviate the tension between environmental protection and default risk, offering new insights for risk management [25]. Li using the expansion of Medium-term Lending Facility collateral and the "Carbon Neutrality" financial bond policy as quasi-natural experiments, explored the impact of structural monetary policy on the risk

premium of green bonds [26]. The study found that such policies can significantly reduce both the issuance cost and trading risk premium of green bonds. From a micro-level analysis, Sun and Liu using A-share listed companies from 2009 to 2023 as a sample, confirmed that green bonds can significantly reduce corporate risk-taking [27]. Xia et al. employing the difference-in-differences method on panel data of Shanghai and Shenzhen A-share listed companies from 2009 to 2022, found that issuing green bonds can reduce corporate debt default risk by enhancing corporate reputation and optimizing bank resource allocation efficiency [28].

3. RESEARCH ON ENVIRONMENTAL BENEFITS

As the concept of green development gains traction, the importance of green bonds in both the economic and environmental spheres has become increasingly prominent. Consequently, research on quantifying their environmental benefits and improving related management mechanisms has attracted significant attention, with numerous scholars conducting in-depth explorations from various perspectives.

Internationally, relevant standards and systems concerning environmental benefits were promulgated relatively early. For instance, in 2005, the International Organization for Standardization (ISO) introduced the ISO14001 standard for corporate environmental management. The following year, the UK's Department for Environment, Food and Rural Affairs (DEFRA) put forward constructive recommendations for environmental performance indicators. They proposed establishing a corporate environmental performance indicator evaluation system to facilitate quantitative assessments both within companies and between them. However, dedicated academic research on green bonds lagged considerably, only beginning to emerge in recent years.

From a theoretical research perspective, studies by Fatica and Panzica indicate that green bond issuers share similarities with traditional bond issuers in terms of financial characteristics and bond ratings [31]. However, after borrowing through green segments, the carbon intensity of assets held by green issuers tends to decrease. Flammer emphasized the positive role of green bonds in addressing funding shortages for green projects [32]. Particularly in most capital-intensive infrastructure projects, some companies achieved considerable success after issuing green bonds. Not only did environmental performance improve substantially, with a significant reduction in carbon emissions from production and operating activities, but there was also a notable increase in the number of green patent applications and green investors. Ahmed through empirical research, revealed the close correlation between green energy deployment and the Sustainable Development Goals (SDGs) [33]. It demonstrated that leveraging a range of emerging financial instruments and policy initiatives, such as green banks, green bonds, community green funds, and green central banks, to scale up investment and financing with environmental benefits, could help achieve environmental SDGs. Furthermore, using the Generalized Method of Moments (GMM), the study estimated and analyzed the relationships among CO2 emissions, green finance, energy efficiency, and the green energy index (GEX), providing strong evidence that green bonds are an effective means to promote green energy projects and substantially reduce CO2 emissions.

Domestically, numerous scholars have conducted comprehensive and in-depth research on various aspects of green bonds, including environmental benefit quantification, information disclosure, their impact on enterprises, and related market issues. According to Xing et al. the environmental benefit information disclosure for green bonds in China is still in its infancy, facing numerous problems that require urgent solutions [34]. Lin suggested that China should draft a "Green Finance Regulation" to standardize the bond information disclosure system [35]. Such a measure would enhance transparency, helping investors clearly and accurately understand the specific use of the raised funds, while also providing a robust basis for market regulators to determine whether a bond qualifies as a genuine green bond, thereby increasing the precision of government-supported projects. Wu explicitly pointed out issues in China's green bond information disclosure system, such as inconsistent standards,

insufficiently comprehensive requirements, and a lack of credibility [36]. From four important dimensions—standard unification, rule refinement, professional assessment, and supporting measures—the study proposed a series of targeted legal recommendations for optimizing the green bond information disclosure system. The core objective is to effectively prevent bonds from "fading" (losing their green credentials) and to genuinely safeguard the "green" attribute of green bonds. Therefore, emphasizing the critical role of the "environmental benefit objective" in ensuring the "green" attribute of green projects is paramount. The urgent need is for China to develop a standardized environmental benefit system to guarantee that the raised funds are fully applied to green and low-carbon industries [37]. Shang using credit-linked corporate bonds as a research sample and referencing disclosed bond environmental benefits, assessed and analyzed the potential final environmental benefits of substantive green bonds directed towards green projects [38]. Additionally, the study recommended that the state should standardize environmental benefit disclosure guidelines and establish a green bond database. Yuan innovatively proposed a green finance environmental benefit assessment framework, encompassing six dimensions of environmental benefit assessment, benchmarks for different industries, indicator weights at different levels, and two distinct assessment methods, providing a relatively comprehensive and systematic approach for evaluating the environmental benefits of green bonds [39]. Zheng based on the "dual carbon" goals, introduced the LCA method for calculating environmental benefits and applied it to quantitatively calculate the environmental benefits generated by green bond projects at various implementation stages [40]. This aimed to present fund usage and project benefits more accurately and in real-time, laying a solid foundation for the healthy and stable development of the green bond market. Furthermore, Chai et al. found through research that the "green" attribute possesses the capacity to significantly lower bond credit spreads, effectively reducing the financing costs for bond issuers, with some heterogeneity in this effect across different types of green bonds [41]. Simultaneously, green bonds demonstrate superior performance in terms of capital income and liquidity compared to ordinary bonds, an advantage that precisely offsets the negative impact on investor enthusiasm caused by lower interest income. Additionally, the study found that corporate issuance of green bonds can enhance the liquidity of both the bond market and the company's own stock. This linkage effect stems from the "reputation spillover" effect, which improves stock liquidity through specific relevant channels. These findings provide valuable references for constructing the green bond market system and advancing sustainable development strategies.

Concurrently, the impact of green bonds on corporate ESG has also become a key area of focus and in-depth exploration for many scholars. Research by Chen et al. indicates that green bonds can significantly improve the ESG performance of other firms in the same industry by intensifying industry competition and encouraging them to adopt more environmental protection actions [42]. Using a sample of non-financial listed companies in China from 2011 to 2022 and employing a multi-period difference-in-differences method, it was found that the issuance of green bonds by Chinese companies generates industry spillover effects related to ESG information. Moreover, this industry spillover effect becomes more pronounced when companies face greater financing constraints and receive higher external attention [43]. Furthermore, besides enhancing corporate ESG performance through industry spillover effects, green bonds can also further elevate corporate ESG levels by incentivizing companies to engage in green innovation and strengthening external supervision. Additionally, the promoting effect of green bonds on corporate ESG performance is more significant when companies operate in a highly market-oriented environment, belong to heavily polluting industries, or have stronger managerial capabilities [44].

4. RESEARCH ON BOND VALUE ASSESSMENT

Within the domain of pricing differences and influencing factors between green bonds and traditional bonds, many scholars have conducted analyses from various perspectives. Hachenberg and Schiereck were among the first to identify, through comparative analysis, non-negligible differences in pricing

between green and traditional bonds [45]. Yao further delved into this, pointing out that factors such as the issuance size and maturity of green bonds, the return on equity of the issuing company, and market interest rates are significant reasons for the pricing discrepancies [46]. Ehlers selected 21 green bonds issued between 2014 and 2017 and compared their primary market issuance prices with those of conventional bonds issued by the same issuers during the same period, concluding that the average price of green bonds was approximately 8 basis points lower than that of conventional bonds [47].

Regarding comparisons of pricing situations between domestic and international green bonds, Zhang et al. through extensive data observation and analysis, found that in recent years, investor enthusiasm for purchasing green bonds in China has been rising [48]. The subscription multiples in the primary market have shown a positive annual increase, and demand has been steadily strengthening year by year. However, despite this, a considerable gap remains between China's green bond market and the global market. In terms of issuance rates, China's green bonds have lower issuance rates compared to other market bonds, a phenomenon indicating that green bonds possess a unique advantage in financing costs, consistent with the international market situation. However, in the secondary market, the enthusiasm of Chinese bond issuers for re-subscribing to quotas is relatively low, forming a stark contrast with the international market situation. This provides a direction worthy of in-depth consideration for further improving China's green bond market mechanism.

Moreover, whether a green bond is labeled also affects its price. Hyun and Tian found through research that labeled green bonds had significantly lower yields, by 24-36 basis points, compared to unlabeled green bonds with similar pricing factors [49]. In the same period, Dorfleitner and Zhang conducting a specialized study on green bond pricing using a sample of as many as 1,248 green bonds, showed that the average premium for different green bonds was as high as 5 basis points [50]. Notably, this premium was not fixed; it varied according to the "greenness" depth of the project, particularly pronounced for bonds financing "dark green" projects. Besides this, Wang et al. also emphasized that factors such as the credit risk of the issuing company and the contagion risk of related network organizations significantly influence bond pricing, adding new dimensions to research in this area [51].

From the perspective of model-based empirical research, numerous scholars have employed various models in an attempt to study the factors influencing green bond pricing. Yang et al. conducted empirical research using a credit spread influencing factor model [52]. Among the many factors affecting green bond pricing, they found that the issuance method of public offering green bonds and national green policy support could reduce corporate financing costs to some extent, indirectly revealing part of the internal logic behind green bond pricing. Chen using 85 green financial bonds as a research sample, employed a multiple linear regression model to conduct a comprehensive and systematic analysis of the factors influencing green bond pricing [53]. The research results indicated that, among many factors, bond market interest rates, the consumer price index, and GDP growth rate showed a significant positive relationship with the issuance rates of green bonds in the Chinese market. Conversely, for the issuing entity, the company's overall capital scale and asset-liability ratio showed a significant negative relationship with green bond issuance rates in the Chinese market. Furthermore, among the relevant factors inherent to the green bond itself, there was a relatively clear positive relationship between bond maturity and issuance rates; however, bond issuance size had no significant impact on green bond issuance rates. Chen et al. also using regression models but from the issuer's perspective, studied the factors influencing green bond pricing, concluding that both the issuer's overall scale and the bond's credit rating could cause the green bond's issuance price to be higher than its par value [54]. In other words, if the bond issuer has a larger asset scale and the issued bond has a higher rating, the issuer holds more advantages in bond pricing and can set a reasonable price more adeptly.

Feng et al. when researching the valuation of medium-term carbon bonds, used the fractal Black-Scholes formula to accurately value European-style bull call spreads [55]. Through in-depth analysis,

they suggested that European-style floating-rate carbon bonds are a more ideal design choice, providing a novel approach for carbon bond valuation. Gao and Yang employed the stochastic volatility Hull-White option pricing model combined with the quasi-Monte Carlo method to price convertible bonds, offering a distinctive methodological path for convertible bond pricing [56]. Gong et al. through in-depth research, suggested that the value of green bonds might be underestimated [57]. To verify this, they selected six green bonds as research objects and used the binomial tree pricing model for calculation and analysis. The final results showed that the calculated theoretical prices were all higher than the actual issuance prices of the bonds. Liu reached the same conclusion and went a step further by using the Black-Scholes model as a control group, applying both models to the same set of green bonds [58]. The calculation results again showed that the theoretical bond prices from both models were higher than the actual prices. Yang et al. based on the risk transmission mechanism in financial markets, modified the discount rate of the traditional income approach to effectively reduce the deviation between valuation results and actual situations, subsequently using the Black-Scholes model to assess the difficult-to-quantify environmental benefits embedded in carbon neutrality bonds [59]. However, it must be noted that the Black-Scholes model is not flawless. Hu explicitly pointed out that the application conditions of the Black-Scholes model are relatively strict, and traditional Brownian motion often fails to accurately capture the complexities of actual market conditions [60]. In contrast, fractional Brownian motion is not bound by these restrictive conditions; it can more precisely and subtly describe market volatility and uncertainty. Introducing it into option pricing could significantly enhance pricing accuracy and reliability, providing a new direction for improving option pricing methods. Hu et al. observed that the assumption of constant volatility in the traditional Black-Scholes model is inconsistent with the complexities of actual financial markets [30]. To address this issue, they utilized G-Brownian motion to depict stock price fluctuations, thereby constructing a financial market mathematical model that aligns with real market dynamics. Empirical research found that the financial market model under the G-Brownian motion environment was more consistent with the dynamic changes in financial markets compared to the traditional Black-Scholes model, offering a strong reference for subsequent model improvements and optimizations. Feng et al. when valuing carbon bonds, employed the Hurst exponent to test carbon futures prices [29]. After detailed analysis, they found that this exponent could effectively reflect the market characteristics of the data, providing a useful reference for carbon bond valuation work.

Meanwhile, Zhou et al. starting from theoretical research on convertible bond pricing, found through rigorous analysis that the value of convertible bonds is significantly affected by interest rate fluctuations [6]. Segnon applied the GARCH model to forecast carbon emission allowance prices and rigorously assessed the model's practicality based on the forecast results [5]. Through in-depth analysis and verification, the GARCH model was considered highly effective in reflecting the volatility characteristics of returns, possessing high predictive accuracy and reliability, thus providing an effective tool for forecasting carbon allowance prices. Domestically, Zhang also adopted the GARCH model to predict the volatility of carbon yield returns [1]. Through empirical testing, they also concluded that the GARCH model could effectively simulate the volatility characteristics of returns, further confirming the model's application value in this field.

As research on green bonds continues to deepen, their value assessment exhibits development trends such as the comprehensive consideration of multi-dimensional influencing factors, model integration and optimization, and close integration with environmental benefit quantification. Future value assessment will increasingly focus on incorporating multi-dimensional influencing factors, including elements related to the green bond's own characteristics and external environmental factors, into a comprehensive evaluation system to measure value accurately and holistically.

In the research field of green bond influencing factors and effects, many scholars have conducted in-depth discussions from various perspectives, clearly revealing the important position and mechanism of action of green bonds within financial markets and corporate development. On one hand, although green bonds share commonalities with traditional bonds in fundraising methods, their allocation of

funds to "green" projects endows them with unique characteristics such as being green, clean, having longer issuance cycles, and lower financing costs, providing strong financial support for the construction of China's green finance system and low-carbon economic transition. However, the late start of China's green bond market and its differences from foreign counterparts in multiple aspects also highlight the necessity for further in-depth research on the development path of green bonds with Chinese characteristics. On the other hand, concerning the interactive relationship with financial markets and corporate development, existing research fully reveals their positive effects at the micro level, such as assisting companies in carbon reduction, enhancing value, and alleviating financing constraints, as well as the complex risk and spillover effects with various financial markets at the macro level. The close connection with the stock market, in particular, has received focused attention and detailed analysis, providing a rich perspective for understanding the role of green bonds in the entire financial ecosystem.

Research on the environmental benefits of green bonds has also yielded fruitful results. The early introduction of relevant international standards and systems laid a certain foundation for subsequent research on the environmental benefits of green bonds. Although academic research lagged relatively, recent findings have already demonstrated the significant role of green bonds in addressing funding shortages for green projects, improving environmental performance, reducing carbon emissions, and promoting green investment.

In research on green bond value assessment, scholars have conducted comprehensive analyses of pricing differences and influencing factors between green and traditional bonds through comparative analysis, model-based empirical research, and other methods. These studies have revealed the impact of various factors on green bond pricing, such as issuance size, maturity, corporate yield, market interest rates, labeling status, and corporate credit risk. Comparisons between domestic and international markets have also identified different characteristics in China's primary and secondary green bond markets, offering directions for improving China's green bond market mechanism. Simultaneously, various model approaches have been attempted in bond valuation. Some studies point to the undervaluation of green bonds, and different scholars have improved and optimized traditional pricing models to address their shortcomings, exploring valuation models and methods that better fit actual market conditions.

Through summarizing existing research findings, it can be observed that current scholarly perspectives on green bond value assessment are relatively singular, lacking integrated analysis encompassing multiple angles such as policy, market volatility, corporate financial status, and environmental benefits. Secondly, the current evaluation system for green bonds is not yet comprehensive. The existing assessment and calculation processes largely reference the evaluation model frameworks of ordinary bonds, failing to adequately consider the unique environmental benefit characteristics of green bonds.

Although existing research continuously expands and deepens the methods and approaches for assessing the investment value of green bonds, due to the complexity and uncertainty of financial markets, current valuation models still struggle to reflect the true value of green bonds with complete accuracy.

5. FUTURE DEVELOPMENT PROSPECTS FOR GREEN BOND ASSESSMENT WORK

Looking ahead, with the deepening opening-up of the green bond market, the increasing number of participating enterprises, and the continuous expansion of issuance scale, supported by relevant policies, the green bond market is poised to unleash greater development potential and innovative vitality. It will play an even more significant role in promoting the high-quality development of the bond market and advancing low-carbon sustainable development processes.

First, improving the information disclosure system and regulatory mechanisms. Government authorities in China should establish a unified national bond information disclosure system, clearly defining the content, frequency, methods, and responsible entities for disclosure. The usage of raised funds, the progress of green project construction, and the results of third-party assessment and certification should be included within the mandatory disclosure scope to safeguard investors' right to information. Concurrently, the supervision and accountability mechanisms for information disclosure must be strengthened. Issuers that fail to disclose as required or engage in false disclosure should face administrative penalties, market bans, and other measures to increase the cost of non-compliance. Furthermore, the quality of information disclosure should be integrated into the credit evaluation system of issuing enterprises, linking it to subsequent bond issuance and financing costs, thereby compelling enterprises to prioritize information disclosure work.

Second, accelerating the formulation of industry standards for third-party assessment and certification of green bonds. This involves clearly defining the processes, methodologies, indicator systems, and reporting standards for assessment and certification to promote the standardization and normalization of evaluation work. Simultaneously, a market access and exit mechanism for assessment institutions should be established, strictly reviewing the professional capabilities of institutions, the qualifications of practitioners, and the assessment technical systems, thereby raising the overall entry threshold for the industry.

Third, further breaking through the limitations of traditional bond assessment models. It is essential to fully consider the green attributes and environmental benefit characteristics of green bonds to construct a multi-dimensional value assessment model that integrates policies, markets, enterprises, and the environment. This model should incorporate policy and market factors such as national green finance policies and carbon market price fluctuations; enterprise factors including the issuer's financial status, green innovation capability, and ESG performance; and environmental factors like carbon emission reductions, environmental benefits, and project sustainability, achieving a comprehensive consideration of multi-dimensional factors.

In the future, with the continuous improvement of the green bond assessment system and the ongoing development of the market, green bonds will better fulfill their financing function, attract more social capital to participate in green and low-carbon industries, and contribute to China's achievement of the "dual carbon" goals and green sustainable development.

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Competing interests

The authors declare no competing interests.

Ethical approval

Ethical approval was not required as the study did not involve human participants.

Informed consent

This article does not contain any studies with human participants performed by any of the authors.

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