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Green Washing, Green Bond Issuance, and the Pricing of Carbon Risk: Evidence from A-Share Listed Companies

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Abstract: As global climate change intensifies and carbon emission policies become increasingly stringent, carbon risk has emerged as a crucial factor influencing corporate operations and financial markets. Based on data from A-share listed companies in China from 2009 to 2022, this paper empirically examines the pricing mechanism of carbon risk in the Chinese capital market and explores how different corporate signaling behaviors affect the carbon risk premium. The findings reveal the following: (1) Carbon risk exhibits a significant positive premium (annualized at about 1.33% per standard deviation), which remains robust over longer time windows and after replacing the measurement variables. (2) Heterogeneity analysis shows that the carbon risk premium is not significant in high-energy-consuming industries or before the signing of the Paris Agreement, possibly due to changes in investor expectations and increased green awareness. Additionally, a significant difference in the carbon risk premium exists between brown and green stocks, reflecting a "labeling effect" of green attributes. (3) Issuing green bonds, as an active corporate signaling behavior, effectively mitigates the carbon risk premium, indicating that market investors highly recognize and favor firms that actively convey green signals. (4) A "greenwashing" indicator constructed from textual analysis of environmental information disclosure suggests that greenwashing leads to a mispricing of the carbon risk premium. Companies that issue false green signals—publicly committing to environmental protection but failing to implement corresponding emission reduction measures—may mislead investors and create adverse selection problems. Finally, this paper provides recommendations for corporate carbon risk management and policy formulation, offering insights for both research and practice in the field.

Keywords: carbon risk; carbon information disclosure; text analysis; green washing; green bonds

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1. Introduction

Global climate change has become a pressing challenge facing all of humanity. In pursuit of the goals set by the Paris Agreement—to limit the global temperature rise to well below 2 °C, and preferably to 1.5 °C—countries around the world have pledged to achieve carbon neutrality. According to data from the Net Zero Tracker, as of April 2024, 148 economies have committed to carbon neutrality, and 1157 of the world's 2000 largest publicly listed companies have set carbon reduction targets. However, the United Nations Environment Programme (UNEP) warned in its 2023 Emissions Gap Report that current mitigation efforts remain far from sufficient. Without stronger actions, global temperatures are projected to rise by 2.5 °C to 2.9 °C by 2030.

Against this backdrop, China, as a key advocate of global climate governance, has not only proposed the strategic goals of peaking carbon emissions by 2030 and achieving carbon neutrality by 2060, but has also actively promoted green and low-carbon development through policy guidance and financial innovation. From issuing the Guidelines on Establishing the Green Financial System and promoting the inclusion of green finance on the G20 agenda, to continuously improving the green finance standard system and information disclosure mechanisms, China has become a pivotal force in the advancement of global green finance. The successive release of the Opinions of the CPC Central Committee and the State Council on Accelerating the Comprehensive Green Transition of Economic and Social Development and the Opinions on Leveraging Green Finance to Support the Construction of a Beautiful China in 2024 marked a new phase for China's green finance, characterized by systemic coordination and comprehensive integration. Subsequently, the Guiding Opinions of the General Office of the State Council on Advancing the "Five Key Financial Tasks" further emphasized the importance of building a modern financial system aligned with the new development paradigm, placing green finance at the core of financial supply-side structural reform.

However, despite the continuous introduction of relevant policies and the ongoing innovation of green financial instruments, the current development of green finance in China remains largely focused on macro-level policy implementation and institutional design, while relatively limited attention has been paid to the identification and management of carbon emission risks at the corporate level. At the same time, the realization of China's "dual carbon" goals is still confronted with the daunting challenge of a tight timeline and heavy tasks [1]. Carbon risk generally refers to the potential risks associated with greenhouse gas emissions, particularly carbon dioxide. For firms, such risks primarily arise from various uncertainties and potential financial impacts encountered during the transition from a "brown economy" to a "green economy" [2]. Depending on the analytical perspective, the academic literature has proposed different classifications of carbon risk. For instance, Subramaniam et al. [3] classify carbon risk into strategic risk, operational risk, compliance risk, reporting risk, and reputational risk. Gasbarro et al. [4] further divide it into seven categories: regulatory risk, physical change risk, reputational risk, changes in customer demand, product and technological innovation, operational risk, and financial risk.

China is currently in a critical and time-sensitive phase of achieving its carbon peaking target [5]. Green finance plays a key role in achieving sustainable development goals [6]. Although notable progress has been made in the field of green finance, risks associated with corporate carbon emissions have yet to receive adequate attention. In many asset pricing studies, the pricing of carbon risk is similarly overlooked. This neglect may lead to misjudgments of potential corporate risks in the market and hinder investors from fully assessing climate-related risks. Meanwhile, the existing literature tends to ignore firms' diverse signaling behaviors—particularly in the contexts of green bond issuance and carbon disclosure—where companies may influence market perceptions of their carbon risks through either credible signals or "greenwashing". As emphasized by UN Secretary-General António Guterres in Integrity Matters at COP27: "We urgently need every company, investor, city, state and region to walk the talk on their net-zero promises. We cannot afford slow movers, fake movers or any form of greenwashing". Therefore, it is of both theoretical and practical significance to explore how different corporate signaling behaviors affect the carbon risk premium.

Based on data from Chinese A-share listed companies from 2009 to 2022, this paper systematically analyzes the pricing mechanism of carbon risk in the capital market. Unlike previous studies, this paper is the first to incorporate corporate green bond issuance and

greenwashing behavior into the analysis. The findings show that green bond issuance can effectively mitigate the carbon risk premium; however, greenwashing, due to investors' reliance on disclosed information, also impacts the carbon risk premium and leads to mispricing of carbon risk in the market. This study enriches the micro-level understanding of risk identification and management in green finance, holds significant theoretical and practical implications, and contributes to the realization of China's "dual carbon" goals and the healthy development of green finance.

2. Literature Review and Hypothesis Development

2.1. Measurement of Carbon Risk

Currently, there is no unified standard for measuring carbon risk in academia. This paper summarizes the existing literature and identifies several commonly used measurement approaches. First, carbon risk is often assessed based on direct carbon emissions and their growth [7], or through derived indicators such as carbon intensity [7,8] and carbon emission efficiency [9]. These fundamental indicators reflect a firm's emission scale and are used to estimate its exposure to carbon-related risks. Second, some studies use indirect emissions to gauge carbon risk. In earlier periods when carbon disclosure was less developed, some papers investigated the relationship between carbon allowance prices and asset prices [10], while others used industry-level carbon emissions as a proxy [11]. Finally, several studies have constructed composite indicators to measure carbon risk. For example, Zhou et al. [12] used penalties and violation types related to carbon emissions to evaluate risk, whereas Görgen et al. [2] have developed a "brown-to-green" score based on ESG databases as a fundamental measure of carbon risk.

2.2. The Impact of Carbon Risk on Asset Pricing

In most of the existing asset pricing literature, the risks associated with corporate carbon emissions have not received sufficient attention. One possible reason for this neglect is that widespread concern over climate change driven by CO_2 emissions has only emerged in recent years. Currently, institutional investors have increasingly regarded carbon emission risk as an important factor in portfolio decision-making [13].

Whether carbon risk commands a positive premium in the stock market remains inconclusive, and even the very existence of a carbon risk premium is still a highly debated issue [14]. This paper summarizes and analyzes the differing perspectives in the existing literature.

First, a prominent strand of research supports the existence of a positive carbon risk premium. Early work can be traced back to Oestreich and Tsiakas [15], who constructed portfolios using EU carbon allowance data and found that firms with greater carbon risk achieved significantly higher returns. Subsequently, Bolton and Kacperczyk [7] utilized data on 2900 publicly listed U.S. companies from the S&P Global database and showed that, after controlling for size, market capitalization, momentum, and other return predictors, stocks of firms with higher carbon emissions and emission growth earned higher returns. They argue that investors demand higher expected returns from high-emission firms as compensation for their greater exposure to climate policy risks. Gerged et al. [16], through an analysis of the UK's mandatory greenhouse gas (GHG) disclosure policy, found an inverted U-shaped relationship between carbon risk and the cost of equity, further supporting the connection between high carbon risk and market performance. Later, Bolton and Kacperczyk [17] extended their research to 77 countries globally, providing broader evidence of the widespread existence of a positive carbon risk premium. Collectively, these studies support the view that firms with higher carbon emissions must offer higher returns to compensate investors for bearing additional risks.

Second, some studies argue the opposite—that companies facing higher carbon risks tend to deliver lower expected returns, suggesting the existence of a negative carbon risk premium. Choi and Luo [18] examined whether voluntary carbon disclosure affects firm valuation and found a negative correlation between carbon emissions and firm value. Two hypotheses have been proposed to explain the negative carbon premium: the "preference hypothesis" suggests that ESG-conscious investors drive up the prices of green stocks [19], while the "inefficiency hypothesis" posits that companies with strong ESG performance might generate higher returns because the market has not fully priced in their favorable fundamentals [20].

Lastly, a third strand of research claims that no significant carbon risk premium exists. Some studies suggest that green firms may benefit from policy support and increased environmental demand, which raise their expected cash flows and partially offset carbon risk effects [2]. Zhang [14] offers another perspective, arguing that previously observed positive carbon risk premiums may not reflect true risk compensation, but rather stem from the forward-looking firm performance information embedded in carbon emission levels.

The pricing effect of carbon risk is not limited to equity markets—it also significantly affects other asset classes. While most studies focus on stock markets, other financial instruments are similarly influenced by carbon risk, as summarized below. For instance, in the bond market, there is no clear consensus on the direction of the carbon premium. Some studies argue that the "carbon risk compensation" hypothesis does not hold, and that bonds issued by firms with higher carbon emissions tend to deliver significantly lower returns [21]. Seltzer et al. [22] found that firms with higher carbon footprints generally receive lower credit ratings and exhibit larger yield spreads. A few studies have also explored the influence of carbon risk on options [23], bank loans [24], and other financial instruments, although this area of research remains relatively underdeveloped.

2.3. Corporate Greenwashing Behavior and Green Bond Issuance

Corporate "greenwashing" refers to a practice where companies claim that their products, services, and operations meet green, low-carbon, and environmental standards through public relations, marketing, and information disclosure, while in reality, there exists a significant discrepancy between their claims and actual performance [25]. Greenwashing primarily manifests in the manipulation or embellishment of carbon emission-related data and disclosures.

So, why do companies adopt greenwashing strategies? One explanation is that greenwashing is a way for corporate managers, under market pressure, to cater to stakeholders' preferences for corporate social responsibility (CSR) [26]. Internally, as commercial banks and investment funds reduce lending and investment in brown (high-carbon) firms and shift toward green firms, greenwashing companies can obtain loans or investment at lower financing costs [27]. For external stakeholders such as institutional investors and government bodies, their preference for green practices signals clear expectations to companies. Investors are increasingly willing to pay a premium for ESG-compliant firms even at the cost of lower excess returns [20], while governments emphasize how corporate ESG practices can help achieve "dual carbon" (carbon peaking and neutrality) goals [28].

Environmental regulation is an important policy tool for promoting green development [29], and green bonds, as a new type of financial instrument that integrates environmental attributes with financial functions, serve as a key pathway for enterprises to respond to environmental regulations and advance green transformation [30]. As a vital component of China's green financial system, green bonds have achieved market-oriented development under policy guidance. According to the Green Finance International Research Institute at the Central University of Finance and Economics, green bond issuance

in 2023 alone reached approximately CNY 838.87 billion. From the issuer's perspective, companies with strong CSR and environmental awareness are more inclined to issue green bonds to support their green transformation [31]. A study by Zhu et al. [32] found that although green bonds can convey green signals, they have not effectively attracted more social investment.

2.4. Hypothesis Development

Based on a review of the existing literature, it is evident that carbon risk pricing has become a key topic in financial market research, especially under the increasingly severe global climate change context. Zhang and Liu [33] point out that carbon risk can affect financial markets through two channels: physical risks and transition risks. Due to the long-term, structural, and systemic nature of carbon emissions and global warming, these risks may profoundly impact the real economy and financial stability [34]. Physical risks stem from the direct environmental damage caused by climate change, such as floods, droughts, hurricanes, and rising sea levels. Transition risks, on the other hand, arise from the challenges associated with the shift to a low-carbon economy, including policy, technological, and market changes. Current research tends to focus more on transition risks, which mainly manifest in three aspects: policy and regulatory risk—emission reduction policies may exert pressure on corporate operations and strategic planning [8]; technological risk—the costs associated with adopting low-carbon technologies, including emission reduction costs [35], green innovation patents [36], and R&D expenditures [37]; investor preference shifts—a sudden surge in demand for low-carbon products or decreased demand for carbon-intensive products can directly affect the cash flows of green and brown firms [19].

To cope with the uncertainty of carbon risks, investors typically demand higher expected returns, which aligns with the classical risk compensation hypothesis. This hypothesis holds that asset prices should reflect the additional returns investors require to bear specific risks. For high-emission companies, investors expect that such risks could lead to future cash flow uncertainty and rising capital costs, thus demanding a higher return to hedge against these potential losses. Based on the above analysis, this paper proposes the following hypotheses:

Hypothesis 1: *Investors will demand higher expected returns for holding stocks of high-emission companies as compensation for their exposure to carbon risk.*

In signaling theory proposed by Kaun and Spence [38], companies can transmit internal quality or values by sending signals. Greenwashing or green bond issuance are different strategies companies use to send signals to the market, reflecting corporate responses to carbon risk and disclosure pressures. Existing research shows that green silence, or reverse greenwashing by heavily polluting firms, can effectively hedge their carbon risk premium. The higher the level of silence, the more it can suppress carbon risk premiums [39]. However, studies on the impact of green bond issuance on carbon risk pricing remain limited. The existing literature mostly focuses on its impact on corporate financing costs and ESG performance [40].

From the reputation perspective, a strong reputation can continuously create value for a firm [41]. Mahmood et al. [42] found that a green corporate image plays an important role in a company's green innovation activities. From the financing perspective, signaling builds communication channels with stakeholders such as governments and financial institutions, allowing firms to access more resources and seize development opportunities [43]. Companies that proactively issue green bonds demonstrate their commitment to sustainability, which helps attract capital from green-oriented investors, enhance brand image, and

strengthen corporate social responsibility, thereby boosting market competitiveness. Amid tightening climate policies, corporate signaling becomes increasingly critical. By issuing green bonds, firms can effectively signal their commitment to environmental stewardship, lower financing costs, and build green reputations, thereby partially hedging carbon risk premiums. Based on the above analysis, this paper proposes the following:

Hypothesis 2: *Green bond issuance, as a proactive green signal from firms, can effectively hedge carbon risk premiums.*

However, some firms choose to adopt greenwashing strategies, whereby they create a false sense of green commitment through misleading or exaggerated claims without taking substantial green actions. This tactic may attract environmentally conscious investors and stakeholders in the short term, enhancing the firm's public image and alleviating immediate negative impacts from climate policies or market pressure, thereby temporarily reducing carbon risk premiums.

Nevertheless, such false green signals undermine trust in genuine green efforts, leading to adverse selection—firms that truly engage in green practices may be misunderstood or overlooked, while non-compliant firms may reap undeserved benefits. This distortion of market signals not only skews carbon risk pricing but also weakens the overall impact of green investment. Worse still, once the deception is exposed, the firm may suffer reputational damage, a loss of investor trust, and regulatory penalties—consequences that can significantly affect its market performance and long-term viability. Based on the above analysis, this paper proposes the following:

Hypothesis 3: *Greenwashing, defined as the transmission of misleading green signals through false "green commitments," can lead to the mispricing of carbon risk premiums in the short term.*

3. Research Design

3.1. Data Sources

This study selects the period from 2009 to 2022 as the sample interval. After excluding ST-designated stocks and firms with missing data, a strongly balanced panel dataset comprising 452 A-share listed companies is obtained. According to the national industry classification, the sample is heavily concentrated in the manufacturing sector, with 312 firms, highlighting the sector's representativeness in carbon emission research.

It is worth noting that, due to the underdeveloped carbon information disclosure system in the early years and limited data availability, the sample size in this study is relatively limited. Moreover, the sample primarily consists of large enterprises with relatively complete and standardized carbon disclosure. As such, the dataset mainly reflects how leading Chinese firms respond to the carbon neutrality goal, particularly their exemplary role in advancing carbon risk management and green finance. However, these firms may not fully represent the broader corporate landscape in terms of carbon risk pricing behavior. Therefore, future research could expand the sample to include small- and medium-sized enterprises as well as firms from a wider range of industries, to provide a more comprehensive assessment of China's market response to climate change and progress toward its "dual carbon" targets.

The data sources for this study are as follows: (1) Carbon emission intensity data were manually collected from corporate social responsibility reports, sustainability reports, and environmental reports disclosed by the companies, and further carbon emission data and emission intensity were calculated following the methods published by the National Development and Reform Commission. (2) "Greenwashing" behavior was measured by

using Python (version 3.11) text analysis techniques to extract carbon information disclosure data from annual reports and combining them with actual emission reduction actions to assess companies' "greenwashing". (3) Green bond data were manually compiled based on the green bonds issued during the sample period. (4) Corporate financial data and stock market data were sourced from the CSMAR database.

3.2. Variable Description

3.2.1. Dependent Variable

Existing studies on carbon risk pricing often use cross-sectional regressions of stock returns [8,17,44], and this paper also adopts this method for testing. The dependent variable in this study is the monthly excess return of stocks, measured by subtracting the risk-free rate from the monthly individual stock return, considering cash dividend reinvestment through CSMAR.

3.2.2. Independent Variable

Not all companies directly disclose their carbon emissions data, but they usually report other information related to carbon emissions, such as fossil energy consumption, electricity usage, and heating usage. This paper follows the research methodology of Wang et al. [8], and for companies that do not disclose carbon emissions data, it uses the calculation methods recommended in the "Corporate Greenhouse Gas Emission Accounting and Reporting Guidelines" issued by the National Development and Reform Commission and the "IPCC Guidelines for National Greenhouse Gas Inventories" (2006) to estimate nine categories of carbon emissions. These include emissions from fossil fuel combustion, emissions from biomass fuel combustion, emissions from raw material extraction and fugitive emissions, fugitive emissions from oil and gas systems, indirect carbon emissions from electricity imports and exports, emissions from production processes, emissions from solid waste incineration, emissions from wastewater treatment, and emissions from land-use changes (such as forest conversion to industrial land). By summing these emissions categories, the overall carbon emissions data for the company are obtained.

Compared to directly using total carbon emissions to measure carbon risk, carbon intensity reflects the amount of carbon emissions per unit of output (such as revenue or assets), linking carbon emissions to company size.

3.2.3. Control Variables

The control variables in this study are divided into two main categories. The first includes daily return-based monthly CAPM Beta [45], market capitalization, and the book-to-market ratio [46]. The second category refers to the research by [47], and incorporates firm age, cash flow, debt-to-asset ratio, return on assets, growth capability, and the number of executives. The definitions and treatment methods of specific variables are summarized in the table below (Table 1).

Table 1. Variable definitions.

Variable Type	Variable Name	Symbol	Definition
Dependent Variable	Excess Return	Excess return	Monthly individual stock return (with reinvested cash dividends) minus the risk-free rate
Independent Variable	Carbon Intensity	Carbon intensity	Ratio of total carbon emissions to operating revenue
Moderating Variable	"Greenwashing" Behavior	Greenwashing	Measured by the gap between corporate statements and actions (i.e., greenwashing)
	Green Bond Issuance	Green bond	Equals 1 if the firm has issued green bonds; 0 otherwise

Table 1. *Cont.*

Variable Type	Variable Name	Symbol	Definition
Control Variable	CAPM Beta	β	Obtained by regressing daily stock returns on market returns over the past year, then averaged monthly
	Market Capitalization	Lnm	Natural logarithm of monthly total market capitalization
	Book-to-Market Ratio	Bm	Ratio of book value of equity to its market value
	Firm Age	Lnage	Natural logarithm of the number of years since the firm's establishment
	Cash Flow	Cash flow	Difference between cash inflows and outflows from operating activities
	Leverage Ratio	Lev	Ratio of total liabilities to total assets
	Return on Assets	Roa	Ratio of net profit to average total assets
	Growth Ability	Growth	Growth rate of operating revenue
	Number of Executives	executives	Natural logarithm of the number of top executives

3.2.4. Moderator Variable

(1) "Greenwashing" Behavior

This paper, from the perspective of environmental information disclosure, will use Python text analysis to identify corporate "greenwashing" behavior. Since "greenwashing" refers to companies that may disclose carbon information externally but do not engage in actual emissions reduction actions, we need to consider both "words" and "actions," meaning we need to account for both the carbon information disclosure and emissions reduction actions of companies.

Specifically, drawing on the methodology of Wu et al. [48], this study constructs a text-mining dictionary based on key national carbon-related policies and regulations. Keywords are categorized into six dimensions: low-carbon strategy, publicity, policy, and philosophy; low-carbon management; carbon emissions disclosure; carbon information; low-carbon research investment and outcomes; and third-party evaluation. For example, the dimension of low-carbon strategy, publicity, policy, and philosophy contains 65 keywords, with representative terms such as "carbon peaking" and "carbon neutrality". A complete list of keywords under the six dimensions can be found in Appendix A.

Using this dictionary, we can obtain word frequency statistics from the annual reports and social responsibility reports of the sample companies under study and use this as a measure of corporate carbon information disclosure behavior. Regarding the measurement of corporate carbon emissions reduction behavior, several measurement methods exist. Cheng et al. [39] built a corporate carbon reduction action scoring system from the perspective of "action-effect-certification" using text analysis. This paper, however, follows the approach of Tian et al. [49], directly measuring companies' actual emissions reduction actions from the perspective of emission reduction results.

After obtaining the "words" and "actions" measurement indicators, this paper, following the method of Sun et al. [50], calculates the discrepancy between words and actions to measure corporate "greenwashing" behavior. The specific calculation method is as follows:

$$\text{Green_washing}_{i,t} = \frac{\left(\text{Word}_{i,t} - \overline{\text{Word}_t}\right)}{\sigma_{\text{Word}_t}} - \frac{\left(\text{Action}_{i,t} - \overline{\text{Action}_t}\right)}{\sigma_{\text{Action}_t}}$$

After obtaining the discrepancy between "words" and "actions" for corporate "greenwashing" behavior, we can further define it. First, we determine whether a company exhibits "greenwashing" behavior. If greenwashing is greater than 0, we consider that the company is engaging in "greenwashing" behavior. Second, we measure the degree of

"greenwashing". When greenwashing is greater than 0, we take the value of greenwashing; when greenwashing is less than or equal to 0, we assign a value of 0.

(2) Green Bond Issuance

This study uses a dummy variable to measure green bond issuance. Specifically, we manually collected information on green bond issuance by listed companies and matched it with the sample used in this study. Among the final sample of 452 firms, 22 companies were identified as having issued green bonds. For these firms, the variable green bond is assigned a value of 1 after the issuance of green bonds; otherwise, it is assigned a value of 0.

3.3. Model Construction

The first step of the empirical analysis in this study is to examine the existence of a carbon risk premium. Drawing on existing literature, this paper employs a two-way fixed-effects model to investigate the relationship between firms' carbon emission intensity and their monthly excess stock returns.

$$\textbf{Excess return}_{i,t+j} = \beta_0 + \beta_1 \textbf{Carbon intensity}_{i,t} + \sum_j \beta_j \textbf{Controls}_{i,t} + \lambda_t + \mu_i + \varepsilon_{i,t}$$

In this model, excess return represents the monthly excess return of a stock and carbon intensity refers to the level of carbon emission intensity of a firm. This study adopts a two-way fixed-effects model, where λ_t denotes time fixed-effects, μ_i denotes firm fixed-effects, and $\varepsilon_{i,t}$ is the error term. The subscripts i and t refer to firm and time, respectively. If β_1 is significantly positive, it indicates a positive carbon risk premium, meaning that firms with higher carbon intensity earn higher excess returns. If β_1 is significantly negative, it indicates a negative carbon premium. If β_1 is statistically insignificant, it suggests no carbon risk premium.

Building on this, to further explore the moderating role of green bond issuance and potential greenwashing behavior in the pricing of carbon risk, this paper constructs an extended model incorporating moderation effects. Specifically, moderating variables and their interaction terms with carbon intensity are introduced into the baseline regression model to test their influence on the carbon risk premium.

4. Baseline Results and Robustness Checks

4.1. Descriptive Statistics

Table 2 presents the descriptive statistics of the key variables used in this study. The monthly excess return reaches a maximum of approximately 2 and a minimum of around −0.65, indicating significant fluctuations in stock prices. Meanwhile, carbon intensity ranges from a minimum of 0.229 to a maximum of 32.532, suggesting notable differences in carbon intensity across firms.

Table 2. Descriptive statistics of key variables.

VarName	Obs	Mean	SD	Min	Median	Max
Excess Return	71,746	0.011	0.124	−0.652	0.001	2.009
Carbon Intensity	71,868	3.256	0.634	0.229	3.232	32.523
CAPM Beta	71,715	1.078	0.584	−7.528	1.075	29.333
Market Capitalization	71,868	0.692	0.267	0.040	0.702	1.522
Book-to-Market Ratio	71,746	16.014	1.082	13.168	15.860	21.748
Firm Age	71,868	2.576	0.540	0.000	2.708	3.401
Cash Flow	71,868	13.386	114.174	−681.250	1.298	3666.550
Leverage Ratio	71,868	0.485	0.196	0.007	0.497	1.096
Return on Assets	71,868	0.049	0.054	−0.364	0.038	0.477
Growth Ability	71,832	0.221	6.185	−2.683	0.033	922.348
Number of Executives	71,856	1.889	0.380	0.000	1.946	3.761

4.2. Baseline Regression Results

The empirical results of carbon risk pricing are presented in Table 3. Overall, the regression analysis confirms a positive relationship between carbon emission intensity and monthly excess stock returns, indicating that carbon risk is effectively priced in the Chinese market and that there exists a significant positive carbon risk premium, thereby validating Hypothesis 1. The specific findings are as follows:

Table 3. Baseline regression results.

	(1) **Excess Return**	**(2)** **Excess Return**
Carbon Intensity	0.00172 **	0.00175 **
	(2.31)	(2.52)
CAPM Beta	−0.00057	−0.00008
	(−0.72)	(−0.09)
Book-to-Market Ratio	−0.02311 ***	0.01948 ***
	(−10.94)	(3.21)
Market Capitalization	0.00550 ***	0.03289 ***
	(11.02)	(13.24)
Firm Age	−0.00832 ***	−0.00693 **
	(−9.41)	(−2.06)
Cash Flow	−0.00002 ***	−0.00001 *
	(−3.56)	(−1.65)
Leverage Ratio	0.01746 ***	0.02759 ***
	(6.15)	(3.94)
Return on Assets	0.04055 ***	0.06925 ***
	(3.87)	(4.69)
Growth Ability	−0.00003	0.00002 **
	(−0.36)	(2.00)
Number of Executives	−0.00357 ***	−0.00715 ***
	(−2.83)	(−3.57)
_cons	−0.04811 ***	−0.52017 ***
	(−5.99)	(−11.97)
Individual Fixed-Effects	No	Yes
Time Fixed-Effects	No	Yes
N	71,579	71,579
Adj. R2	0.007	0.381

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 3 reports the regression results of carbon intensity on excess stock returns. In Column (1), a range of control variables are included—such as the book-to-market ratio, firm size, firm age, and cash flow—to account for firm-specific fundamentals. The results show that carbon intensity remains positively and significantly associated with excess returns, suggesting that the carbon risk premium persists even after controlling for financial characteristics. Column (2) builds upon Column (1) by further incorporating firm and time fixed-effects to control for unobservable firm-level heterogeneity and macroeconomic trends. Despite the more stringent model specification, the coefficient on carbon intensity remains significantly positive, implying that the carbon risk premium is not driven by omitted variable bias or market noise, but is robust. This further confirms that carbon risk is priced in China's capital market.

The estimated coefficient of carbon intensity ($\beta = 0.00175$) indicates that a one-unit increase in carbon intensity is associated with a 0.175 percentage point increase in monthly excess returns. Given that the standard deviation of carbon intensity is 0.634, a one-standard-deviation increase corresponds to an increase of approximately 0.111 percentage

points in monthly excess returns, or about 1.33 percentage points annually. Comparing firms with high and low carbon intensity reveals that carbon-intensive firms earn significantly higher excess returns. This suggests that the capital market provides positive compensation for carbon risk, indicating that the carbon risk premium has been recognized by investors and incorporated into the asset pricing process.

As for the control variables, several deserve attention. First, the market beta is found to be insignificant, which aligns with the findings of Pan and Xu [51], who suggest that the traditional beta coefficient does not effectively explain stock returns in the Chinese A-share market. Although both firm size and the book-to-market ratio are significant, the sign of the book-to-market ratio changes from negative to positive after the inclusion of fixed effects. Nevertheless, this paper does not focus on these factors; different samples and control variables may yield different outcomes, but these do not affect the core conclusion regarding carbon risk.

4.3. Robustness Check

4.3.1. Carbon Risk Pricing over a Longer Time Horizon

Existing studies on carbon risk pricing in China primarily examine the effect of current carbon risk on excess returns in the following month. Building on this approach, this paper further investigates the impact of carbon risk on excess returns three months ahead. As shown in Table 4, the significance of carbon intensity increases compared to the baseline results. This not only provides further evidence supporting the existence of a positive carbon risk premium, but also enhances the robustness of the findings, indicating that carbon risk continues to have a significant impact on firm stock returns over a longer time horizon.

Table 4. Carbon risk pricing over a longer time horizon.

	(1) **Excess Return**	**(2)** **Excess Return**
Carbon Intensity Lagged by Three Periods	0.00184 ** (2.42)	0.00230 *** (3.94)
_cons	−0.07899 *** (−9.76)	−0.54117 *** (−11.83)
Control Variables	Yes	Yes
Individual Fixed-Effects	No	Yes
Time Fixed-Effects	No	Yes
N	70,227	70,227
Adj. R^2	0.007	0.376

** $p < 0.05$, *** $p < 0.01$.

4.3.2. Replacing the Dependent Variable

To enhance the robustness of the empirical results, this study further re-examines carbon risk using alternative variables. Specifically, carbon emissions are first used as a measure of carbon risk. Secondly, a carbon intensity metric based on a firm's direct operational activities is introduced, which primarily includes emissions from fuel combustion and production processes, excluding indirect and other sources of emissions. This approach helps to focus on the carbon risk arising from a firm's own activities, minimizing the influence of external factors, and thereby providing a more accurate risk identification. The regression results, as shown in Table 5, indicate that carbon risk continues to exhibit a significant positive premium under the alternative variables, further validating the robustness of the baseline regression results.

Table 5. Replacing the independent variable.

	(1) **Excess Return**	**(2)** **Excess Return**
Total Carbon Emissions (in Million Tons)	0.00013 * (1.79)	
Carbon Intensity Based on Direct Operational Activities		0.00292 *** (3.27)
_cons	−0.51108 *** (−11.73)	−0.52205 *** (−12.01)
Control Variables	Yes	Yes
Individual Fixed-Effects	No	Yes
Time Fixed-Effects	No	Yes
N	71,579	71,579
Adj. R^2	0.381	0.381

* $p < 0.1$, *** $p < 0.01$.

4.3.3. Instrumental Variables Regression

This study has already validated the presence of a positive carbon risk premium in the Chinese stock market. However, since there may be omitted variable bias or other issues between carbon risk and stock returns, endogeneity problems may arise. Although the baseline regression uses a two-way fixed-effects model, which partially addresses endogeneity issues, the fixed-effects model can only control for unobservable individual heterogeneity and time effects. It cannot fully eliminate potential endogeneity between carbon risk and other control variables. Therefore, this paper adopts the instrumental variable (IV) method to further resolve the endogeneity problem. A valid instrument must meet two conditions: relevance and exogeneity. We choose the Paris Agreement as the instrumental variable because it represents a significant global climate governance event that directly impacts a firm's exposure to carbon risk, but it has no direct relationship with excess returns of individual stocks, thus satisfying the exogeneity requirement for an instrument. At the same time, the policy changes resulting from the Paris Agreement could indirectly affect firms' carbon risk through channels such as carbon emission regulations and carbon trading markets, thus fulfilling the relevance requirement.

The endogeneity test results are shown in Table 6. In the first-stage regression, the coefficient of the Paris Agreement is significantly negative, indicating that corporate carbon emission intensity generally declined following the implementation of the Agreement. This result is consistent with the policy intention of the Paris Agreement to guide emission reductions by strengthening environmental regulations and disclosure requirements. It suggests that the instrument has strong explanatory power in capturing changes in carbon emissions. The F-statistic for the first-stage regression is 24.28, indicating that the instrumental variable is strongly correlated in the first stage and passes the weak instrument test. This also suggests that the Paris Agreement has significantly constrained firms' carbon emission behavior, pushing them to implement more proactive emission reduction actions through international policy initiatives. The second-stage regression results further confirm that carbon risk still exhibits a significant positive premium, validating the robustness of the model results and effectively addressing the endogeneity issue. This result clearly demonstrates that, even after controlling for potential endogeneity, the impact of carbon risk on stock market returns remains significant and displays a positive premium.

Table 6. Two-stage least squares regression.

	(First Stage) Carbon Intensity	(Second Stage) Excess Return
Paris Agreement	−0.12982 ***	
	(−5.18)	
Fitted Carbon Intensity		0.93882 ***
		(18.41)
_cons	4.74519 ***	−5.27021 ***
	(37.59)	(−19.58)
Control Variables	Yes	Yes
Individual Fixed-Effects	Yes	Yes
Time Fixed-Effects	Yes	Yes
N	71,579	71,579
Adj. R2	0.081	0.050

*** $p < 0.01$.

5. Further Analysis

5.1. Heterogeneity Analysis

5.1.1. Pricing Differences Between High-Energy-Consumption and Low-Energy-Consumption Industries

According to the definition in the "Letter on Clarifying Matters Related to the Implementation of the Policy for Reducing Electricity Costs in Stages" issued by the National Development and Reform Commission, high-energy-consuming industries include six major sectors: petroleum, coal, and other fuel-processing industries; chemical raw materials and chemical products manufacturing; non-metallic mineral products; ferrous metal smelting and rolling; non-ferrous metal smelting and rolling; and electric power and heat production and supply industries. In this paper, the sample is divided into high-energy-consuming and low-energy-consuming industries to examine industry heterogeneity. The results, as shown in Table 7, indicate that carbon risk is not effectively priced in high-energy-consuming industries. This finding is consistent with previous studies, which generally attribute it to two factors: investors' misclassification of industries, and their potential tendency to avoid investing in high-energy-consuming firms [8]. However, this paper argues that these two hypotheses have limited explanatory power. Investors are unlikely to overlook a company's core business, and when comparing excess stock returns between high-energy and low-energy industries, no significant difference was found.

Table 7. Industry heterogeneity test.

	(1) Low-Energy-Consumption Industries	(2) High-Energy-Consumption Industries
Carbon Intensity	0.00179 **	0.00235
	(2.38)	(1.39)
_cons	−0.50350 ***	−0.61536 ***
	(−10.48)	(−6.29)
Control Variables	Yes	Yes
Individual Fixed-Effects	Yes	Yes
Time Fixed-Effects	Yes	Yes
N	56,550	15,029
Adj. R^2	0.381	0.408

** $p < 0.05$, *** $p < 0.01$.

However, from the perspective of investors, even if a thermal power company faces risks such as equipment upgrades, investors are unlikely to demand excessive returns, as power generation is its core business and carbon emissions are inevitable. Therefore, investors tend to anticipate such issues and price in carbon risks in advance, rendering carbon emission disclosures by high-emission firms less informative. At the same time, investors may believe that such firms, under policy support or expectations of technological advancement, could see an improvement in their carbon risk exposure. This line of reasoning is more applicable in countries with stable institutional environments and clearly defined paths toward energy transition [52,53], such as China. Hence, under a context of well-established regulatory frameworks and market expectations, the carbon risks faced by high-emission firms may be "digested" by the market and thus fail to result in significant excess return premiums.

5.1.2. Pricing Differences Between Brown and Green Stocks

The concept of "green stocks" was first introduced through a collaboration between a Swedish bank and the Center for International Climate and Environmental Research (CICERO). In 2020, the world's first green stock was officially launched in Sweden. Recently, seven departments, including the People's Bank of China, jointly issued the Guidelines on Further Strengthening Financial Support for Green and Low-Carbon Development, which explicitly called for "researching and formulating standards for green stocks and unifying green stock business rules". Although research on green finance has expanded from green bonds to green stocks, studies on the pricing differences in carbon risk between green and brown stocks remain relatively limited. On the one hand, green and brown companies face drastically different climate policy pressures and market preferences, which may lead to differences in how investors price their carbon risks. On the other hand, this disparity reflects shifts in investors' risk attitudes and market allocation tendencies in the context of rising climate awareness.

This paper draws on the approach of Ardia et al. [54], which defines green (brown) firms as those that minimize (rather than just reduce) the harm of climate change while creating economic value. Firms are ranked by their greenhouse gas emission intensity, and their classification as green or brown depends on their relative position within the distribution (the first two columns). Additionally, this paper also classifies firms based on the average emission level (the last two columns). As shown in Table 8, carbon risk has opposite impacts on the excess returns of brown and green stocks.

Table 8. Pricing differences between brown and green stocks.

	(1) **Brown Stocks**	**(2)** **Green Stocks**	**(3)** **Brown Stocks**	**(4)** **Green Stocks**
Carbon Intensity	0.00383 ***	−0.00631 **	0.00396 ***	−0.00436
	(5.40)	(−2.22)	(5.47)	(−1.62)
_cons	−0.57164 ***	−0.56277 ***	−0.57108 ***	−0.56069 ***
	(−10.59)	(−9.18)	(−10.31)	(−9.57)
Control Variables	Yes	Yes	Yes	Yes
Individual Fixed-Effects	Yes	Yes	Yes	Yes
Time Fixed-Effects	Yes	Yes	Yes	Yes
N	35,753	35,826	33,942	37,637
Adj. R2	0.382	0.380	0.383	0.379

** $p < 0.05$, *** $p < 0.01$.

Specifically, for brown stocks, the significantly positive coefficient of carbon intensity supports the carbon risk premium hypothesis—that is, firms with higher carbon intensity

must offer greater excess returns to compensate for perceived risk by investors. In contrast, the carbon intensity coefficient for green stocks is either insignificant or significantly negative. This may reflect the "label effect" of green attributes—as an important component of the green finance system, green stocks benefit from policy support and investor preference, giving them a unique advantage. Policy incentives, market perception, and green transition potential lead investors to show greater tolerance for high-carbon-intensity green firms and accept lower return expectations. In other words, although some green stocks currently exhibit high carbon intensity, the market may be more focused on their potential for future green transition, which weakens the direct influence of carbon intensity on risk premiums.

5.1.3. Pricing Differences Before and After the Paris Agreement

In the global effort to address climate change, the 21st Conference of the Parties (COP21) to the United Nations Framework Convention on Climate Change (UNFCCC), held in December 2015, marked a significant milestone. The Paris Agreement adopted at this meeting sent a strong signal, accelerating the transition toward green and low-carbon development worldwide and promoting climate-resilient and sustainable growth [55]. Based on this critical turning point, this paper divides the study sample into two periods to examine the heterogeneity in carbon risk pricing across different timeframes.

As shown in Table 9, although the regression coefficients of carbon intensity are positive in both periods, the results are not significant prior to the Paris Agreement, whereas they become statistically significant afterward. This indicates that, with the strengthening of global carbon emission regulations and the rise in investors' green awareness, the market has become more explicit in pricing carbon risk. The Paris Agreement, as a pivotal policy shift, significantly enhanced the market's reflection of corporate carbon risk.

Table 9. Pricing differences before and after the Paris Agreement.

	(1) Before the Paris Agreement	(2) After the Paris Agreement
Carbon Intensity	0.00148	0.00212 **
	(1.15)	(2.06)
_cons	−0.84522 ***	−1.15787 ***
	(−9.62)	(−8.26)
Control Variables	Yes	Yes
Individual Fixed-Effects	Yes	Yes
Time Fixed-Effects	Yes	Yes
N	37,775	33,804
Adj. R^2	0.462	0.258

** $p < 0.05$, *** $p < 0.01$.

5.2. Mechanism Analysis

5.2.1. The Moderating Effect of Green Bond Issuance

The issuance of green bonds signifies a company's commitment to allocating funds to environmental projects, such as reducing carbon emissions or improving energy efficiency. This demonstrates the firm's proactive attitude toward sustainable development and significantly enhances its "green reputation" [56]. The backdrop of increasing climate awareness means that investors are more likely to perceive such companies as being forward-looking in addressing climate-related risks. Moreover, these firms can further strengthen market confidence in their carbon management capabilities through transparent disclosures regarding fund usage and project progress. However, some argue that companies may issue green bonds merely to meet market expectations or gain policy support, without genuinely fulfilling their environmental commitments in practice. In such cases, the funds

may be directed toward projects that fail to meet green standards, leading to the issue of "greenwashing".

Given that only 22 green bond issuers were identified in our sample, the sample size ratio between the treatment and control groups exceeds 1:10. This imbalance may lead to significant distribution differences between the two groups, potentially introducing confounding variables that distort the relationship between the treatment and the outcome [57]. Such imbalance may result in the control group differing from the treatment group in important characteristics, thereby affecting the accuracy of the estimated effects. Therefore, we adopt a propensity score-matching (PSM) approach, following the methodology of Wang et al. [58], to mitigate selection bias. This method aims to ensure that individuals in the treatment and control groups are as similar as possible based on observable characteristics, thus reducing bias in estimating the treatment effect.

While Wang et al. [58] applied a 1:2 matching ratio between green and conventional bonds, this paper uses a 1:1 nearest-neighbor matching approach to compare firms that issued green bonds with those that did not. This method emphasizes similarity in firm-level fundamentals rather than merely bond-level characteristics, making it more suitable for analyzing the role of green bonds in carbon risk pricing in the context of this study.

The regression results based on the matched sample are presented in Table 10. The findings indicate that the issuance of green bonds indeed plays a hedging role in carbon risk pricing, thereby supporting Hypothesis 2. Specifically, the interaction term between carbon intensity and green bond issuance yields a coefficient of −0.01090, which is statistically significant at the 10% level. This suggests that green bond issuance effectively mitigates the carbon risk premium. Furthermore, the absolute value of the interaction term exceeds that of carbon intensity alone, implying that green bond issuance may even reverse the carbon risk premium from positive to negative. This phenomenon likely reflects investors' strong recognition and preference for firms that proactively send green signals.

Table 10. Moderating effect of green bond issuance.

	(1) **Excess Return**	**(2)** **Excess Return**
Carbon Intensity	0.00696 ***	0.00824 ***
	(2.81)	(4.32)
Green Bond	0.04019 **	0.04040 **
	(1.98)	(2.11)
Carbon Intensity × Green Bond	−0.01023 *	−0.01090 *
	(−1.75)	(−1.96)
_cons	−0.01414 *	−0.64354 ***
	(−1.72)	(−4.58)
Control Variables	Yes	Yes
Individual Fixed-Effects	Yes	Yes
Time Fixed-Effects	Yes	Yes
N	6028	6014
Adj. R^2	0.384	0.397

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

This finding has important practical implications. For enterprises, green bonds are not only a financing tool but also a powerful signal of their carbon management capability and commitment to sustainability, helping to enhance their competitiveness in the green transition. For investors, green bonds serve as a key indicator for assessing carbon risk exposure, facilitating optimized portfolio allocation. For policymakers, promoting the development of green bonds can help direct capital efficiently toward green projects and support a sustainable economic transition.

5.2.2. The Moderating Effect of "Greenwashing" Behavior

"Greenwashing" is a trade-off between a company's "words" and "actions," which specifically manifests in the decision-making trade-off between carbon information disclosure and actual emission reduction actions. Although some companies may not take carbon reduction actions, they still engage in "greenwashing" by falsely advertising their environmental achievements, attempting to exaggerate their environmental performance to avoid the potential legal and reputational risks that may arise as a result of disclosing real information. Compared to actively disclosing truthful information, choosing "greenwashing" has become a risk-avoidance strategy for some companies, which seems safer in the short term. However, Bond and Zeng [59] point out that with stricter government and public supervision over corporate "greenwashing" behaviors, the risks of "greenwashing" accusations and environmental lawsuits are growing at an increasing rate.

Therefore, studying the impact of corporate carbon information disclosure strategies on carbon risk premiums is particularly important. Based on existing research on carbon risk premiums, this paper conducts an in-depth analysis of the impact of companies' choice of "greenwashing" strategies on carbon risk premiums. Table 11 shows the regression results of the moderating effect of "greenwashing" behavior on carbon risk premiums. Specifically, the coefficient of "greenwashing" behavior and its interaction with carbon intensity is negative and significant at the 1% and 5% significance levels, indicating that through "greenwashing," companies can not only misprice carbon risk premiums but may even change the premium from positive to negative, thus confirming hypothesis 3 and further proving that companies have motives to engage in "greenwashing" behavior. This finding differs from the conclusions drawn by Cheng et al. [39], who found that corporate silence behavior can partially offset the risks presented by high carbon intensity. However, this paper finds that "greenwashing" can lead to mispricing of carbon risk premiums, which may be because the sample in this paper is not limited to heavy-pollution industries. By issuing false green signals and superficially committing to environmental protection, but not implementing corresponding emission reduction measures in practice, companies mislead investors' perceptions of their environmental performance. This phenomenon suggests that governments and the public need to strengthen the supervision of "greenwashing" behaviors to prevent companies from evading carbon risks through false advertising.

Table 11. Moderating effect of "Greenwashing" behavior.

	(1) **Excess Return**	**(2)** **Excess Return**
Carbon Intensity	0.00311 ***	0.00252 ***
	(6.08)	(3.98)
"Greenwashing" Behavior	0.02336 ***	
	(3.84)	
"Greenwashing" Behavior × Carbon Intensity	−0.00688 ***	
	(−3.50)	
Degree of "Greenwashing"		0.00763 **
		(2.36)
Degree of "Greenwashing" × Carbon Intensity		−0.00224 **
		(−2.35)
_cons	−0.52905 ***	−0.62280 ***
	(−12.27)	(−12.80)
Control Variables	Yes	Yes
Individual Fixed-Effects	Yes	Yes
Time Fixed-Effects	Yes	Yes
N	71,579	66,120
Adj. R^2	0.381	0.369

** $p < 0.05$, *** $p < 0.01$.

This finding holds important practical significance. "Greenwashing" represents a short-term risk avoidance strategy for some companies, allowing them to mislead investors by overstating their environmental performance without real emission reductions. While it may appear safer initially, increasing regulatory scrutiny and public awareness heighten the risks of legal consequences and reputational damage. Therefore, strengthening oversight of corporate environmental disclosures is crucial to ensure transparency and protect investors from carbon risk mispricing. This also calls for policymakers to enhance regulations and enforcement to curb misleading green claims and promote genuine sustainability efforts.

6. Recommendations

Based on the conclusions, the paper proposes the following recommendations: (1) Establish a comprehensive carbon information disclosure system: The government should draw on international experience, such as the practices of the International Accounting Standards Board (IASB) and the International Sustainability Standards Board (ISSB), and incorporate the Climate Disclosure Project (CDP) framework to establish a scientific and standardized carbon information disclosure system. The disclosure subjects, scope, and conditions should be clarified to reduce the space for greenwashing and green silence by companies, improve market transparency, alleviate information asymmetry, and enhance investor confidence. (2) Promote the development of the green bond market: The government should encourage the issuance of green bonds by providing tax incentives, interest rate subsidies, and other policies to reduce the costs for companies, thereby promoting the development of the green finance market. At the same time, a transparent evaluation and certification mechanism for green bonds should be established to ensure the authenticity of their environmental benefits, boost investor confidence, and attract more funds to support companies' low-carbon transformation. (3) Strengthen supervision of greenwashing behavior. To address the issue of companies misleading the market through false green signals, the government and relevant regulatory bodies should intensify scrutiny and strengthen the regulation of carbon information disclosure. A penalty mechanism should be established to impose severe sanctions on greenwashing behavior, curb companies' attempts to seek short-term benefits through false information, and ensure the healthy development of the green finance market. (4) Improve the incentive and constraint mechanism: The government should establish a mechanism that combines incentives and penalties to encourage companies to actively disclose carbon information. Fiscal subsidies and honor rewards should be used to incentivize companies that disclose information proactively, while penalties for companies failing to meet disclosure obligations should be increased to raise their disclosure costs, thereby improving market transparency and reducing information asymmetry risks. (5) Formulate differentiated policy support: Policymakers should design differentiated policy support based on the carbon emission characteristics of industries and companies. For instance, high-carbon-emitting industries could receive technological support and guidance for transformation, while low-carbon companies could receive financial support and market promotion to enhance their competitiveness. Differentiated policies would contribute to more effective low-carbon transformation.

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Appendix A

Appendix A.1

Low Carbon Strategy, Promotion, Policies, and Concepts	Low Carbon Policy	Low Carbon Strategy	Low Carbon Promotion
	Low Carbon Concept	Low Emissions	Low Carbon Plan
	Low Carbon Awareness	Carbon Reduction Plan	Carbon Reduction Strategy
	Low Carbon Development	Zero Carbon Strategy	Zero Carbon
	Low Carbon Development Strategy	Zero or Low Carbon Energy	Carbon Targets
	Dual Carbon Construction	Dual Carbon	Dual Carbon Policy
	Dual Carbon Concept	Dual Carbon Strategy	Dual Carbon Targets
	Energy Conservation and Emission Reduction	Energy Conservation and Emission Reduction Targets	Energy Conservation Concepts
	Energy Conservation Awareness	Green Environmental Protection	Green Development
	Green Development Concept	Green Low Carbon	Green Energy
	Green Strategy	Green Policy	Green Concept
	Pollution Prevention	Carbon Peak	Carbon Neutrality
	Carbon Emission Reduction Measures	Carbon Emission Reduction Projects	Carbon Emission Reduction
	Carbon Emission Reduction Targets	Emission Reduction Targets	Emission Reduction Strategy
	Emission Reduction Plan	Emission Reduction Policy	Emission Reduction Concept
	Emission Reduction Promotion	Carbon Reduction	Carbon Reduction Plan
	Greenhouse Gases	Reduce Carbon Dioxide	Energy Saving and Consumption Reduction
	Energy Saving and Emission Reduction Strategy	Energy-Saving Targets	Energy-Saving Strategy
	Negative Carbon Targets	Negative Carbon Plan	Negative Carbon Strategy
	Green Transformation	Energy-Saving Retrofit Plan	Environmental Protection Awareness
	Environmental Protection Training	Clean Travel	Earth Day
	Energy-Saving Promotion	Environmental Protection Promotion	
Low Carbon Management	Low Carbon Management Procedure	Low Carbon Professional Committee	Low Carbon Management Department
	Low Carbon Organization	Low Carbon Organizational Structure	Low Carbon Leadership Group
	Low-Carbon System Construction	Low-Carbon Functional Department	Low-Carbon Team Leader
	Low-Carbon Organizational Institution	Environmental Protection Management	Environmental Protection Assessment System
	Environmental Monitoring Station	Environmental Management	Low-Carbon Leadership Group
	Low-Carbon Leadership Institution	Low-Carbon Management Institution	Green Institutional Setup
	Green System Construction	Green Organizational Institution	Green Professional Committee

Low Carbon Management	Green Management Department	Green Organizational Structure	Green Leadership Group
	Green Functional Department	Green Leadership Group	Green Leadership Institution
	Green Management Institution	Environmental Institution Setup	Environmental System Construction
	Environmental Organizational Institution	Environmental Professional Committee	Environmental Management Department
	Environmental Organizational Structure	Environmental Leadership Group	Environmental Functional Department
	Environmental Protection Leadership Group	Environmental Protection Leadership Institution	Environmental Protection Management Institution
	Emission Reduction Institution Setup	Emission Reduction System Construction	Emission Reduction Organizational Institution
	Emission Reduction Environmental Monitoring Station	Emission Reduction Professional Committee	Emission Reduction Management Department
	Emission Reduction Organizational Structure	Emission Reduction Leadership Group	Emission Reduction Functional Department
	Emission Reduction Team Leader	Emission Reduction Leadership Group	Emission Reduction Leadership Institution
	Emission Reduction Management Institution	Energy-Saving Institution Setup	Energy-Saving System Construction
	Energy-Saving Organizational Institution	Energy-Saving Professional Committee	Energy-Saving Management Department
	Energy-Saving Organizational Structure	Energy-Saving Leadership Group	Energy-Saving Functional Department
	Energy-Saving Team Leader	Energy-Saving Leadership Group	Energy-Saving Leadership Institution
	Energy-Saving Management Institution	Environmental Verification	Environmental Impact Assessment
	Environmental Impact Assessment Report		
Carbon Emission Situation	Carbon Emissions	Carbon Emission Distribution Situation	Carbon Emission Distribution
	Carbon Emission Standards	Carbon Emission Concentration	Carbon Emission Measurement
	Carbon Emission Methods	Carbon Dioxide Emission Concentration	Carbon Dioxide Emission Quantity
	Carbon Emission Points	Carbon Dioxide Emission Standards	Carbon Dioxide Emission Methods
	Carbon Emission Points	Carbon Dioxide Emission Points	Carbon Dioxide Emission Distribution
	Distribution of Carbon Dioxide Emissions	Carbon Dioxide Emission Outlets	Measurement of Carbon Dioxide Emissions
	CO_2 Emission Concentration	CO_2 Emissions	CO_2 Emission Standards
	CO_2 Emission Methods	Number of CO_2 Emission Outlets	CO_2 Emission Outlet
	CO_2 Emission Distribution	Status of CO_2 Emission Distribution	CO_2 Emission Measurement
	Amount of Carbon Capture	Volume of Carbon Capture	Amount of Carbon Dioxide Captured
	Volume of CO_2 Capture	Carbon Dioxide Monitoring	Carbon Detection
	Carbon Concentration Detection	Carbon Emission Prevention	Carbon Emission Reduction

Carbon Information	Carbon Disclosure	Carbon Accounting	Carbon Accounting Information
	Carbon Accounting Disclosure	Carbon Information	Carbon Information Auditing
	Carbon Trading Disclosure	Carbon Audit	Carbon Assets
	Carbon Trading Rights Disclosure	Carbon Trading	Carbon Quotas
	Carbon Accounting	Carbon Emission Rights	Carbon Finance
	Carbon Capture	Carbon Sequestration	Carbon Emission Rights Accounting
	Carbon Emission Rights Assets	Carbon Emission Rights Trading	Carbon Emission Rights Quotas
	CCUS	Carbon Source	Carbon Sink
	Carbon Market	Carbon Trading Market	Carbon Emission Rights Market
	Carbon Emission Rights Trading Market	Carbon Dioxide Sequestration	Carbon Dioxide Absorption
	Carbon Liabilities	Carbon Liability Risks	Carbon Regulation
	Carbon Price	Carbon Standards	Carbon Risk
	Carbon Inventory	Carbon Emission Rights Trading Income	Carbon Trading Income
	Carbon Emission Rights Information	Carbon Emission Rights Liabilities	Carbon Emission Rights Liability Risks
	Carbon Emission Rights Regulation	Carbon Emission Rights Price	Carbon Emission Rights Standards
	Carbon Emission Rights Risk	Carbon Emission Rights Inventory	
Low Carbon Research Investment and Achievements	Low-Carbon Key Technologies	Carbon Capture Processes	Low-Carbon Technology Upgrades
	Advanced Low-Carbon Technology	Emission Reduction Technology	Emission Minimization
	Low-Carbon Technology Transformation	Optimization of Emission Reduction Processes	Innovation in Emission Reduction Processes
	New Low-Carbon Process	Investment in Carbon Emission Reduction	Low-Carbon Emission Reduction
	Low-Carbon Production	Low-Carbon Technology	New Low-Carbon Technology
	Upgrade of Low-Carbon Products	Carbon Dioxide Treatment	Carbon Treatment
	R&D of Low-Carbon Technology	Innovation in Low-Carbon Technology	Low-Carbon Equipment
Third-Party Evaluation	Carbon Audit	Environmental Impact Assessment Report	Professional Environmental Assessment Organization
	Carbon Review	Specialized Environmental Assessment Agency	Government Subsidy for Low-Carbon Projects
	Low-Carbon Evaluation	Government Low-Carbon Subsidy	Low-Carbon Subsidy
	Verification of Environmental Impact	Carbon Reduction Subsidy	Emission Reduction Subsidy
	Assessment of Environmental Impact	Carbon Emission Subsidy	

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