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Research on the Impact of Financing Constraints on Environmental Investment under Carbon Peaking and Carbon Neutrality Policy

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Abstract

Since the 13th Five-Year Plan, China has solemnly put forward the overall goal of "carbon neutrality and carbon peaking". Toward this goal, in order to increase energy conservation and emission reduction, China has released carbon peaking implementation plans and a series of carbon peaking in key areas and industries, and has built a carbon-peak, carbon-neutral "1+N" policy system. Based on that, this paper takes the A-share listed companies in China's Shanghai and Shenzhen stock exchanges from 2009 to 2020 as a research sample and uses the double difference model to explore the "Notice on Carrying out the Pilot Work of Carbon Emissions Trading". Whether the "dual carbon" policy, represented by the establishment of the pilot carbon emission trading market, has a positive impact on the environmental protection investment of enterprises, and the impact on the relationship between financing constraints and environmental protection investment. In this paper, factors such as company size, profitability are added to the model as control variables, and the differences in policy effects are further studied, and the inhibitory effect of the policy on financing constraints on environmental protection investment is obtained. There is a positive moderating effect, and the effect of policies on promoting environmental protection investment in non-state-owned enterprises is more significant than that of state-owned enterprises. Based on the research results, the article gives some suggestions to the government and enterprise.

Keywords

Environmental Investment; Financing Constraints; Carbon Peaking and Carbon Neutrality Policy.

1. Introduction

1.1. Research Background

Since 2010, the global greenhouse gas emissions have been growing at an average annual rate of 1.4%, and the pressure to reduce emissions is huge. The issue of global warming is an urgent non-traditional security issue that needs to be addressed. Climate change has become the most severe non-traditional security issue in today's world. In 2020, the European Union took the lead in announcing absolute emission reduction targets, and countries around the world have made political commitments. In the same year, China also clearly proposed the goal of "carbon neutrality and carbon peaking". Currently, China is in the stage of industrial structure adjustment and upgrading, and economic growth has entered a new normal, with carbon emissions gradually entering a "plateau period". To further achieve the "dual carbon" goal, it is necessary not only to adjust the industrial structure and energy structure but also to increase the research and development of green-related new technologies, and achieve emission reduction through technological development. In 2011, the State Council first issued the "12th

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Five-Year Plan for Controlling Greenhouse Gas Emissions", which determined the overall requirements for China to control the emission of carbon dioxide greenhouse gases, and China's low-carbon process has since had a new development idea. In addition, China has carried out pilot carbon emission trading in provinces and cities such as Beijing and Tianjin, providing a more economical choice for key emission units to fulfill their obligations. In 2015, the China Banking and Insurance Regulatory Commission issued the "Energy Efficiency Credit Guidance" to guide banking and financial institutions to support enterprises in improving energy efficiency and saving energy through credit financing. Financial policy, as one of the national energy-saving and emission reduction policies, can support enterprises to launch innovative green credit products and strengthen the complementary mechanism between green credit and marketization. In 2016, the Ministry of Finance and seven other departments jointly issued the "Guiding Opinions on Building a Green Financial System", proposing the first relatively complete policy framework in the field of green finance development in China. In 2017, the construction of the national carbon emission trading system was officially launched. In July 2021, the national carbon emission trading market was officially launched for trading.

Heavy pollution industries, as important targets for energy saving and emission reduction, bear greater social responsibility in the process of achieving the "dual carbon" goal. Only by fulfilling environmental obligations and responsibilities and strengthening green innovation investment can the increasing constraints on environmental resources be alleviated. This will inevitably occupy a part of the enterprise's operational resources, and the issue of financing constraints caused by the high cost of external financing due to internal capital insufficiency will become serious due to the long payback period and great uncertainty of green investment. If the enterprise's existing resources cannot be invested in projects with the greatest economic benefits, its normal operation may also be affected. With the support of relevant government policies, whether enterprises will compromise to increase environmental protection investment in the face of maximizing benefits still needs to be studied. Therefore, this paper will explore whether the implementation of the "dual carbon" policy can effectively promote green innovation and its impact on the relationship between enterprise financing constraints and environmental protection investment.

1.2. Research Innovation

The contribution of this paper is that, based on the uniqueness of China's carbon emissions, not only is the scale huge, but the industry composition is also quite different from other countries. The achievement of the "dual carbon" goal will inevitably bring investment opportunities and social structural changes. This paper provides relatively objective empirical evidence on the relationship between enterprise financing constraints and green investment. Different from the limitations of previous studies that may cause deviations in results by using single-element indicators to measure financing constraints, this paper can systematically and accurately reflect the level of enterprise financing constraints and provide relatively objective empirical evidence for the study of the economic consequences of enterprise green investment and other environmental expenditures.

2. Literature Review

2.1. Research on Environmental Investment

2.1.1. Effects of Environmental Investment

Green environmental innovation has higher risk than general innovation activities, high uncertainty of input and return, and dual attributes of "innovation" and "green" leading to dual externalities. In terms of the effects of environmental investment, existing studies believe that environmental investment can play economic, environmental, and social benefits. Eri (2011)

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analyzed the impact of increasing environmental investment information disclosure on the operating performance of Japanese listed companies from multiple financial data, supporting the view of green investment economic benefits [1]. However, Yao Sheng and Lin Yunyan (2021) believe that the environmental and social benefits of environmental investment are often greater than economic benefits and have typical externality characteristics. Because of this characteristic, environmental investment is more susceptible to the influence of uncertain factors[2]. Rational managers who prefer short-term profits and their own economic benefits are unlikely to actively use limited financial resources for environmental investment. Zhao Lingdi and Wang Xiaofei (2021) found that as innovation gradually becomes the core of dynamic competitiveness, companies with strong innovation capabilities have also become the most competitive companies[3]. This change has made it possible for companies to transform green investment expenditures under environmental regulation into technological innovation, gain competitive advantages, and achieve a win-win situation for environmental performance and operating performance.

2.1.2. Factors Affecting Environmental Investment

The factors affecting the scale of environmental investment mainly come from internal and external economic environments of the enterprise. First, from the internal factors, environmental investment behavior is closely related to corporate strategy and management. Ding Hongyan et al. (2020) believe that the more power a CEO has, the more inclined they are to increase R&D investment[4]. Executive compensation and gender also affect the level of environmental investment. From the perspective of corporate governance, Ren Guangqian (2017) explored that the company's equity structure and board characteristics have a direct impact on corporate environmental investment behavior, and internal control quality is positively correlated with investment scale.[5] External influencing factors are mainly reflected in the development of the financial market and GDP growth. Government environmental policies can promote green investment by improving the external economic environment.

In recent years, the scale of China's environmental investment has been growing, but there are still many problems. Cheng Liang et al. (2021) analyzed the evolution of China's environmental investment policy over the past 40 years and identified the key bottlenecks of insufficient high-quality development of environmental investment, imperfect return mechanisms, and the need to improve the performance mechanism of investment and financing[6]. It is still necessary to encourage the exploration of innovative investment and financing mechanisms, guide social capital to invest in environmental protection, and based on the urgency of tasks, technological maturity, and completeness of returns, to unblock the key points of environmental investment benefits to optimize investment policies.

2.2. Research on Financing Constraints

2.2.1. Basic Connotation of Financing Constraints

Financing constraints refer to the problem of financing cost differences for financing subjects with different asset scales, operational efficiency, and governance structures due to the existence of information asymmetry when engaging in similar financing behaviors. The pecking order theory believes that enterprises will prioritize internal financing methods, followed by external financing methods such as debt and equity financing. This is due to the consideration that information asymmetry in the capital market leads to a large difference in the cost of internal and external financing.

In fact, external financing channels have gradually become an important source of corporate investment. Zhang Jie et al. (2012) found that the financing channels for corporate innovation investment have a priority order from internal financing to external financing methods[7]. Enterprises tend to rely on increasing cash flow, registered capital, and commercial credit for financing. However, considering the characteristic of high initial investment in R&D investment,

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even if there are uncertainty and moral hazard issues in the benefits of corporate R&D activities, external financing channels have gradually replaced internal financing as an important source of corporate R&D investment.

2.2.2. Factors Influencing Financing Constraints

Additionally, various scholars have explored the factors that affect the strength of financing constraints, starting from the characteristics of enterprises. Guo Jie (2022) believes that agricultural-related enterprises generally face more severe financing constraints[8]. This is mainly because when enterprises have poor operating conditions and profitability, or if the company is small in scale and its governance system is not standardized, with timely disclosure of information leading to insufficient corporate credit, banks and other financial institutions will cautiously consider and provide only limited funds, or even give up such profit opportunities to avoid risks. This increases the difficulty and cost of financing for these enterprises. The level of financing constraints is generally associated with financial indicators. Luo Changyuan and Zeng Shuai (2020) used the ratio of net cash flow from operating activities and the turnover rate of accounts receivable to measure internal financing constraints, and used the interest coverage ratio, current ratio, solvency ratio, tangible asset-to-net-worth ratio, and profitability to measure external financing constraints[9]. Kuang Xue Wen (2010) and others divided the samples into high and low financing constraint groups based on company size and interest coverage ratio, finding that companies with high financing constraints had higher debt-to-asset ratios and market-to-book values, but lower net working capital, return on equity, and cash dividends, and their investment-cash flow sensitivity was significantly higher than that of companies with low financing constraints[10].

2.3. Research on the Impact of "Dual Carbon" Policies on Corporate Behavior

"Dual Carbon" policies call for enterprises to focus on low-carbon transformation and promptly adjust corporate strategies, while also having a positive impact on the scale and efficiency of corporate green innovation. Tan Xian Chun et al. (2022) summarized that most of China's low-carbon policies are implemented through administrative orders, and increasingly rely on market-oriented means to achieve goals. She also pointed out the urgent need for China's social development path to transition from resource dependence to technology-driven transformation in the process of achieving "carbon neutrality and carbon peaking" goals[11]. To fundamentally solve the issues of industrial adjustment and energy structure in the long term, it is ultimately necessary to achieve a breakthrough in technological means. According to the research by Wang Xiao et al. (2021), the timing of China's corporate carbon neutrality commitment goals is generally lagging behind the global level, and they are still in the stage of establishing goals and strategic planning[12]. Enterprises urgently need to seek paths for carbon neutrality development, strengthen capacity building, and scientifically and reasonably formulate strategic plans. This requires domestic enterprises to grasp the core of emission reduction, increase environmental investment, focus on improving in areas such as clean energy and technological innovation, create a carbon-neutral technology source, and explore the path of green and low-carbon transformation. Tian Hong Na et al. (2021), against the backdrop of green development in China's industry, explored that government subsidies help to enhance the green technology capabilities of larger enterprises, and considered this method as an important financing channel for balancing green innovation[14]. Zhu Dong Dan et al. (2021), through the study of government environmental regulation on enterprise pollutant emissions, the proportion of pollution control investment, and the treatment rate of industrial "three wastes", found that such environmental regulation can significantly improve the green innovation efficiency of manufacturing enterprises[14].

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2.4. Literature Review

By reviewing the literature of domestic and foreign scholars, it can be found that the level of corporate environmental investment is mainly influenced by internal factors such as corporate strategy and management characteristics, and external economic factors such as GDP growth and the development of the financial market, and has strong externality characteristics, with significant environmental and social benefits. The scale and cost of corporate financing are affected by company characteristics such as company size, profitability, and available cash flow, and banks and other financial institutions will make investment decisions based on this. In the research discussing the relationship between financing constraints and green investment, most scholars believe that financing constraints restrict corporate environmental investment behavior and propose that this suppressive effect can be alleviated through environmental disclosure, government subsidies, and other means.

China is currently in the initial stage of achieving the "dual carbon" goals, and there is little research discussing the relationship between financing constraints and environmental investment in this context. Based on this, this paper will attempt to establish a difference-in-differences model to study the "dual carbon" policies, financing constraints, and environmental investment within a unified framework, to better explore the mechanism of government policy on corporate green investment. Can the implementation of "dual carbon" policies promote the level of corporate environmental investment? What is the mechanism of action? Does the "dual carbon" policy have a differential impact on promoting environmental investment in enterprises of different property rights nature? These issues are worth in-depth exploration.

3. Institutional Background and Research Hypotheses

3.1. Institutional Background

As climate issues become a global concern, China has also started to pay attention to the adverse impacts of carbon emissions on the environment and economy. In the allocation of resources, the market often plays a fundamental regulatory role through price mechanisms. However, in areas where market regulation fails, government participation is required. To address environmental pollution and ecological destruction, it is necessary to rely on government policies for macroeconomic regulation. Well before the clear proposal of the "dual carbon" goals, China has gradually combined low-carbon strategies with energy saving, emission reduction, and environmental protection, successively carrying out macro and micro adjustments in the fields of energy, environment, and finance.

During the deepening reform phase, China's low-carbon progress has taken on a new developmental approach, focusing on exploring and improving the policy system related to energy saving and emission reduction, guiding micro enterprises to adjust their strategies, and valuing new paths for low-carbon transformation development. In October 2011, the National Development and Reform Commission issued the "Notice on Carrying Out Pilot Work for Carbon Emission Trading," announcing the establishment of carbon emission trading pilots in seven provinces and cities, including Beijing and Tianjin. These seven provinces and cities actively explored carbon emission trading, determined the list of pilot enterprises for carbon trading, formulated interim management measures for quotas, and prepared for carbon trading venues. In June 2014, the seven pilot provinces and cities successively launched the carbon emission trading market, providing more economical options for key emitting units to fulfill their obligations.

In 2015, the development of "dual carbon" policies entered a new phase. Financial policies, as one of the national energy-saving and emission reduction policies, attract more social capital to invest in green and low-carbon industries through green bonds, green stock indices, and other related financial products. They strengthen the complementary mechanism between green

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credit and marketization, creating a better green investment and financing environment for enterprises and alleviating the difficulties of green and low-carbon transformation. In 2015, the China Banking and Insurance Regulatory Commission issued the "Energy Efficiency Credit Guidelines," guiding the banking industry and financial institutions to support enterprises in energy saving and consumption reduction through credit financing. In 2016, the People's Bank of China and seven other departments jointly issued the "Guiding Opinions on Building a Green Financial System," proposing the first relatively complete policy framework in the field of China's green finance development. To develop a low-carbon economy with significant externality characteristics, guidance from fiscal and tax policies is also needed. In addition, the government relies on the market to continuously improve the carbon emission trading mechanism and strengthen the guiding role of the environmental rights market represented by the carbon emission trading market. In December 2017, the construction of the national carbon emission trading system was launched. At the 75th United Nations General Assembly in September 2020, China formally proposed the solemn commitment to "strive to reach a peak in carbon dioxide emissions before 2030 and achieve carbon neutrality before 2060." To achieve the "dual carbon" goals, it is necessary to improve the energy structure, use renewable energy to reduce carbon emissions, and upgrade technology to optimize energy efficiency and save energy.

The "dual carbon" policies in China have been increasingly developed and improved. In recent years, investment in technological research and development in fields with technical demands such as atmosphere and water has increased year by year, and the emission of pollutants has significantly decreased. This series of policies has truly improved environmental quality and also indirectly reflects that enterprises have actively transformed towards low-carbon development under policy guidance and have initially achieved success.

3.2. Hypothesis Proposal

3.2.1. "Dual Carbon" Policies and Environmental Investment

The external environmental benefits of green environmental investment far exceed economic benefits. When making decisions, managers face a dilemma between pursuing economic benefits and alleviating external environmental pressures. If limited funds are invested in environmental protection and emission reduction, it is highly likely that the effects will not be seen in the short term, resulting in significant sunk costs and loss of profits from normal business operations, thereby worsening financial levels such as profitability and debt repayment ability. However, if the effects of low-carbon transformation are significant, enterprises will be more capable of dealing with external environmental uncertainties, will have greater competitiveness in the market, and will drive efficient enterprise operation. Improved financial conditions will greatly reduce the difficulty of financing, forming a virtuous cycle of investment and financing.

According to the Porter Hypothesis, a certain degree of environmental regulation can promote corporate technological innovation activities or the adoption of innovative technologies to enhance corporate productivity, thereby offsetting the costs of environmental protection and enhancing corporate profitability. "Dual Carbon" policies, as government interventionist environmental regulation measures, mainly influence environmental investment through direct and indirect methods. On the one hand, the government will provide certain government subsidies and tax incentives to enterprises that respond to environmental policies and strive to develop environmental protection technologies. On the other hand, it will also promote the establishment and improvement of the market trading system through the establishment of carbon emission trading markets, give full play to the market mechanism, assetize carbon emission rights, and promote the more efficient circulation of carbon emission rights among enterprises. When the price of carbon rises, if the actual carbon emissions exceed the quota,

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more compliance costs will be incurred. At the same time, enterprises will also realize the possibility of profiting from having more carbon emission rights in the trading market through carbon reduction, thereby stimulating the enthusiasm for enterprise emission reduction.

H1: "Dual Carbon" policies significantly promote corporate environmental investment.

3.2.2. Financing Constraints and Environmental Investment

Corporate financing activities are usually achieved through internal and external financing methods. However, due to the uncertain returns, long investment periods, and high investment costs of environmental investment, internal funds are not sufficient to support investments in green emission reduction, and external financing through bank loans, equity financing, venture capital, and other methods is generally required. But banks, trusts, and other financial institutions often have strict standards for corporate credit ratings, which are related to the financing scale and cost that enterprises can obtain. Credit rating assessments are usually linked to corporate financial indicators and enterprise value, and financing activities will change the capital structure of enterprises. Restricted by financing costs and the need to maintain a reasonable level of capital structure, enterprises with limited funds will reduce or even abandon environmental investment in the short term. Financing constraints limit enterprises from obtaining external financing at a low cost, exacerbate the contradiction of reducing environmental investment due to insufficient internal capital accumulation, and prevent enterprises from seizing favorable investment opportunities. In addition, companies may be unwilling to disclose their newly developed technological innovations to the outside world in order to protect them, making it difficult for external investors to understand the current situation of the enterprise. This intensifies the problem of information asymmetry, weakens investment willingness, and also leads to enterprises facing a shortage of financing channel resources.

H2: Financing constraints inhibit corporate environmental investment.

3.2.3. "Dual Carbon" Policies, Financing Constraints, and Environmental Investment

The government, as the main force in guiding the market towards higher efficiency and more innovative development, has issued a series of "dual carbon" policies that convey the government's strong support for enterprises to carry out energy saving, emission reduction, and green and low-carbon transformation, thereby generating a policy incentive effect in society. In addition to enterprises, commercial banks and other financial institutions can also perceive policy guidance, respond to government calls, and actively tilt towards enterprises undergoing green and low-carbon transformation. For example, the establishment of the carbon emission trading market has made the carbon trading behavior of enterprises transparent, and the outside world can gain a deeper understanding of the results of corporate environmental protection technology innovation and the fulfillment of environmental obligations through this channel, thereby alleviating the problem of information asymmetry. Furthermore, China has accelerated the implementation of the green financial system, attracting the attention of financial institutions and social capital to green and environmental protection by issuing green credit, green bonds, and other green financial instruments, injecting more funds into corporate green and low-carbon projects, effectively expanding the financing channels for enterprises, and alleviating the financing constraints of enterprises. External institutions providing sufficient external funding support have to some extent reduced the operational pressure and the high cost of environmental investment on enterprises, ensuring the normal operating cash flow of enterprises and supporting the normal progress of corporate low-carbon transformation. Thus, we propose:

H3: "Dual Carbon" policies alleviate the suppressive effect of financing constraints on corporate environmental investment.

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4. Research Design

4.1. Sample Selection and Data Sources

Considering the high carbon emission requirements of heavily polluting industries and their more significant response to the "dual carbon" policy, which is easier to study, this paper includes heavily polluting industries such as mining, hydropower and coal industry, textile, apparel, fur and leather industry, metal and non-metal industry, petrochemical and plastic industry, and food and beverage industry in the research scope according to the "List of Industries Classified for Environmental Verification of Listed Companies" released by the Ministry of Environmental Protection. The sample consists of A-share companies in heavy pollution industries listed on the Shanghai and Shenzhen stock exchanges from 2009 to 2020, excluding ST and *ST companies, resulting in 4,080 unbalanced panel data from 438 sample companies. Among them, there are 122 sample companies located in the pilot provinces and cities designated in the "Notice". To exclude the adverse effects of extreme values in the data, this paper performs Winsorize tail treatment on continuous variables at the 1% and 99% levels. The data comes from the CSMAR database.

4.2. Variable Description

4.2.1. Dependent Variable - Environmental Investment

The research and development investment of listed companies' annual reports is manually screened based on project descriptions using keywords such as desulfurization projects, sewage treatment, water body restoration, dust and ash removal, and clean production to identify investments related to energy saving and emission reduction. The increase in investment for the current year is taken as the company's green investment. To reduce the difference in orders of magnitude, the logarithm of corporate environmental investment is taken.

4.2.2. Independent Variable - Degree of Financing Constraints

This paper refers to the methods of scholars such as Hadlock and Pierce (2010) and Ye Cuihong (2021)[15], and constructs the SA index related to the scale and listing duration of enterprises through an ordered logit regression model. Then, the logarithm of the absolute value of SA is taken to ultimately obtain FC. The lower the FC value, the more severe the financing constraints of the enterprise.

$$SA = 0.043 \times Si^2 - 0.737 \times Si - 0.04 \times Age \quad (1)$$

$$FC = \ln|SA| \quad (2)$$

4.2.3. Control Variables

Drawing on the research of scholars such as Zhao Dandan (2021), this study selects data that reflects corporate characteristics as control variables: company size (Si), company listing duration (Age), gross profit margin (GP), turnover rate of current assets (Cturn), and debt-to-asset ratio (Lev)[16]. Companies with a longer listing time may have more experience in investment and financing and are less restricted by financing channels. The gross profit margin, which reflects the operating conditions, also affects the decision to make environmental investments.

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Table 1. Variable Definition

Variable Type	Variable Name	Variable Symbol	Variable Definition
Dependent Variable	Environmental Investment	RD	The natural logarithm of environmental investment
Independent Variable	Policy Dummy Variable	Treat	1 if the enterprise is in a carbon trading pilot area, 0 for other provinces
	Time Dummy Variable	Post	0 before 2014, 1 and after for 2014 and later
	Financing Constraint	FC	Financing constraint index
Control Variable	Company Size	Si	The natural logarithm of total company assets
	Company Listing Duration	Age	Listing duration
	Gross Profit Margin	GP	Gross profit / operating income
	Turnover Rate of Current Assets	Cturn	Operating income / average current assets
	Debt-to-Asset Ratio	Lev	Total liabilities / total assets

4.3. Model Design

This paper constructs Model 1 to verify the impact of "dual carbon" policies on corporate environmental investment.

$$RD_{it}=\lambda_0+\lambda_1(post\_{}_{2014}*treat_i)+\lambda_i Z_{it}+\gamma_i+\varepsilon_{it} \quad (3)$$

Since the 13th Five-Year Plan, China has introduced a series of policies that aid in achieving the "dual carbon" goals. This paper mainly studies the policy of establishing a carbon emission trading market. According to the "Notice," pilot provinces and cities such as Shenzhen, Beijing, and Shanghai successively launched the carbon emission trading market from the middle and late period of 2013 to the beginning of 2014. Considering that there is a certain lag in the specific implementation of policies in various places, this paper uniformly takes 2014 as the time node when the policy begins to take effect. The time variable $post\_{}_{2014}$ is set to 1 for the years 2014 and later, and 0 before that. In the early stage of the carbon emission trading market, seven provinces and cities, including Beijing, Shanghai, Tianjin, Guangdong, Shenzhen, Chongqing, and Hubei, were selected as pilots. The basis for division is whether the company is located in the policy-affected area. Companies within the designated areas are set as the treatment group, with treat set to 1, and companies outside the designated areas are the control group, with treat set to 0. λ_1 is the coefficient of primary concern, reflecting the impact of "dual carbon" policies on corporate environmental investment.

$$RD_{it}=\beta_0+\beta_1 FC_{it}+\beta_i Z_{it}+\varepsilon_{it} \quad (4)$$

This paper constructs Model 2 to verify the impact of financing constraints on corporate environmental investment. The dependent variable RD represents the scale of corporate environmental investment, and the independent variable FC represents the degree of financing constraints. Model 2 mainly focuses on the coefficient β_1; if β_1 is significantly positive, it proves that financing constraints limit green environmental investment, and Hypothesis 2 is established.

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$$RD_{it}=\eta_0+\eta_1 FC_{it}+\eta_2\ post\_{}_{2014t}*treat_i+\eta_3\ Interact+\eta_i Z_{it}+\varepsilon_{it} \quad (5)$$

In this model, the dependent variable RD represents the level of corporate environmental investment, the independent variable FC represents the degree of financing constraints, $pos_{t\_2014t}*treat_i$ is a dummy variable indicating whether it is affected by the policy, Interact is the interaction term between the financing constraint level and the policy implementation dummy variable, and Z is the control variable. Model 3 mainly focuses on the coefficient η_3; if η_3 is significantly negative, it indicates that the policy implementation can alleviate the suppressive effect of financing constraints on corporate environmental investment, and Hypothesis 3 is established.

5. Empirical Results Analysis

5.1. Descriptive Statistics

The maximum value of the environmental investment variable is 21.03, the minimum value is 13.02, and the standard deviation is 1.507, indicating a significant difference in the level of environmental technology R&D investment among different enterprises. Regarding the financing constraint index FC, a lower FC value indicates a stronger financing constraint, with an average FC value of 1.246, suggesting that enterprises generally face significant financing constraints. In addition, the average gross profit margin (GP) is 0.34 with a standard deviation of 0.243. The average debt-to-asset ratio (Lev) is 0.327 with a standard deviation of 0.201. The turnover rate of current assets (Cturn) of the sample enterprises also varies, which may be due to differences in industries and operational capabilities.

Table 2. Descriptive Statistics

Variables	N	mean	sd	min	max
RD	4,080	17.61	1.507	13.02	21.03
FC	4,080	1.246	0.0844	1.050	1.406
GP	4,080	0.340	0.243	0.0500	0.943
Lev	4,080	0.327	0.201	0.00453	0.856
Cturn	4,080	0.954	0.830	0.00115	4.800
Si	4,080	8.244	1.237	4.534	14.47
Age	4,080	9.926	6.823	0	27

5.2. Benchmark Regression Analysis

5.2.1. The Impact of "Dual Carbon" Policy on Environmental Investment and the Relationship between Financing Constraints and Corporate Environmental Investment

Columns (1) and (2) present the regression results of Model 1, where the coefficient of $post\_{}_{2014}*treat$ is significantly positive at the 1% level. This indicates that the "dual carbon" policy has a positive promoting effect on corporate environmental investment, and Hypothesis 1 is established. Columns (3) and (4) show the regression results of Model 2, where the coefficient of the financing constraint index (FC) on environmental investment is significantly positive at the 1% level. The financing constraint index FC is a negative indicator, with higher values indicating lower levels of financing constraints, hence there is a negative correlation between corporate financing constraints and environmental investment. The tighter the financing constraints, the less funds companies can invest in green and environmental protection, and the smaller the scale of environmental investment, which means financing constraints inhibit corporate green investment, and Hypothesis 2 is established.

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Considering the impact of both the "dual carbon" policy and financing constraints, as shown in column (5), the coefficients of post_2014*treat and FC are significantly positive, indicating that the implementation of the dual carbon policy has a significant effect on promoting the expansion of corporate environmental investment scale, and financing constraints have a significant inhibitory effect on the green investment scale of heavily polluted industries. Hypotheses 1 and 2 are verified again.

Table 3. Empirical Results Analysis

Variables	RD	RD	RD	RD	RD
post_2014*treat	0.331***	0.130**			0.167***
	(0.0575)	(0.0513)			(0.0511)
FC			1.891***	1.446***	5.958***
			(0.293)	(0.538)	(0.701)
GP		0.555***		0.633***	0.600***
		(0.0895)		(0.0932)	(0.0889)
Lev		-0.409***		-0.503***	-0.424***
		(0.112)		(0.116)	(0.111)
Cturn		0.0925***		0.150***	0.132***
		(0.0253)		(0.0271)	(0.0255)
Age		-0.0293***		-0.0501***	-0.0982***
		(0.00341)		(0.00731)	(0.00878)
Si		0.592***		0.671***	0.620***
		(0.0185)		(0.0200)	(0.0186)
Constant	17.53***	12.84***	15.26***	10.58***	5.818***
	(0.0258)	(0.147)	(0.365)	(0.679)	(0.839)
N	4,080	4,080	4,080	4,080	4,080
R-squared	0.099	0.297	0.010	0.249	0.310

5.2.2. Analysis of the Moderating Effect of the "Dual Carbon" Policy

Table 4. Model3 Empirical Results

	before	after	whole
Variables	RD	RD	RD
FC	7.009***	3.783**	4.536***
	(0.900)	(1.523)	(0.780)
post_2014*treat			2.272***
			(0.659)
Interact			-1.561***
			(0.522)
GP	0.634***	0.451**	0.531***
	(0.102)	(0.197)	(0.0902)
Lev	-0.694***	-0.000932	-0.698***
	(0.122)	(0.280)	(0.118)
Cturn	0.121***	0.0832	0.149***
	(0.0289)	(0.0578)	(0.0271)
Age	-0.0969***	-0.0522***	-0.0658***
	(0.0111)	(0.0193)	(0.00940)
Si	0.702***	0.502***	0.713***
	(0.0214)	(0.0478)	(0.0207)
Constant	3.890***	9.311***	6.579***
	(1.022)	(1.979)	(0.913)
N	3,170	910	4,080
R-squared	0.293	0.170	0.278

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Table 4 shows the regression results of Model 3. Comparing the FC regression coefficients in columns (1) and (2), the FC regression coefficient is significantly positive at the 1% level before the implementation of the "dual carbon" policy; after implementation, it is significant at the 5% level, with a coefficient smaller than before implementation. This indicates that after the policy was implemented, the inhibitory effect of financing constraints on environmental investment has weakened. In column (3), the coefficient of the financing constraint index FC on environmental investment is significantly positive at the 1% level, indicating that the more severe the financing constraints, the smaller the scale of environmental investment. The regression coefficient of the "dual carbon" policy implementation dummy variable (post_2014*treat) is significantly positive, indicating that it has promoted corporate environmental investment. The coefficient of the interaction term between financing constraints and policy implementation (Interact) is significantly negative at the 1% level. This shows that the policy has a negative moderating effect on the relationship between financing constraints and corporate environmental investment, and Hypothesis 3 is established.

5.3. Robustness Test

5.3.1. Parallel Trend Test

It is a prerequisite for applying the difference-in-differences model that the experimental group and the control group must have a parallel trend before the policy is implemented. Referring to the method of Yu Bo (2021), this paper uses data from 2009 to 2013 as the sample and selects 2010, 2011, and 2012 as the policy implementation years for regression[17]. The regression results in Table 5 show that the coefficients of the interaction terms are not significant, meaning that before the policy was implemented, the changes in the scale of environmental investment in the experimental and control groups had a common trend, satisfying the common trend assumption, and the policy effect can be assessed using the difference-in-differences model.

Table 5. Parallel Trend Test

Variables	RD	RD	RD
post_2010*treat	0.0526		
	(0.197)		
post_2011*treat		0.124	
		(0.194)	
post_2012*treat			0.193
			(0.148)
FC	-0.690	-0.662	-0.655
	(0.860)	(0.861)	(0.860)
GP	-0.0401	-0.0457	-0.0551
	(0.173)	(0.174)	(0.174)
Lev	-0.739***	-0.739***	-0.736***
	(0.192)	(0.192)	(0.192)
Cturn	-0.00935	-0.00935	-0.00890
	(0.0306)	(0.0306)	(0.0306)
age	-0.0267**	-0.0270**	-0.0272**
	(0.0133)	(0.0133)	(0.0133)
Si	0.686***	0.686***	0.683***
	(0.0339)	(0.0339)	(0.0339)
Constant	13.00***	12.97***	12.98***
N	1,227	1,227	1,227
R-squared	0.309	0.309	0.310

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5.3.2. Variable Substitution

Following the practice of Jiang Yingbing (2019), the KZ index is used to replace the FC index to measure the level of financing constraints and to test the robustness of the regression results. A larger KZ index indicates a higher degree of financing constraints.

KZ=-1.002×CF/asset+0.283×Q+3.139×Lev-39.368×Dividend/asset -1.315×Cash/asset (6)

Where CF/asset represents the ratio of operating cash flow to total assets, Q is the Tobin's Q value, Dividend/asset is the ratio of cash dividends paid in the current period to total assets, and Cash/asset is the ratio of cash holdings to total assets.

Table 6 shows the regression results, where the regression coefficient of post_2014*treat is significantly positive at the 5% level, consistent with the benchmark regression results, proving that the empirical analysis results are not affected by the choice of indicators and are robust. The "dual carbon" policy effectively promotes corporate environmental investment.

Table 6. Variable Substitution

Variables	RD
post_2014*treat	0.125**
	(0.0514)
KZ	-0.0930***
	(0.0200)
GP	0.538***
	(0.0900)
Lev	-0.137
	(0.136)
Cturn	0.0907***
	(0.0255)
Age	-0.0259***
	(0.00345)
Si	0.563***
	(0.0196)
Constant	13.02***
	(0.151)
N	3,978
R-squared	0.299

6. Conclusion

As the environmental issue of climate change becomes increasingly severe and carbon emissions become a global focus, China has also begun to pay attention to the adverse effects of excessive carbon emissions. Accordingly, low-carbon and energy-saving emission reduction have been made policy priorities. Against this backdrop, this paper selects heavily polluting industries listed on the Shanghai and Shenzhen A-share markets from 2009 to 2020 as the research sample and uses the difference-in-differences method to conduct an empirical study on the impact of the pilot policy of establishing a carbon emission trading market on corporate environmental investment and whether the policy has a moderating effect on the relationship between financing constraints and environmental investment. The following conclusions are drawn: (1) The "dual carbon" policy has promoted corporate environmental investment. Further analysis from the perspective of property rights heterogeneity shows that there are differences in policy effects, and the "dual carbon" policy has a more pronounced effect on promoting environmental investment in non-state-owned enterprises. (2) The scale of

corporate environmental investment is constrained by financing constraints. (3) The "dual carbon" policy alleviates the restrictive effect of financing constraints on environmental investment.

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