Research on the Impact of Green Bond Issuance on the Environmental Performance of Chinese State-Owned Enterprises

LI Siqi
Central University of Finance and Economics, Beijing, China

Abstract: With the rapid development of China's green bond market, state-owned enterprises have accounted for 68% of the issuance share, playing a crucial role in achieving the "dual carbon" goals. However, whether the green bond funds are truly and effectively used for environmental improvement projects and whether there is "greenwashing" behavior have become the focus of market and policy attention. Based on the signal transmission theory and the resource dependence theory, this paper constructs a theoretical framework for the impact of green bond issuance on the environmental performance of enterprises, and conducts empirical tests using panel fixed effect models, propensity score matching method (PSM), and case analysis method. The research results show that green bond issuance can significantly improve the environmental performance of state-owned enterprises, especially in high-pollution industries and large enterprises. The mechanism test reveals that green bonds reduce financing costs and increase environmental protection investment, thereby promoting the improvement of environmental performance. This study provides theoretical basis and practical references for the government to optimize green financial policies, enterprises to implement green transformation, and investors to identify high-quality green bonds.

Keywords: Green Bonds; State-Owned Enterprises; Environmental Performance; ESG The Dual-Carbon Target

1. Introduction

Since China released the "Green Bond Support Project Catalogue" in 2015, the green bond market has grown at an average annual rate of over 30%, and has now become the second-largest green bond market in the world. State-owned enterprises, as the main issuers of green bonds, undertake the dual functions of policy implementation and social responsibility. Their environmental performance directly affects the realization of the country's "carbon neutrality" goals. However, there is currently a "greenwashing" phenomenon in the green bond market, where some enterprises issue green bonds ostensibly but the actual funds are not truly used for environmental improvement projects, seriously affecting the healthy development of the market. Existing research mostly focuses on the financing cost advantages of green bonds, lacking causal identification and mechanism exploration of their impact on environmental performance. Therefore, this paper starts from the micro level to explore the impact of green bond issuance on the environmental performance of state-owned enterprises, filling the gap in empirical research in this field, and providing scientific basis for policy formulation and market practice.

2. Literature Review

2.1 Research on the Economic Consequences of Green Bonds

The current research on the economic consequences of green bonds mainly focuses on the following two aspects:

Impact on the enterprise itself. A large number of studies have shown that green bonds can significantly reduce the financing costs of enterprises, enhance their value and market reputation. Some scholars have found that after the issuance of green bonds, enterprises have increased their investment in environmental protection technology research and development, and their innovation capabilities have been improved. In addition, some research has pointed out that the promotion effect of green bonds on the short-term financial performance of enterprises is uncertain, but it helps to enhance the sustainable development ability of enterprises in the long term[1]

Impact on the environment. Research on the

relationship between green bonds and environmental performance is still in its infancy both domestically and internationally. A few case studies and correlation analyses indicate that green bonds may indirectly improve the environmental performance of enterprises by guiding funds to green projects. However, the existing results are mostly based on qualitative descriptions or simple statistical correlations, lacking rigorous causal identification tests, and the analysis of the impact mechanism is also relatively weak, making it difficult to accurately reveal the actual path and effect of green bonds on environmental performance.

2.2 Research on the Influencing Factors of Enterprise Environmental Performance

Apart from green bonds, academic research has identified various factors that influence a company's environmental performance. On one hand, environmental regulations and policy pressures are widely regarded as the key forces driving companies to adopt environmentally friendly behaviors; on the other hand, external pressures such as media attention and public supervision can also prompt companies to improve their environmental performance. Within the company, factors such as the environmental awareness of senior executives, the characteristics of the management team, and the nature of the enterprise (for example, state-owned enterprises bear more environmental responsibilities compared to non-state-owned enterprises) all have a significant impact on environmental decisions and performance. These studies provide a diverse perspective for understanding corporate environmental behavior, but they also highlight the insufficiency of research that takes a financial tool perspective.

In summary, the existing research has made certain progress in exploring the economic benefits of green bonds, but there are still significant gaps in the field of environmental performance: Firstly, there is a lack of causal empirical tests on the environmental effects of green bonds; secondly, there is insufficient systematic analysis of the influencing mechanisms; thirdly, there is relatively less focus on the special circumstances of state-owned enterprises. Therefore, this paper aims to systematically examine the impact of green bond issuance on the environmental performance of state-owned enterprises and its internal mechanisms by constructing a rigorous causal identification strategy, in order to make up for the deficiencies of existing literature and provide theoretical support and empirical evidence for promoting the healthy development of the green bond market.[2]

3. Theoretical Analysis and Research Hypotheses

This paper, based on the theory of signal transmission and the theory of resource dependence, constructs a theoretical framework for the impact of green bonds on the environmental performance of enterprises.

3.1 From the Perspective of Signal Transmission Theory

The signaling theory posits that in markets with information asymmetry, enterprises with positive internal information have the motivation to convey "signals" to the market through specific actions in order to distinguish themselves from other enterprises. Applying this theory to green bonds: When enterprises issue green bonds that have undergone strict certification, they are essentially conveying to investors and the public a "high-quality" signal of their commitment to green transformation. This signal not only enhances the enterprise's reputation and attracts investors with environmental preferences, but also generates external supervision pressure through market and media attention, thereby indirectly motivating the enterprise to allocate more resources to environmental governance, ultimately achieving improvements in environmental performance.[3]

3.2 From the Perspective of Resource Dependence Theory

The resource dependence theory emphasizes that the survival and development of an organization rely on obtaining key resources from the external environment. In the context of this study: State-owned enterprises, as a special type of market entity, their operation and development are highly dependent on the policy support and legitimacy recognition from the government. The issuance of green bonds not only provides enterprises with low-cost special funds, but also is a valuable resource for obtaining policy preferences from the government and social public recognition. In order to continuously obtain and maintain these key resources, enterprises have a strong motivation to precisely

invest the obtained funds in environmental improvement projects, in order to fulfill their green commitments, consolidate their resource acquisition channels, and in the process, effectively improve environmental performance.

3.3 Research Hypotheses Proposed

Based on the above theory, this paper puts forward the following hypotheses:

H1: The issuance of green bonds can significantly enhance the environmental performance of state-owned enterprises.

H2: This effect is more pronounced in high-pollution industries and large enterprises.

H3: Green bonds influence environmental performance through the intermediary mechanism of reducing financing costs and increasing environmental protection investment.

4. Research Design

4.1 Data Sources and Variable Definitions

This study utilized data from Chinese A-share state-owned listed companies from 2018 to 2023.[6] The data were sourced from Wind, CSMAR databases, and corporate social responsibility reports. The key variables include:

Environmental performance, as the dependent variable, is measured from two dimensions: first, carbon emission intensity, an indicator that objectively quantifies a firm's carbon efficiency. Specifically, it is measured as "the ratio of total carbon emissions to total operating income," with lower values indicating better environmental performance; second, the China Securities ESG Environmental Score, which comprehensively reflects a firm's performance in various aspects such as environmental management, disclosure, and effectiveness, with higher scores representing superior performance.

The core independent variable of the study is green bond issuance, and its impacts are captured from both "quality" and "quantity" perspectives: first, a dummy variable is set to identify whether a firm issued green bonds in the sample year; second, the issuance scale is examined to further explore the differential effects brought by the intensity of financing.

To identify the net effect of green bonds as accurately as possible, this study introduces a series of control variables. These variables include firm size (expressed as the natural logarithm of total assets), asset-liability ratio, industry attributes (controlled by industry dummy variables), and government subsidies. These variables are selected to control for factors such as firms' inherent resource endowments, financial structures, industry characteristics, and external policy support, all of which may simultaneously affect firms' financing decisions and environmental performance.

This study utilized data from Chinese A-share state-owned listed companies from 2018 to 2023. The data were sourced from the Wind database, the CSMAR database, and the publicly released social responsibility reports of enterprises. The definitions of the core variables are as follows:

The table 1 systematically lists the two types of environmental performance indicators involved in the research (carbon emission intensity, ESG environmental score), the variables related to green bond issuance (dummy variables and scale variables), and the control variables (company size, debt-to-equity ratio, etc.), and clearly specifies the measurement methods and units for each variable.

Table 1. Measurement Methods and Units of Measurement for Each Variable

Types of variables	Variable name	Variable symbol	Measure	Unit / Dimension
Dependent variable	Environmental Performance (Indicator One)	CEP1	The ratio of the total annual carbon dioxide emissions of an enterprise to its operating income. To alleviate heteroscedasticity, the ratio is transformed into the natural logarithm.	Dimensionless
dependent variable	Environmental Performance (Indicator Two)	CEP2	The environmental dimension score from the Huazheng ESG rating system is adopted. This score comprehensively assesses the performance of the enterprise in environmental management, performance, and disclosure.	grade
independent variable	Green bond issuance	GB_Dum	Dummy variable. If the company successfully issued green bonds in the current year, its value is 1; otherwise, it is 0.	dummy variable
independent	The issuance	GB_Size	The total amount of green bonds issued by the	Ten thousand

variable	scale of green bonds		company in that year was logarithmically transformed by adding 1 to the total amount to mitigate heteroscedasticity.	yuan (logarithmic)
Control variable	Enterprise scale	Size	The natural logarithm of the total assets at the end of the year.	Ten thousand yuan (logarithmic)
Control variable	Asset-liability ratio	Lev	The ratio of total liabilities at the end of the year to total assets at the end of the year measures the financial leverage of the enterprise.	Percentage
Control variable	Profitability	ROA	The ratio of net profit to average total assets reflects the efficiency of an enterprise's asset utilization.	Percentage
Control variable	Enterprise age	Age	The natural logarithm of the duration from the establishment of the company to the current year.	Year (Logarithm)
Control variable	Growth	Growth	The year-on-year growth rate of operating income. (Current period operating income - Previous period operating income) / Previous period operating income.	Percentage
Control variable	Industry classification	Industry	The industry dummy variables set according to the 2012 industry classification standard of the China Securities Regulatory Commission.	Dummy variable
Control variable	Year	Year	The annual dummy variables set according to the year of the sample are used to control the impact of macroeconomic fluctuations.	Dummy variable

4.2 Model Specification

The panel fixed effects model is adopted as follows:

\text{Env_Perf}_{kt} = \alpha + \beta \cdot \text{GreenBond}_{kt} + \gamma \cdot \text{Controls}_{kt} + \text{FirmFE} + \text{YearFE} + \varepsilon_{kt}

4.3 Endogeneity Handling

To address the endogeneity issue, the lagged term of green bond issuance was matched with the propensity score matching method (PSM) to construct an counterfactual framework for causal identification.

4.4 Heterogeneity Analysis and Mechanism Testing

Grouping the regression by industry pollution characteristics and enterprise size to test the heterogeneity of the green bond effect. Further constructing an intermediary effect model to examine the role of the "financing cost - environmental protection investment" path.

5. Empirical Results and Analysis

5.1 Baseline Regression Results

The baseline regression shows that the issuance of green bonds is significantly positively correlated with the environmental performance of enterprises, supporting hypothesis H1.[2]

5.2 Heterogeneity Analysis

The environmental improvement effect of green bonds in high-pollution industries and large enterprises is more obvious, thus verifying hypothesis H2.

5.3 Mechanism Verification

Green bonds significantly enhance environmental performance by reducing financing costs and increasing investment in environmental protection. The mediating effect is notable, supporting Hypothesis H3.

5.4 Robustness Test

After changing the variable measurement method, adjusting the sample range, and controlling for more fixed effects, the results remained robust.[6]

6. Case Analysis

Under the backdrop of the "carbon neutrality" goal, the green transformation of Chinese enterprises is imminent. Green bonds, as a financial instrument specifically designed for financing environmental projects, play a crucial "catalyst" role in this process. By comparing China Three Gorges Corporation (which issued green bonds) with Huaneng Group (which did not issue), and analyzing the green bond

practices of Baosteel Co., Ltd., we can clearly see how green bonds drive the substantial improvement of enterprises' environmental performance at the levels of funds, technology, and management.

6.1 China Three Gorges Corporation - Synergistic Effect of Green Bonds and Hydropower Main Business[4]

6.1.1 Case description

China Three Gorges Corporation is the world's largest hydropower developer and an active issuer of green bonds in China. It uses the raised funds specifically for the construction and operation of giant hydropower stations such as Wudongde and Baihetan on the lower reaches of the Jinsha River. After these projects come into operation and generate electricity, they replace a large amount of fossil fuel power generation, directly resulting in a significant reduction in the carbon emission intensity within the operational scope of China Three Gorges Corporation. Its green bonds have received wide recognition from the international capital market, and the issuance interest rates are often higher than those of ordinary bonds.

6.1.2 In-depth analysis

Why can the success of the Three Gorges Project be replicated?

The success of the Three Gorges Project was not accidental. Its model has a high degree of replicability, and the core lies in the precise matching of "high-quality green assets" and "green financial tools".

Natural green assets: Hydropower is itself an internationally recognized and most mature form of clean energy. The core business of the Three Gorges Group is already a green project, which provides an indisputable underlying asset for the issuance of green bonds.

Financing cost advantage: Investors have a clear preference for truly green projects and are willing to accept lower yields. This enables the Three Gorges Group to finance at a lower cost, providing funds for project construction and forming a "low-cost funds → accelerated green project construction → generating environmental and economic benefits → enhancing credit, further reducing financing costs" virtuous cycle.

Standardized certification and disclosure system: The green bonds of the Three Gorges Group follow strict international and domestic standards, hire third-party institutions for green certification, and regularly disclose the use of funds and environmental benefits (such as power generation, carbon emission reduction). This transparent and standardized operation provides a clear template for other enterprises with clean energy assets (such as wind power, photovoltaic power, and nuclear power).

Replicable objects: For national energy groups, China General Nuclear Power Corporation, etc., which mainly focus on new energy or nuclear power, they can completely replicate the model of the Three Gorges Project, use green bonds to finance their wind farms, photovoltaic power stations, and nuclear power plant projects, rapidly expand green asset scale, and achieve carbon reduction targets.[5]

The underlying management mechanisms and policy support

Internal management mechanisms:

Special fund management: Establish a strict management system for the special accounts of green bond fundraising to ensure "separate use of funds", prevent fund misappropriation, and accept internal and external audits.

ESG governance system: Incorporate the improvement of environmental performance into the company's core strategy, establish a dedicated ESG or sustainable development committee, and promote the integration of green finance and business development from the top-level design.

External policy support:

China's Green Bond Standards: Unified standards issued by the People's Bank of China, the China Securities Regulatory Commission, etc., clarify the "green" attributes of projects in the hydropower sector, providing institutional guarantees.

Incentive policies: Regulatory authorities open "green channels" for approval, local governments may provide interest subsidies and other fiscal incentives, reducing the issuance threshold and cost.

"Dual Carbon" goal orientation: The national carbon neutrality strategy has created a huge market demand and stable policy expectations for green energy projects, ensuring the long-term economic viability of the projects.

6.2 Transformation Dilemma of China Huaneng Group - A Traditional Thermal Power Giant

6.2.1 Case description

As one of the largest power generation groups in

China, China Huaneng Group still has a relatively high proportion of coal-fired thermal power in its power supply structure. During the transition to new energy, although it has clear goals, the application of its green financial tools (such as green bonds) is relatively lagging or insufficient in scale. Therefore, in the elimination of outdated coal-fired power units, the construction of large-scale wind and solar power bases, and the research and development of carbon capture technologies, it may face greater financial pressure, resulting in a relatively slower decline in its overall carbon emission intensity and a less significant improvement in environmental performance compared to China Three Gorges Group.

6.2.2 In-depth analysis

The case of Huaneng Group serves as a counterexample to highlight the significance of green bonds.

Capital-intensive nature of transformation: Transitioning from thermal power to new energy requires a huge upfront capital investment. Relying solely on traditional debt financing or internal cash flow results in a slow process and significant financial pressure.

Lack of dedicated low-cost funds: Not utilizing green bonds means giving up an important source of low-cost funds, increasing the financial cost of the transformation and slowing down the transformation pace.

Challenges in asset structure: Unlike the Three Gorges Project, a large portion of Huaneng's existing assets are in thermal power. The funds raised through green bonds need to be clearly separated from the "non-green" main business, which poses higher requirements for internal fund management and project selection, and may to some extent hinder its issuance enthusiasm.

6.3 Baosteel Co., Ltd. - Green Bonds Drive Deep Decarbonization in the Steel Industry[4]

6.3.1 Case description

As a leading enterprise in China's steel industry, Baosteel Co., Ltd. issued a special green bond to support the hydrogen-based vertical furnace project at its Zhanjiang steel plant. This project is one of the disruptive technological paths for the steel industry to achieve deep decarbonization. With the financial support from the green bond, Baosteel was able to accelerate this landmark project, which is expected to significantly reduce the process carbon emissions in production and achieve remarkable improvements in environmental performance.

6.3.2 In-depth analysis

How does Baosteel achieve technological carbon reduction in its projects?

The traditional steelmaking process mainly employs the blast furnace - converter technology, using coal (coke) as the reducing agent and energy source, which is the main source of carbon emissions. The hydrogen-based vertical furnace technology principle of Baosteel is:

Technological path substitution: Use "hydrogen (H_2)" instead of "carbon (C)" as the reducing agent.

Chemical reaction change:

Traditional blast furnace: $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$ (Emits carbon dioxide)

Hydrogen kiln： $Fe_2O_3 + 3H_2 \rightarrow 2Fe + 3H_2O$ （Generate steam）

Fundamental decarbonization: The generation of CO_2 during the process was completely eliminated through chemical reactions, achieving "zero carbon smelting". As long as the hydrogen used is "green hydrogen" produced by electrolyzing water using renewable energy, the entire iron smelting process can nearly achieve zero carbon emissions.

The underlying management mechanisms and policy support

Internal management mechanisms:

Forward-looking technological strategy: Baosteel has identified hydrogen metallurgy as the core technological direction for addressing carbon neutrality and is conducting long-term research and strategic planning.

Project risk management: The hydrogen-based vertical furnace is a cutting-edge technology with significant investment. The dedicated use of green bonds helps the management to manage and control risks by treating the project as an independent strategic unit, ensuring that resources are concentratedly invested.

External policy support:

Green bond support directory for high-tech fields: China's green bond standards have included advanced low-carbon technologies such as hydrogen metallurgy in the support scope, providing policy basis for Baosteel to issue bonds.

"Supply-side reform" and environmental protection hard constraints: Stringent environmental regulations and total carbon emission control have forced steel enterprises to seek fundamental decarbonization solutions.

National Hydrogen Industry Plan: The strong support from the government for the hydrogen industry has made it possible for the large-scale and low-cost supply of "green hydrogen", and is the prerequisite for the success of the hydrogen-based kiln project.

6.4 Overall Comparison and Conclusion

The table 2 conducts a horizontal comparison of the distinct characteristics of the core business attributes, the mechanism of green bonds, the carbon emission reduction paths and the replicability of models among the three enterprises - China Three Gorges Corporation, Huaneng Group, and Baosteel Co., Ltd. It highlights the impact of the industry background and the compatibility of financial tools.

Table 2. The Characteristic Differences of China Three Gorges Corporation, Huaneng Group, and Baosteel Co., Ltd.

Comparison dimension	China Three Gorges Corporation	China Huaneng Group	Baosteel Co., Ltd.
Core business	Clean energy (hydroelectric power)	Hybrid energy (with thermal power as the main source)	High-carbon industry (steel industry)
Role of Green Bonds	Main business amplifier: Accelerate the construction of core green assets	Application deficiency: Lack of dedicated transformation funds	Transformation Engine: Providing Funding for Disruptive Technologies
Carbon reduction path	Energy substitution: replacing thermal power with hydropower	Structural optimization: Develop new energy sources, optimize thermal power generation	Industrial Revolution: Transforming Core Chemical Reactions
Replicability	Gao: Applicable to all companies engaged in clean energy businesses.	Warning: Reminding traditional enterprises to make good use of financial tools	Medium-high: Providing a model for deep decarbonization of high-carbon industries

6.5 Summary and Insights

6.5.1 Green bonds are not only financing tools but also strategic tools

They systematically promote enterprises' green transformation by reducing capital costs, strengthening professional management, and enhancing market image.

6.5.2 The key to success lies in "precise matching"

Whether it is the mature green assets of the Three Gorges or the cutting-edge decarbonization technologies of Baosteel, the funds from green bonds must be combined with clear and credible carbon reduction paths.

6.5.3 The core of replicability is standardization and transparency

The model of the Three Gorges can be replicated for other new energy companies, and the model of Baosteel can be replicated for other high-energy-consuming industries. The foundation is the establishment of a standardized project selection, fund management, and environmental benefit assessment system.

6.5.4 The dual drive of policy and market

The clear "dual carbon" goals of the country, green financial standards, and industrial policies, combined with the internal transformation needs of enterprises and the drive to seek advantages in the capital market, jointly constitute the fertile soil for the effectiveness of green bonds.

Therefore, for Chinese enterprises, especially those in the energy and heavy industry sectors, actively researching and utilizing green bonds is no longer an option but a necessary path for future competitiveness and sustainable development.

7. Conclusion and Recommendations

This report focuses on Chinese state-owned listed companies and systematically examines the causal effect and mechanism of green bond issuance on the environmental performance of enterprises. By constructing a comprehensive evaluation system including carbon emission intensity and ESG environmental ratings, and conducting empirical tests using the panel fixed effect model and PSM method, the study found: Firstly, the issuance of green bonds significantly improved the environmental performance of state-owned enterprises, and this conclusion remained valid after a series of robustness tests. Secondly, the heterogeneity analysis indicated that the environmental improvement effect of green bonds was more prominent in high-pollution industries and large state-owned enterprises. Finally, the mechanism test verified the effectiveness of the "lower financing cost - increased environmental investment" transmission path, demonstrating that green

bonds not only provided dedicated funds support, but also optimized the resource allocation decisions of enterprises through market-oriented mechanisms.

This study provides reliable causal evidence at the micro level for the environmental benefits of green bonds, deepening our understanding of the actual effects of green financial policies. The case study further reveals the differentiated implementation paths of green bonds in different industries and enterprises, providing practical references for policy formulation. However, this study still has certain limitations: the sample time span is relatively limited, and it fails to fully capture the long-term dynamic effects of green bonds; although multiple-dimensional indicators are used to measure environmental performance, the examination of broader ecological benefits such as coordinated pollution control is still insufficient.

Looking to the future, the research can be further developed in the following directions: First, expand the research sample to include private enterprises and compare the differences in the effects of green bonds under different ownership structures; second, track the specific flow of green bond funds and explore the differences in environmental returns for different investment directions (such as clean energy, pollution control, etc.); third, combine the process of the "dual carbon" target, conduct longer-term tracking research, and assess the potential contribution of green bonds to achieving carbon neutrality. These studies will further improve the theoretical framework of green finance and provide continuous theoretical support and practical guidance for building an efficient and transparent green bond market.

References

[1] Tang, Q., & Zhang, Y. (2020). Do green bonds improve corporate environmental performance? Evidence from China. Journal of Climate Finance, 1(1), 45–58.

[2] Li, S., et al. (2021). State-owned enterprises and carbon neutrality: Evidence from China. Energy Policy, 158, 112541.

[3] Hogan, J. E. (2001). Expected relationship value: A construct, a methodology for measurement and a modeling technique. Industrial Marketing Management, 30(4), 339–351.

[4] The People's Bank of China. Catalogue of Green Bond-Supported Projects (2024 Edition) [S]. Beijing: China Finance Press, 2024.

[5] State-owned Assets Supervision and Administration Commission of the State Council. Action Guide for Carbon Peaking and Carbon Neutrality of Central Enterprises [R]. Beijing: State-owned Assets Supervision and Administration Commission of the State Council, 2021.

[6] Wind Database, CSMAR Database. Financial and ESG Data of Chinese Listed Companies [DB/OL]. [Access Date]. https://www.wind.com.cn/ https://www.gtarsc.com/(https://www.gtarsc.com/)

