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Does Environmental Regulation Promote Corporate Green Innovation? Empirical Evidence from Chinese Carbon Capture Companies

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Abstract: The proposal of the "double carbon" goal of "carbon peak, carbon neutralization" highlights the determination of China's green and low-carbon development. Carbon capture is one of the essential ways to reduce carbon dioxide (CO_2) emissions and cope with climate change. Then, how to improve the green innovation capability of organizations and promote the transformation and upgrading of enterprises with green development is a practical problem that needs to be dealt with quickly. This paper uses multiple linear regression to investigate the impact of environmental regulation on corporate green innovation and explores the mediating effect of corporate environmental investment and the moderating effect of corporate digital transformation. The analysis results show that government environmental regulation can effectively enhance the green innovation of enterprises and environmental investments play an intermediary role. However, the development of environmental regulation in China is still relatively backward, and its positive incentive role needs to be further played. As a result, the government should strengthen environmental legislation while also accelerating system development, increasing corporate investment in environmental protection, and raising protection awareness among companies using digital network technology.

Keywords: carbon capture technology; environmental regulation; green innovation

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1. Introduction

Environmental protection is currently humanity's greatest worldwide challenge. The world is entering an era of low-carbon development, and the shift to renewable energy sources is a worldwide objective. Now, global energy is evolving toward high efficiency [1], cleanliness, and diversification, and key countries are accelerating the energy transition toward low carbonization or decarbonization [2]. China has proposed carbon peak and carbon neutral targets to implement environmental protection actively, which is, on the one hand, an inherent requirement for China to achieve sustainable development and an irreplaceable grip to consolidate the construction of ecological civilization and succeed in the goal of creating a beautiful China; on the other hand, it is also the responsibility of China as a responsible power to fulfill its international commitment and promote the building of a sustainable global community. President Xi Jinping announced China's new goal of actively addressing climate change twice in less than 100 days, first at the general debate on 22 September 2020. Then, on 12 December 2020, the Climate Ambition Summit was held to mark the 5th anniversary of the signing of the Paris Agreement. This strengthened China's resolve to pursue a green and low-carbon development path and illustrated the blueprint

for China's future growth. It has also shown its role as a great power in the international community and provided a solid political impetus for the execution of the Paris Agreement, the worldwide climate protection process, and the green recovery after the pandemic.

President Xi Jinping stated in a speech, and he said, "China will make more effective efforts, enforce stricter rules and regulations to achieve the goal by 2060 [3]". The solemn dedication of. Then, at the general meeting, on 12 December 2020, Xi said that "by 2030 [4], China's CO2 emissions per unit of gross domestic product will decrease by more than 65 percent in comparison to 2005" [5]. In this context, the Central Economic Work Conference convened in December 2020 identified "making effective use of carbon peaking and carbon neutrality" as one of 2021's eight most important priorities. The 4th Session of the 13th National People's Congress (NPC) in March 2021 adopted the "Outline of the 14th Five-Year Plan and 2035 Vision for National Economic and Social Development of the People's Republic of China", which emphasized "completing the target of national independent response to climate change and specifying an action plan for peaking carbon emissions by 2030". In October 2022, Xi, General Secretary of the NPC Central Committee, reiterated that "we should actively and steadily promote carbon peaking and carbon neutrality" and that "achieving carbon peaking and carbon neutrality is a change that will affect the long-term development of China and the world [6]".

China's "double carbon" aim, also known as the carbon peak and carbon neutral aim, is the reflection of China's promise of green and low-carbon development [7], which will have a substantial impact on global climate change and China's future socioeconomic growth [8]. Carbon reduction must be achieved by energy substitution, energy saving, source reduction [9], efficiency improvement [10], process transformation, recycling, and carbon capture, utilization, and storage to realize this objective and achieve green, low-carbon change [11]. In this series of procedures, carbon capture, use, and storage technology are among the most feasible and good methods to reduce carbon dioxide emissions and combat climate change [12]. Carbon capture, utilization, and storage (CCUS) stands for the industrial process of letting out CO_2 from industrial [13], energy, and other emission sources or the atmosphere and directly utilizing or storing it to reduce CO_2 emissions [14]. CCUS is a crucial technology option for global low-carbon development [15]. Carbon capture technology, which plays a vital role as the principal link [16], is still in the industrial demonstration phase in China, and there is still a great deal of space for improvement [17].

China's economic growth has been driven by the traditional model of relying primarily on conventional factor inputs and resource consumption since the reform and opening policy [18]. The country has made significant contributions to the global economy. As China is no longer inclined to high-speed development, but to pursue a higher quality of development, the current issues of an inappropriate industrial structure, poor value-added technologies, and environmental limits will become "bottlenecks" for high-quality economic development [19]. In this context, academics typically view innovation as the most critical factor in sustaining high-quality economic growth. The Party and the administration also highly value innovation's crucial role in fostering economic growth. The report of the 20th Party Congress reaffirms that innovation is the primary factor driving development [20], emphasizes innovation's important place in the context of China's modernization, and makes significant arrangements surrounding innovation-driven development [21]. Based on this, how to actualize the improvement of companies' green innovation capability [22] and promote the transformation and upgrading of firms with green development [23] is a genuine challenge that must be resolved as soon as possible.

Consequently, based on the current development situation of carbon capture technology and the carbon capture industry [24] and the critical role of carbon capture technology and the carbon capture industry in achieving the goal of "double carbon" and high-quality development [25]. It is undoubtedly of great significance for China's carbon capture industry to face up to the critical position of the improvement of green innovation ability for the development of technology and industry and to keep stable and far ahead on the road of healthy development.

Many studies have pointed out that environmental regulation is an effective way to solve the problem of promoting enterprises' green innovation capability and industrial structure upgrading [26–28]. After sorting out the existing studies on the effects of various specific environmental regulation measures on firms' green innovation performance, it was found that they are relatively mature in terms of research theory and research methodology. Li et al. (2022) selected Chinese firms as a sample to study the effects of environmental regulation on firms' innovation outcomes. It was concluded that stricter environmental regulation had a positive impact on the increase in firms' innovation output [29]. Liu and Li (2022) explored how to achieve a win–win situation for both environmental protection and economic development by focusing on the impact of environmental regulation on green innovation, and their study found that a pilot carbon emissions trading policy promoted green innovation among firms in the region [30]. A more in-depth study classifies the types of environmental regulation. Song and Han (2022) decompose environmental regulation into two types, where command-based environmental regulation has a negative impact on carbon reduction and market-based environmental regulation has the opposite [31]. Sun et al. (2023) examined the heterogeneity of these two types of environmental regulation and conclude that only enhanced environmental regulation can examined the heterogeneity of these two types of environmental regulation and concluded that only enhanced environmental regulation can achieve green development of the marine economy [32]. These inconsistent findings provide two important inspirations for empirical studies: first, it is reasonable to distinguish the types of environmental regulations, and there are obvious differences in the mechanisms of action of command-based and market-based environmental regulations on green technological innovation [33]. Theoretically, market-based environmental regulations can provide more flexible and effective incentives for innovation than command-based environmental regulations [34,35]. In the process of environmental regulation policies playing a role in improving firms' green innovation, previous studies have pointed out that firms' research and development (R&D) investment and environmental protection investment play an important role, which provides necessary insights for this study [36]. Huang et al. (2021) found through an empirical study that environmental regulation can stimulate firm innovation by enhancing firms' R&D investment, which is particularly evident in Chinese low-carbon pilot cities [37]. Ahmed et al. (2022) and Guo et al. (2021) showed that increasing national public investment in renewable energy is important to curb CO_2 emission reduction and green energy transition [38,39]. Meanwhile, there are some differences in the innovation behavior of firms due to their different property rights. By combing existing studies, we found that the results differ by the nature of firms' property rights under the same environmental regulatory constraints. Castelnovo (2022) found that patents or the sales of new products were used as indicators of innovation performance, and government subsidies had a stronger effect on the innovation capacity of state-owned enterprises (SOEs). The study found that government subsidies had a stronger effect on the innovation capacity of SOEs, regardless of whether the number of patent applications or new product sales revenue was chosen as a measure of innovation performance [40]. It has also been argued that environmental regulation can have a negative impact on SOEs' performance, and SOEs tend to invest inefficiently when they receive additional credit resources, and these can lead to a decrease in firms' technical efficiency [41]. In addition, existing research on how digital transformation will affect firms' green innovation mainly supports that advancing digital transformation can help improve resource allocation efficiency and integration efficiency and improve firms' green innovation performance [42]. Digital transformation is important for companies to achieve value enhancement by promoting an efficient flow of data elements and enhancing their innovation capabilities [43,44]. Additionally, it has been shown that digital transformation also helps to improve the supply of trade credit, thus significantly enhancing the external financing capacity of firms [45]. Few existing studies have explored the significance of digital transformation in the context of environmental regulation, so it is also worth inves-

tigating what role digital transformation plays in the path of environmental regulation's impact on green innovation in carbon capture firms.

Moreover, in general, looking at the existing research in the academic circle, the relatively mature part focuses on several relatively independent discussions on government subsidies and enterprise R&D innovation, environmental regulation and industrial structure upgrading [46], intelligence, digitalization, and enterprise green innovation capabilities [47], or is more common in the relatively common realistic context. However, in the existing literature, especially in the context of China's carbon capture listed companies that have a direct significance for the realization of the "dual carbon" goal, the role of environmental regulation as an incentive for enterprises' environmental protection investment, and the role of enterprises' environmental protection investment as an intermediary for enterprises' green innovation under the support of regional intelligence and enterprise digitalization. Thus, the discussion on the complete transmission path to promote the realization of the "double carbon" goal and the transformation and upgrading of the industrial structure and high-quality development is relatively rare.

Therefore, the novelty and contribution of this paper focus on the basis of existing research, introduces and launches from the introduction and correlation of environmental regulation and green innovation of carbon capture listed companies in China, and further evaluates the impact of environmental regulation on green innovation capability of carbon capture listed companies as a whole through theoretical analysis, reasonable variable selection and empirical research under model construction, Through the analysis of data, we further explore the mechanism of environmental regulation on the green innovation promotion function of carbon capture listed enterprises, and further exert the positive incentive effect of environmental regulation policies on improving the green innovation performance of carbon capture green enterprises in China. At the same time, further study the impact of environmental regulation on green innovation through the play path of the intermediary role of enterprise environmental protection investment, and straighten out the play channel of this intermediary role. In addition, combined with relevant data, we determine the different effects of enterprises with varying rights of property on the improvement of green innovation capability of carbon capture listed enterprises under the influence of environmental regulations, so as to explore the reasons reflected behind the data and implement policies according to the property rights of different enterprises. Furthermore, it discusses the impact of digital transformation degree on environmental regulation on the green innovation process of carbon capture listed enterprises, and studies explicitly how to fully mobilize the regulatory role of the digital transformation degree of enterprises.

Through this study, we are expected to fill the gap between environmental regulation and green innovation in China's carbon capture industry at the theoretical level under the guidance of the overall goal of sustainable development [48]. With the help of the logic and suggestions of this paper, we can better form a new and more efficient linkage between the government, enterprises, and other stakeholders, serving the government at the legislative level to introduce and implement specific policy formulation on environmental regulation of carbon capture listed enterprises [49]. It serves as a feasible path for the maximum efficiency transformation of China's carbon capture listed enterprises under the general background of environmental regulation and specific policies, and focuses on the development of carbon capture enterprises, and explores constructively how environmental regulation can better promote green innovation of China's carbon capture listed enterprises from the aspects of environmental legislation policies, artificial intelligence development, and intellectual property protection. We should take various measures to promote green innovation of carbon capture technology and transformation and upgrading of the carbon capture industry from the perspective of environmental regulation, so as to give full play to comprehensive governance efficiency, and further promote the better realization of China's "dual carbon" goals, sustainable development, and high-quality development.

The introduction introduces the relevant content of carbon capture, analyzes the problem of insufficient innovation ability faced by the current enterprise development, makes a supplement based on combining the existing literature, expounds the similarities and differences between this paper and the existing research, and finally puts forward the research vision. The second part is hypothesis development, which, respectively, expounds on the relationship between environmental regulation and green innovation of enterprises, the intermediary role of environmental protection investment, the role difference of different enterprise property rights, and the regulatory role of enterprise digital transformation. The third part is the research method. While adopting the literature and hypothesis methods, this paper uses more data analysis methods to explain the relationship between various elements by establishing models to draw more scientific conclusions. The fourth and fifth parts are mainly the result analysis and discussion. The sixth part is based on the previous part and put forward the conclusion and policy implications.

2. Hypothesis Development

2.1. Environmental Regulation and Corporate Green Innovation

Enterprises are the primary source of innovation development [50], and the enhancement of their innovation capacity is the key to enhancing their core competitiveness [51], as well as playing a crucial role in technological breakthroughs [52] and industrial upgrading of their respective fields [53]. However, due to the externality of technology research and development [54], businesses cannot reap the full benefits of research and development, resulting in market failure. In addition to enterprise efforts and accumulation, government intervention is a crucial supplementary method for addressing market failure [55], mitigating firms' R&D innovation deficiencies, and promoting industrial development [56]. As for the relationship between subsidies provided by the government, a typical manifestation of government intervention, and enterprise R&D innovation, existing research has looked at the connection between government funding of business R&D and innovation performance from a variety of angles, including the scale of government subsidies [57], government pro-subsidies (i.e., subsidies when enterprises make profits), and government anti-subsidies (i.e., subsidies when enterprises lose money). The moderating influence of government subsidies on the link between firm investment in R&D and innovation performance is examined [58], and it is concluded that government subsidies provide the most significant direct external resource support for enterprise R&D and innovation. Most academics believe that environmental regulation effectively addresses the challenges above associated with industrial structure modernization [59]. As an essential component of government social regulation [60], environmental regulation stands for the government's act of regulating the economic operations of businesses to prevent pollution by creating matching policies and actions. The literature suggests that environmental regulation can correct the negative externalities of the market and improve ecological quality while also influencing technological innovation, input, and output behavior of enterprises by imposing environmental constraints on them and rationally guiding the industrial structure toward rationalization and accelerated development, thereby creating a situation with multiple benefits. To achieve high-quality economic growth and protect the environment, it is essential to investigate suitable environmental legislation and execute environmental policies with differentiation and targeting to encourage industrial structure upgrading.

For carbon capture technology and industrial innovation, carbon capture listed enterprises [61], which plays an irreplaceable role in the scientific and technological innovation and technological progress of carbon capture technology, face obstacles such as insufficient technical maturity, high economic success, a single financing channel, limited application fields, and low profitability, as well as the upgrading of their green innovation capacity and innovation level [62]. Therefore, there is an urgent need for a more rational and practical form of environmental regulation to offer governmental assistance on their journey to green innovation [27]. Consequently, exploring and implementing better environmental regulations is necessary to carry forward green innovation of listed carbon capture firms in

China, thereby empowering the construction of a green low-carbon economy, promoting the renewal of industrial structure, and is a necessary guarantee to reach the "double carbon" goal and construct a modern economy. This paper argues that reasonable environmental regulation is an essential guarantee for China's carbon capture listed enterprises to conduct R&D activities and carbon capture technology innovation and is a critical facilitator to improve the green innovation performance of Chinese carbon capture green enterprises and proposes the following hypotheses.

Hypothesis 1 (H1): *Environmental regulation significantly promotes innovation in China's carbon capture listed companies.*

2.2. The Intermediary Role of Corporate Environmental Investment

Research indicates that R&D expenditure can foster company innovation [63]. Unquestionably, enterprise R&D investment, as the foundation of enterprise innovation capacity enhancement, is a crucial way for enterprises to achieve a competitive advantage and plays an irreplaceable role in the social innovation process [64]. China's company R&D investment has exhibited a rapid development tendency from year to year, with the 2019 amount reaching CNY 2150.41 billion, or 76.9% of the total social R&D investment. This serves as a reminder of how innovation can be promoted in carbon capture technology and industry—exploring the intermediary role played by the environmental protection investment of listed enterprises of carbon capture in China during the process of environmental regulation to promote their green innovation is, without a doubt, an unavoidable requirement for understanding environmental regulation better to advance innovation and industrial upgrading of carbon capture technology and industry in China.

As an external measure, environmental investment reveals a corporation's level of environmental protection efforts. It seeks environmental, social, and economic gains as a one-of-a-kind investment [65]. Internally, the urge to survive and compete is a motivating force for innovation within businesses. Additionally, environmental protection investments provide financial support for enterprise green technology innovation; high-quality investment in environmental protection can significantly promote the green development of enterprises; and environmental protection investments and enterprise green technology innovation have a corresponding input–output relationship that contributes to enhancing their value. Consequently, according to the chain rule, environmental protection tax can impact business green technology innovation by influencing environmental protection investment [66].

Carbon capture listed firms' increased investment in environmental protection leads to a continual increase in knowledge, technological innovation, new products, and new methods, and contributes to the accumulation of corporate resources. Resource-based theory suggests that precious and scarce resources can typically become a competitive advantage for enterprises, and when enterprises have some heterogeneous resources that are difficult to imitate or replace and can be effectively utilized, they tend to promote their success; enterprises also tend to use resources to achieve improved innovation performance and thereby enhance their innovation capability; and R&D activities are a type of heterogeneous resources [67].

Suppose the logic of environmental regulation in China's listed carbon capture enterprises and environmental investment in green innovation in China's listed carbon capture enterprises can be understood more precisely. In that case, the role of environmental investment in listed carbon capture enterprises can be identified as a regulating role in the context of green innovation in the listed carbon capture firms in China [68]. Consequently, this paper argues, based on the study above, that environmental investment mediates the relationship between environmental regulation and green innovation via the influence path that enterprises can be encouraged by environmental regulation to increase their investment in environmental protection and that the increase in environmental investment can also enable firms to promote green innovation. The following hypotheses are also suggested.

Hypothesis 2 (H2): *Environmental investments by listed carbon capture companies in China mediate between environmental regulation and corporate green innovation.*

2.3. Differences in the Role of the Nature of Property Rights of Different Enterprises

Research indicates that R&D expenditure can foster company innovation [69]. Unquestionably, enterprise R&D investment, as the foundation of enterprise innovation capacity enhancement, is a crucial way for enterprises to achieve a competitive advantage and plays an irreplaceable role in the social innovation process. China's company R&D investment has exhibited a rapid development tendency from year to year, with the 2019 amount reaching CNY 2150.41 billion, or 76.9% of the total social R&D investment. This serves as a reminder of how innovation can be promoted in carbon capture technology and industry—exploring the intermediary role played by the environmental protection investment of listed enterprises of carbon capture in China during the process of environmental regulation to promote their green innovation is, without a doubt, an unavoidable requirement for gaining a better understanding of the regulation of environment to advance the innovation and industrial upgrading of carbon capture technology and industry in China [70].

As an external measure, environmental investment reveals a corporation's level of environmental protection efforts [71]. It seeks environmental, social, and economic gains as a one-of-a-kind investment. Internally, the urge to survive and compete is a motivating force for innovation within businesses. In addition, environmental protection investments provide financial support for enterprise green technology innovation; effective environmental protection investments are conducive to enterprise green technology innovation; and environmental protection investments and enterprise green technology innovation have a corresponding input-output relationship that contributes to enhancing their value [72]. Consequently, according to the chain rule, environmental protection tax can impact business green technology innovation by influencing environmental protection investment [73].

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Hypothesis 3 (H3): *Environmental regulation can promote SOEs to carry out green innovation.*

2.4. Moderating Role of the Degree of Digital Transformation of Enterprises

During the past several years, the digital economy, which is built on several emerging information technologies, including the Internet and cloud computing, has been critical in achieving economic growth, industrial transformation and upgrading, and the reduction of environmental pollution [75]. The national 14th Five-Year Plan and the Vision 2035 outline suggest making the digital economy and other aspects a significant pillar for achieving

carbon neutrality and expanding the digital application of production and manufacturing processes [44]. The more diverse and complicated nature of digital innovation will alter the traditional competition landscape; for instance, big data has changed how businesses manage innovation and will be characterized by iterative innovation, platform innovation, and user engagement. With the acceleration of the digitization process, digital empowerment has altered organizations' business models and management styles, influenced their transformation, and upgraded. Based on research tools such as resource orchestration theory, the existing literature has constructed a model of the mechanism of digital empowerment on enterprises' green transformation and conducted a good exploration of its intrinsic transmission mechanism, as well as initiated a systematic discussion of the issue in the context of listed enterprises, which is suggestive of the extent of enterprises' digital transformation studied in this paper in terms of its operativity.

A company's research and development (R&D) capacity for green innovation demonstrates its capacity to deploy resources to address environmental issues. Green innovation in enterprises is stimulated by digital transformation, especially the listed companies' capacity for green innovation, which is mainly proven in the following three characteristics.

First, the digital transformation of businesses might enable environmental regulation to encourage green innovation by boosting the financial capacity of companies and reducing their financing limitations [76]. Digital transformation may considerably enhance the effectiveness of corporate financing and alleviate the issue of complex and costly funding for businesses. This is because digital transformation can facilitate the flow of a large amount of data and information within an enterprise to integrate and rapidly output available information, significantly improve the transparency of enterprise information, lessen the information asymmetry between internal and external to the company, and reduce external transaction costs such as information search and contract signing for investors [77]. For example, information on the government's compensation or incentives for firms' technological innovation in reducing low-end capacity or for enterprises can be transmitted externally via digital platforms, sending a good signal to external investors. Therefore, digital transformation can aid in enhancing the finance capacity of businesses, attracting more external investment, and successfully relieving financing limitations.

Second, the digital revolution of businesses enables environmental regulation to boost corporate green innovation by enhancing external oversight and reducing internal agency conflicts [78]. The character that environmental regulation played on green innovation in carbon capture listed companies may be constrained by the high level of uncertainty and risk associated with innovation activities, as well as the fact that green innovation technologies are more specialized than traditional technology innovation, with more excellent information opacity during the research, development, and application of results. The use of digital technology can make it easier for shareholders to track key performance indicators and the most recent financial data, making the management process and business results more transparent and visualized, which can help reduce the space for opportunistic speculation of corporate managers, significantly reduce their discretion and an overall reduction in the cost of monitoring innovation activities [79].

Using the findings above as a foundation, this paper illustrates that the level of digitalization also benefits the green innovation of enterprises, and the greater the degree of digital transformation within corporations, the greater the effect of environmental regulation on corporate green innovation. The following hypotheses are also suggested. The hypothetical development path is shown in Figure 1.

Hypothesis 4 (H4): *The degree of digital transformation of firms plays a positive moderating role between environmental regulation and green innovation of firms.*

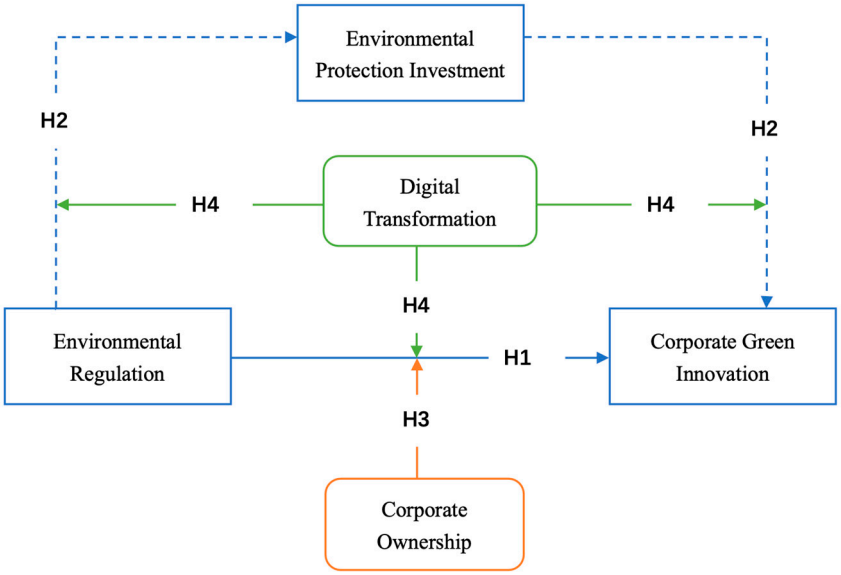

Figure 1. Hypothetical development path.

3. Research Methodology

3.1. Sample Selection and Data Sources

This paper selects A-share listed enterprises in the carbon capture sector in China from 2013 to 2020 as the research object. The data required for this paper's empirical study are obtained from the corporate annual reports of relevant enterprises, the WIND database, local government work reports, and the China Research Data Service Platform (CNRDS), and the data of patent applications are obtained from the State Intellectual Property Office. In this paper, Stata16 is used to organize the data and calculate and analyze the model.

3.2. Variable Definition

Combining the research hypothesis and theoretical model of this paper, considering this availability of data, and referring to the research results of previous scholars, the study's research methodology is as follows:

(1) Dependent variable: corporate green innovation (GRE)

Various methods can be adopted to survey green innovation in enterprises, and from the standpoint of green innovation goods, this research assesses the level of green innovation among businesses [80,81]. The innovation output indicators generally include the new product output value, revenue of recent product sales, number of corporate patent applications, number of corporate patent licenses, etc. The sample selected in this paper is the listed firms of carbon capture in China. The data disclosed in the annual reports of the listed enterprises of carbon capture in China do not compulsorily require the data of new products to be listed separately in that year. Considering the data's availability, this paper uses the single metric of innovation output that is the most straightforward and chooses the patent data of enterprises as the indicator of green innovation. The number of patent applications and the number of patents awarded are included in the patent-related statistics businesses have reported [82]. For the trade-off between these two indicators, this paper considers that the patent approval system and the preferences and efficiency of relevant institutions influence the number of patents granted. The number of patent applications can better reflect the R&D and innovation capability and level of enterprises in that year compared with the number of patent applications [83]. Drawing on the ideas of previous scholars, the article selects the number of patent applications to measure the green innovation of Chinese carbon capture of listed companies, considering the availability and applicability of data and the higher standardization of the number of patent applications.

(2) Independent variable: intensity of government environmental regulation (ER)

There are many ways to define the intensity of governmental environmental regulation. This paper measures the strength of governmental environmental regulation in terms of the importance of the environment in the work reports of prefecture-level municipal governments [84,85]. Considering the various ways and means of government environmental regulation, the vertical evolution and horizontal differences, the comparability of data and the uniformity of research standards, and the relatively stable and essential influence of local governments' work reports on governmental policies, the ratio of the number of environmental words to the frequency of local governments' work reports are chosen in this paper to measure the efforts of government environmental supervision [86,87].

(3) Mediating variable: corporate environmental protection input (INPUT)

As the central part of green innovation activities, the willingness of carbon capture listed enterprises to make environmental protection investments and the improvement of innovation capability impact green innovation ridicule [88]. Like previous studies, this paper considers capital as a variable for enterprises to make environmental protection investments, screens critical words related to environmental protection investment in construction in progress, other payables, and the management cost of the financial statements in the listed company, obtains relevant environmental protection investment data, and takes logarithms to measure the investment of enterprises spent on environmental protection [89].

(4) Moderating variable: the degree of digital transformation of enterprises (INTE)

Digitization is a complex and dynamic process that is extremely difficult to quantify, so the degree of digitization is introduced to measure the relatively static level of implementation of digitization in a company [90]. By drawing on existing research, this paper decides to use the proportion of the year-end intangible asset line items disclosed in the notes to the company's financial report that relate to digital technology to total intangible assets as a yardstick to measure the degree of digital transformation of the company [91].

(5) Control variables.

In addition, in this paper, the following control variables are presented.

① Nature of ownership (STATE): Carbon capture listed enterprises with different property rights have erratic behavior to make their decisions after receiving government subsidies, which may affect the environmental protection investment and green innovation results of carbon capture listed enterprises [92].

Carbon capture listed enterprises are classified into SOEs carbon capture listed capture listed enterprises and non-state-owned enterprises (non-SOEs) carbon capture listed enterprises in this paper, according to the nature of ownership, and assigns "0" to SOEs and "1" to non-SOEs.

② Salary payable to employees (SALA): The amount payable to employees has a particular influence on the labor efficiency and motivation of employees in listed carbon capture enterprises. If the salary payable to employees is low, the cause of employees will not be fully released in the process of promoting environmental protection investment, which is challenging to be effective during a short period, thus affecting the implementation of environmental protection investment under the environmental regulation policy and the formation of green innovation technology of enterprises, and involving the promotion of environmental regulation on the green innovation ability of listed carbon capture firms in China [93]. Conversely, if employees are rewarded and incentivized accordingly, their willingness to engage in green-based innovation can be effectively stimulated. Therefore, in this paper, the various forms of compensation given by firms to obtain the services provided by their employees and other related expenditures are used to measure the payroll payable to their employees and used as control variables.

③ Independent director ratio (DIRE): The influence that environmental regulation exerts on green innovation in carbon capture listed companies is influenced by the board

composition in the process. The independent director ratio affects companies' decision-making intention on environmental investment spending under the sway of environmental regulation [94]. Therefore, in this study, one of the control variables is the ratio of independent directors to the total number of boards.

④ Operating income growth rate (RATE): The operational income growth rate indicates the company's profitability. The better profitability of the enterprise shows that the enterprise will fast forward to the maturity stage of the enterprise life cycle. From the shareholders' point of view, they want the enterprise to obtain long-term income and maintain good competitiveness. At this point, companies want to increase their market share and will continue to explore new growth areas. Previous studies have shown that a company's profitability positively influences its investment in technological innovation. Therefore, this paper uses the ratio of the current year's operating income increase to the previous year's operating income to measure the operating income growth rate as a control variable.

⑤ Gearing ratio (TDR): The gearing ratio reflects the enterprise's solvency and the firm's capital structure, measured by the ratio percentage of total liabilities to total assets. For projects with long time cycles and high risks, such as corporate environmental investments, creditors usually set restrictive terms on using the released funds. Companies with high gearing and debt service pressure will be relatively more cautious when faced with green innovation activities and invest less in environmental protection. In summary, Table 1 provides definitions and relevant descriptions of the variables used in this paper's study.

Table 1. Variable definitions.

Type	Symbol	Name	Definition
Dependent variable	GRE	Corporate Green Innovation	Annual green patent applications for enterprises
Independent variable	ER	Government environmental regulation intensity	The ratio of the frequency of environmental words to the frequency of words in the work reports of prefecture level municipal governments
Intermediate variables	INPUT	Enterprise environmental protection investment	Screen the keywords related to environmental protection investment in the notes to the financial statements of listed companies for construction in progress, other payables, and administrative expenses, obtain the relevant environmental protection investment data and take the logarithm
Adjustment variables	INTE	The degree of digital transformation of enterprises	Proportion of the portion of the year-end intangible asset line items disclosed in the notes to the company's financial report relating to digital technology to total intangible assets
Control variables	STATE	Nature of business ownership	SOEs are assigned a value of 0; non-SOEs enterprises are assigned a value of 1
	SALA	Employee payroll payable	Various forms of compensation and other related expenses are given by the enterprise to obtain the services provided by employees
	DIRE	Percentage of independent directors	Number of independent directors as a percentage of board members
	RATE	Operating income growth rate	Ratio of the increase in the enterprise's operating income for the current year to the total operating income for the previous year
	TDR	Gearing ratio	Ratio of total enterprise liabilities to total assets
	YEAR		Year fixed effects

3.3. Model Design

The research method in this paper is multiple linear regression. A variable often associated with various factors, it is more accurate and effective to use multiple independent variables to measure dependent variables than to use only one independent variable. Therefore, multiple linear regression is used in this paper instead of univariate linear regression. This paper discusses how environmental regulation directly has impact on green innovation in carbon capture firms and the regulating effect of firms' environmental investment. As shown in Equation (1), Model 1 examines the effects of environmental regulation on green innovation in carbon capture firms. As shown in Equation (2), Model 2 is a regression model to assess the effects of environmental regulation on corporate environmental investment. The variable INPUT represents a corporate environmental investment, as shown in Equation (2). Model 3 is derived from Model 1 with a new variable of corporate environmental investment. It examines how environmental investment exerts an influence on corporate green innovation.

$$GRE = \beta_0 + \beta_1 ER + \beta_2 SALA + \beta_3 DIRE + \beta_4 RATE + \beta_5 TDR + \beta_6 YEAR + \varepsilon \quad (1)$$

$$INPUT = \beta_0 + \beta_1 ER + \beta_2 SALA + \beta_3 DIRE + \beta_4 RATE + \beta_5 TDR + \beta_6 YEAR + \varepsilon \quad (2)$$

$$GRE = \beta_0 + \beta_1 ER + \beta_2 SALA + \beta_3 DIRE + \beta_4 RATE + \beta_5 TDR + \beta_6 INPUT + \beta_7 YEAR + \varepsilon \quad (3)$$

For the sake of probing the different performance of environmental regulation of green innovation for SOEs and non-SOEs, the dummy variable STATE is now introduced into the model. In Model 4, if the coefficient of the interaction term between ER and STATE is significant, this indicates that the impact of environmental regulation on green innovation is significantly different between SOEs and non-SOEs. In Model 5, if the coefficient of the interaction term between ER and STATE is significant, this indicates that the effect of environmental regulation on firms' environmental investment is significantly different between SOEs and non-SOEs. In Model 6, if the coefficient of the interaction term between INPUT and STATE is significant, this indicates that environmental regulation's influence on green innovation is significantly different between SOEs and non-SOEs.

$$GRE = \beta_0 + \beta_1 ER + \beta_2 SALA + \beta_3 DIRE + \beta_4 RATE + \beta_5 TDR + \beta_6 ER \times STATE + \beta_7 STATE + \beta_8 YEAR + \varepsilon \quad (4)$$

$$INPUT = \beta_0 + \beta_1 ER + \beta_2 SALA + \beta_3 DIRE + \beta_4 RATE + \beta_5 TDR + \beta_6 ER \times STATE + \beta_7 STATE + \beta_8 YEAR + \varepsilon \quad (5)$$

$$GRE = \beta_0 + \beta_1 ER + \beta_2 SALA + \beta_3 DIRE + \beta_4 RATE + \beta_5 TDR + \beta_6 INPUT + \beta_7 INPUT \times STATE + \beta_8 STATE + \beta_9 YEAR + \varepsilon \quad (6)$$

Next, this article studies the regulatory effect of the digital transformation of enterprises. In Model 7, if ER and INTE interaction coefficients are significant, this indicates that the digital transformation of enterprises in direct models has a significant regulatory role. In Model 8, if the cross-term between ER and INTE is significant, then the moderating effect exists in the first half of the mediated model path. If the cross-term between INPUT and INTE is significant in Model 9, this indicates that the moderating effect is present in the second half of the mediated model path.

$$GRE = \beta_0 + \beta_1 ER + \beta_2 SALA + \beta_3 DIRE + \beta_4 RATE + \beta_5 TDR + \beta_6 ER * INTE + \beta_7 INTE + \beta_8 YEAR + \varepsilon \quad (7)$$

$$INPUT = \beta_0 + \beta_1 ER + \beta_2 SALA + \beta_3 DIRE + \beta_4 RATE + \beta_5 TDR + \beta_6 ER * INTE + \beta_7 INTE + \beta_8 YEAR + \varepsilon \quad (8)$$

$$GRE = \beta_0 + \beta_1 ER + \beta_2 SALA + \beta_3 DIRE + \beta_4 RATE + \beta_5 TDR + \beta_6 INPUT + \beta_7 INPUT * INTE + \beta_8 INTE + \beta_9 YEAR + \varepsilon \quad (9)$$

4. Results

4.1. Descriptive Statistics

The data of A-share listed companies in China's carbon capture sector from 2013 to 2020 is selected in this paper. Firstly, descriptive statistics of the sample as a whole are

conducted. As Table 2 shows, the sample of carbon capture listed companies' greatest and lowest patent application values differ significantly generally, however, the standard deviation exceeds the mean value, illustrating the huge gap between the green innovation performance of sample companies. The minimum value of the environmental regulation intensity of the carbon capture listed enterprises is 0.136, and the maximum value is 0.715, which indicates that a difference exists among the power of the government's environmental regulation on different carbon capture listed enterprises. At the same time, the minimum value is 0, and the maximum value is 22.122 after taking the logarithm of the investment in environmental protection by the listed carbon capture enterprises themselves, which indicates that environmental protection investment requires much financial support, with the characteristics of long cycles and high risk, which affects the enthusiasm and strategic choice of the listed carbon capture enterprises for green innovation. The highest value of the gearing ratio in the sample is 79.1%, the lowest value is 19.1%, and the average value is 49%, which indicates that the selected carbon capture listed companies have a large variability in insolvency.

Table 2. Descriptive statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
GRE	102	23.48	37.223	0	170
ER	104	0.369	0.121	0.136	0.715
INPUT	104	10.978	8.719	0	22.122
SALA	102	17.459	1.327	13.487	19.272
DIRE	102	0.349	0.032	0.273	0.429
RATE	102	0.101	0.295	−0.505	0.94
TDR	102	0.49	0.152	0.191	0.791
INTE	83	0.098	0.144	0.001	0.701
STATE	104	0.462	0.501	0	1

4.2. Correlation Analysis

According to Table 3, ER is positively correlated with GRE with a coefficient of 0.206 and a *p*-value of 0.038, which confirms the hypothesis that environmental regulation can enhance corporate green innovation. INPUT is positively correlated with GRE with a coefficient of 0.394 and a *p*-value of 0.000, which to a certain extent, can indicate that environmental investment enhances corporate green innovation.

Table 3. Pairwise correlation.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) GRE	1.000							
(2) ER	0.206	1.000						
	0.038							
(3) INPUT	0.394	0.111	1.000					
	0.000	0.261						
(4) SALA	0.342	−0.023	0.106	1.000				
	0.000	0.821	0.289					
(5) DIRE	−0.014	−0.032	0.174	−0.091	1.000			
	0.887	0.753	0.080	0.365				
(6) RATE	−0.039	−0.094	−0.116	−0.062	0.201	1.000		
	0.695	0.348	0.245	0.538	0.043			
(7) TDR	0.520	0.091	0.277	0.554	0.136	−0.094	1.000	
	0.000	0.364	0.005	0.000	0.172	0.346		
(8) INTE	−0.151	0.172	−0.226	0.007	−0.167	−0.111	−0.318	1.000
	0.172	0.120	0.040	0.951	0.130	0.319	0.003	

4.3. Multicollinearity Test

From the multicollinearity test in Table 4, the variance inflation factors VIF of the independent variables are below 2.4, indicating no multicollinearity between the variables.

Table 4. Multicollinearity test.

Variable	VIF	1/VIF
INPUT	1.33	0.74946
ER	1.47	0.682341
SALA	1.68	0.594215
DIRE	1.22	0.820458
RATE	1.38	0.724707
TDR	1.73	0.577725
YEAR		
2014	1.82	0.549793
2015	1.95	0.514134
2016	1.87	0.533637
2017	2.11	0.473973
2018	2.14	0.467566
2019	2.07	0.484013
2020	2.39	0.418564
Mean VIF	1.78	

4.4. Mediation Effect Test

According to Table 5, the ER coefficient in Model 1 is 84.460 and is significant ($p < 0.01$). This indicates that government environmental regulation has a facilitating effect on the green innovation of carbon capture firms. The greater the environmental supervision, the more the green innovation of an enterprise. In Model 2, the coefficient of ER is 18.866 and is significant at the ($p < 0.05$). This indicates that environmental regulation has a facilitating effect on the environmental investment of carbon capture enterprises. With the increase in government environmental regulations, the environmental protection investment of enterprises will also increase. In Model 3, the INPUT coefficient is 1.095 and is significant ($p < 0.01$). This shows that carbon capture companies' investments in environmental protection have a catalytic impact on green innovation. When enterprises increase their environmental protection investment, their green innovation will also be enhanced. The findings above show that between corporate green innovation and government environmental regulation, carbon capture businesses' environmental investments serve as a bridge. On the one hand, environmental regulation can help companies to innovate in a greener way. On the other, government environmental regulation can help businesses innovate in a more innocent way by making it easier for businesses to invest more in environmental protection. Hypothesis 1 and Hypothesis 2 are verified.

Table 5. Mediation effect test.

	GRE	INPUT	GRE
Variables	**Model 1**	**Model 2**	**Model 3**
INPUT			1.095 ***
			(2.74)
ER	84.460 ***	18.866 **	63.802 **
	(2.81)	(2.45)	(2.13)
SALA	0.760	−0.832	1.671
	(0.25)	(−1.08)	(0.57)
DIRE	−59.458	54.551 **	−119.189
	(−0.57)	(2.03)	(−1.15)
RATE	−0.875	−5.078	4.685
	(−0.07)	(−1.63)	(0.39)
TDR	122.981 ***	17.264 **	104.078 ***
	(4.76)	(2.61)	(4.02)
YEAR		Omission	
Constant	−76.615	−12.918	−62.470
	(−1.17)	(−0.77)	(−0.99)
Observations	102	102	102
R-squared	0.380	0.251	0.429

T-statistics in parentheses; *** $p < 0.01$, ** $p < 0.05$ (the same below).

4.5. Test for Heterogeneity of Firm Ownership

According to Table 6, the coefficient of ER*STATE is −143.437, and it passes the significant test ($p < 0.01$). This demonstrates that environmental regulation exerts more influence on SOEs' green innovation than on non-SOEs. In Model 5, ER*STATE is 22.357, which does not pass the significant test, indicating that the impact of corporate environmental investment on green innovation is not significantly different between SOEs and non-SOEs. In Model 6, the coefficient of INPUT*STATE is −2.586 and passes the significant test ($p < 0.01$). It means that environmental regulation strongly influences green innovation in SOEs and has a significantly lower impact on green innovation in non-SOEs. The above shows that the nature of ownership of carbon capture enterprises has a significant effect on environmental regulation. Under the same conditions, SOEs perform significantly better than non-SOEs in green innovation.

Therefore, Hypothesis 3 is verified.

Table 6. Test for heterogeneity of firm ownership.

	GRE	**INPUT**	**GRE**
Variables	**Model 4**	**Model 5**	**Model 6**
INPUT			2.090 ***
			(4.34)
ER	119.293 ***	7.734	71.037 **
	(3.44)	(0.84)	(2.49)
INPUT*STATE			−2.586 ***
			(−3.74)
STATE	−14.844 **	−3.101 *	−9.629
	(−2.26)	(−1.79)	(−1.53)
SALA	−0.878	−1.482 *	1.799
	(−0.29)	(−1.82)	(0.60)
DIRE	−46.668	43.330	−121.051
	(−0.46)	(1.62)	(−1.26)
RATE	−2.574	−4.940	1.214
	(−0.22)	(−1.62)	(0.11)
TDR	127.303 ***	18.771 ***	96.616 ***
	(5.16)	(2.88)	(3.94)
YEAR		Omission	
ER*STATE	−143.437 ***	22.357	
	(−2.69)	(1.58)	
Constant	−61.812	7.273	−72.441
	(−0.89)	(0.39)	(−1.11)
Observations	102	102	102
R-squared	0.456	0.298	0.524

T-statistics in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$ (the same below).

4.6. Moderating Effect Test

Table 7 shows that in Model 7, the coefficient of ER*INTE is −56.027, which fails the test of significance. Therefore, even digital transformation cannot effectively promote the positive incentive effect of environmental regulation on green innovation and fails to play a positive moderating effect. In Model 8, the coefficient of ER*INTE is −166.691 and is significant ($p < 0.01$). The data reflects that the degree of digital transformation of enterprises significantly inhibits the promotion effect of environmental regulation on enterprises' environmental investment. The influence of environmental regulation on encouraging environmental protection investment in organizations has diminished as the digital transformation of businesses has advanced, and enterprise digital transformation plays a reverse role. In Model 9, the coefficient of INPUT*INTE is −2.872, which fails the significance test. This shows that the degree of digital transformation of enterprises cannot enhance the promotion effect of enterprise environmental protection investment on enterprise green innovation and fails to play a positive moderating effect.

Table 7. Moderating effects of the degree of digital transformation of enterprises.

	GRE	INPUT	GRE
Variables	**Model 7**	**Model 8**	**Model 9**
INPUT			1.237 **
			(2.38)
ER	123.923 ***	21.316 ***	86.323 **
	(3.48)	(2.68)	(2.12)
INPUT*INTE			−2.872
			(−0.75)
INTE	5.386	−0.362	8.144
	(0.16)	(−0.05)	(0.27)
SALA	0.587	1.022	−1.731
	(0.15)	(1.15)	(−0.40)
DIRE	−54.462	60.595 **	−138.879
	(−0.47)	(2.34)	(−1.17)
RATE	−2.121	−7.719 **	10.059
	(−0.15)	(−2.39)	(0.66)
TDR	145.635 ***	2.169	145.530 ***
	(3.99)	(0.27)	(4.13)
YEAR		Omission	
ER*INTE	−56.027	−166.691 ***	
	(−0.21)	(−2.79)	
Constant	−103.987	−39.089 **	−31.848
	(−1.33)	(−2.24)	(−0.35)
Observations	83	83	83
R-squared	0.435	0.368	0.479

T-statistics in parentheses; *** $p < 0.01$, ** $p < 0.05$ (the same below).

The above results indicate that the degree of digital transformation only makes a substantial negative adjustment impact on the first half of the intermediary effect model, "environmental regulation-environmental inputs". Hypothesis 4 is not tested.

4.7. Robustness Test

This paper uses two approaches to robustness check the results. First, since the number of green patents granted can also reflect the green innovation of enterprises to a certain extent, the dependent variable is replaced with the number of green patents granted (GAPA) in this paper. The results of the main effects regression are shown in Table 8. There is a promoting effect of ER on green innovation, and INPUT has a mediating role between the two. This result is the same as the results above. Second, since the number of patents fits the characteristics of a discrete variable, this paper uses Poisson regression for robustness testing. The results of the main effects regression are shown in Table 9. As can be seen, this result is also the same as the results above, indicating that the results are robust.

Table 8. Substitution of variables method.

	GAPA	INPUT	GAPA
Variables	**Model 1**	**Model 2**	**Model 3**
INPUT			0.804 ***
			(2.86)
ER	76.796 ***	18.866 **	61.626 ***
	(3.62)	(2.45)	(2.92)
SALA	0.719	−0.832	1.389
	(0.34)	(−1.08)	(0.67)
DIRE	−37.906	54.551 **	−81.770
	(−0.51)	(2.03)	(−1.12)
RATE	1.756	−5.078	5.840
	(0.20)	(−1.63)	(0.70)
TDR	81.955 ***	17.264 **	68.074 ***
	(4.49)	(2.61)	(3.74)
YEAR		Omission	
Constant	−64.130	−12.918	−53.743
	(−1.39)	(−0.77)	(−1.21)
Observations	102	102	102
R-squared	0.394	0.251	0.446

T-statistics in parentheses; *** $p < 0.01$, ** $p < 0.05$ (the same below).

Table 9. Poisson regression method.

	GAPA	INPUT	GAPA
Variables	**Model 1**	**Model 2**	**Model 3**
INPUT			0.059 ***
			(15.84)
ER	1.946 ***	18.866 **	0.827 ***
	(9.67)	(2.45)	(3.81)
SALA	0.340 ***	−0.832	0.326 ***
	(10.09)	(−1.08)	(9.89)
DIRE	−1.038	54.551 **	−2.525 ***
	(−1.46)	(2.03)	(−3.69)
RATE	−0.738 ***	−5.078	−0.375 ***
	(−7.10)	(−1.63)	(−3.67)
TDR	4.778 ***	17.264 **	3.872 ***
	(24.22)	(2.61)	(18.68)
YEAR		Omission	
Constant	−6.592 ***	−12.918	−5.621 ***
	(−10.29)	(−0.77)	(−9.00)
Observations	102	102	102
R-squared	0.546	0.251	0.614

T-statistics in parentheses; *** $p < 0.01$, ** $p < 0.05$, (the same below).

5. Discussion

According to the data in Section 4.4, the environmental protection investment of carbon capture enterprises can promote green innovation. In the process of enterprises increasing environmental investment, their green innovation will also be improved. The environmental investment of carbon capture enterprises is an intermediary between government environmental regulation and enterprise green innovation [95]. On the one hand, environmental regulation can play a very direct role in improving the green innovation ability of enterprises; on the other hand, government environmental regulation can also promote green innovation by promoting enterprises to increase environmental investment.

In the process of enactment and enforcement of relevant legal provisions, the government regulates the economic activities of China's carbon capture listed enterprises to reduce pollution and correct the negative externalities of the market [96]. It influences the technological innovation, input, and output behavior of corresponding enterprises by imposing environmental constraints on China's carbon capture listed enterprises, through the innovation compensation effect and optimization of factor allocation, the industrial structure of carbon capture will be rationally guided towards rationalization and upgrading. China's carbon capture listed enterprises will increase their investment in environmental protection and will also promote the accumulation of resources of China's carbon capture listed enterprises through the emergence of technological innovation, new products, and new methods [97]. The corresponding environmental protection investment and its role in R&D activities improve the innovation capacity of enterprises.

Through the analysis of the data in Section 4.5, it can be concluded that the nature of enterprise ownership can strongly and directly affect the effectiveness of environmental regulation. Compared with non-SOEs, environmental regulations can effectively lead SOEs to carry out green transformation and upgrading. However, the impact of enterprise environmental protection investment on green innovation is not apparent between SOEs and non-SOEs. Under the same conditions, the green innovation performance of SOEs is significantly better than that of non-SOEs.

The conclusion is also consistent with the previous theoretical discussion. The extent to which enterprises with government background can improve their green innovation capability under environmental regulation is more substantial than other enterprises, to a considerable extent, because SOES have advantages in existing resources and stuff, and

because SOES can more easily access funds and policy resources that are more closely related to green innovation in environmental regulation [98].

It can be concluded from the data in Section 4.6 that the degree of enterprise digital transformation plays a negative role in the role of environmental regulation in green innovation of carbon capture listed enterprises. On the one hand, the degree of enterprise digital transformation cannot enhance the promotion effect of enterprise environmental protection investment on enterprise green innovation. It cannot play a positive regulatory role [90]. On the other hand, it even plays a significant negative regulatory effect in the first half path of the intermediary effect model, "environmental regulation-environmental protection investment".

After analysis, the main reason for this phenomenon is that the existing environmental regulation mode conflicts with the more common path of corporate digital transformation. The positive regulatory role of enterprise digital transformation degree in the promotion of environmental regulation on enterprises' green innovation ability is mainly achieved through enhancing enterprises' financing ability, strengthening external supervision and alleviating internal agency conflicts, optimizing internal and external resource allocation, etc., the current digital transformation of China's carbon capture listed enterprises does not correspond to the promotion of environmental regulation on enterprises' green innovation ability, but partially led to the opposite result. The increased transparency brought about by the digital transformation has allowed investors to obtain adverse signals from environmental supervision and other negative effects. In addition, some studies have pointed out that the formation process of green innovation capability, as a manifestation of the dynamic capability concept of enterprises, may be affected by organizational inertia [99]. Organizational inertia makes the past development path of an organization fail to adjust its behavior in time according to major national policies and social environment changes, which leads to its inability to adapt to the trend and severe erosion of organizational change and innovation; in turn, it significantly inhibits the role of environmental regulation in green innovation of carbon capture listed enterprises [31]. These problems need to be further optimized and adjusted under the guidance of the government and the cooperation of enterprises, as well as comprehensively implemented under the background of digital transformation to make a positive connection between digital transformation and green innovation of carbon capture listed enterprises.

6. Conclusions

6.1. Research Finding

This paper's findings indicate that environmental regulation is a necessary guarantee for China's carbon capture listed enterprises to conduct R&D activities and carbon capture technology innovation, as well as a significant factor in enhancing the green innovation performance of China's carbon capture green enterprises [100]. Nevertheless, compared to the vast space and market for industrial optimization and upgrading, China's environmental rules are still behind. There is ample area for adjustment and optimization from full play. Therefore, continuing to play environmental supervision policies is essential for my country's carbon capture to capture the green innovation of listed companies and continue transforming and upgrading carbon capture technology and industry. In the way environmental regulation promotes green innovation in China's carbon capture enterprises, the internal environmental protection investment of carbon capture enterprises plays an intermediary role. Environmental supervision can encourage enterprises to increase environmental protection investment and promote the green innovation of firms. Under the premise of investigating the implementation of applicable environmental rules, it is also essential to consider how to actively direct the environmental protection investments of publicly traded carbon capture companies. In addition, the various property rights of listed carbon capture firms in China may influence the amount to which environmental rules affect the green innovation of listed carbon capture enterprises [101]. The heterogeneity analysis indicates that substantial differences exist in the efficacy of green innovation across

firms with different property rights and geographical locations, meaning that non-state enterprises should prioritize resource accumulation and enhance resource utilization efficiency. This study did not conclude that the digital transformation of enterprises in environmental supervision concluded that the active regulation role of carbon capture listed enterprises in environmental management; however, it provides essential insights for us to concentrate on the corporate governance role of digital transformation so that carbon capture listed enterprises can successfully leverage the digital platform to take more significant advantage of environmental regulation.

6.2. Policy Implications

The first thing the government must do is boost the environmental supervision system and enhance environmental supervision. Additionally, it is important to continue to improve our capacity for environmental oversight. The government should establish strict environmental standards from the legislative level, fundamentally restrict pollution-intensive production methods, and promote the rationalization and heightening of the structure of the carbon capture industry; at the same time, the government should increase investment and subsidies for the carbon capture industry, i.e., the listed enterprises of carbon capture, and strengthen the support for the upgrade of carbon capture technology [102]. Simultaneously, the government should increase investment and subsidies for the carbon capture industry, i.e., listed carbon capture enterprises, increase support and investment in environmental research institutions, and establish special industrial development funds for the introduction of green technologies and the upgrading of low-carbon environmental protection equipment to compensate for the short-term cost increase in such innovative enterprises that caused by green innovation [103].

Secondly, enterprises should increase their environmental consciousness. Improve their sense of responsibility and positive environmental image. Provide talent assistance, adopt more flexible and effective innovative reward policies, and expand efforts to attract and educate talent while encouraging businesses to equip and introduce professional talent in pollution monitoring and environmental accounting [104,105]. Strengthen the collaboration between listed companies, universities, and scientific research institutions in carbon capture, and promote the formation of an innovation consortium led by leading companies, supported by universities and institutes, and in which all innovation subjects collaborate to accelerate the development and commercialization of clean production technology, monitoring and testing technology, and green products [106].

For firms to obtain investment in environmental protection, the proportion of matching subsidies will increase their willingness to make investments contributing to environmental protection. Developing comprehensive subsidy application procedures and requirements and strict supervision of the use of funds will ensure that enterprises use them for innovation in green technology [107,108]. Expand the financing channels for corporate environmental investment, minimize financing risks and financing constraints, lower the cost of financing for corporate environmental investment, and assist businesses in overcoming the cash flow shortage that constrains corporate environmental investment [109]. Simultaneously, the active use of economic and incentive-based policies, the development of incentives and voluntary policies to strengthen the "inherent constraints" of social and economic development, to encourage carbon capture listed companies to explore newly available resources, the result of new materials utilization, clean production technologies, and environmental pollution control technologies, to steer the transformation of carbon capture technology and industry. The company will encourage listed carbon capture enterprises to explore new resources, develop further material utilization, clean production technology, and the technology of pollution limitation, guide the transformation and upgrading of carbon capture technology and industry, and promote high-quality economic growth in China [110].

Finally, the government should continually improve digital hardware facilities and network system construction, adapt, and optimize the original management model, and

continually solidify digital transformation's technological and managerial basis. Carbon capture listed enterprises should actively incorporate more subjects into the organization's innovation network to realize the effective change from value co-creation to value multi-creation, thereby promoting the construction of the enterprise ecosystem; carbon capture listed enterprises should also concentrate on the cultivation of green innovation capabilities to reduce corporate transformation and upgrading caused by lack of green innovation capabilities [111]. Through learning green knowledge and effectively sharing green resources, it is vital to establish an organization-wide culture of continuous learning, expand the degree of data exchange, and increase the innovative capacity of enterprise subjects. The government should use the digital platform to demonstrate and communicate the positive influence of environmental regulations on firm transformation and upgrading, as well as revenue growth, so that the digital medium can fulfill its mission and fulfill the expectation of enhancing the character that environmental regulations play in fostering green innovation capacity of listed firms with carbon capture [112].

6.3. Limitations and Future Research

The principal shortcomings of this paper are highlighted by the following: due to the characteristics of the carbon capture industry, to carry forward the green innovation of carbon capture listed firms, the government has implemented various environmental regulation policies. However, the diversity of policies on environmental regulation and the fact that many of them are not required to be presented in the government work report make it difficult to collect certain information and data comprehensively, which may have some impact on the carbon capture industry. Second, there is more than one way for environmental legislation to affect the green innovation of carbon capture listed companies. Due to the limitation of time and resources, this paper solely focuses on the path of corporate environmental investment to impact the green innovation of carbon capture of listed companies, eliminating other variables that may affect the green and innovative performance of listed companies. In the future, we will further investigate ways to improve the precision of the critical variables and do our best to enhance the results' dependability and generalizability. In the future, research should investigate how government environmental regulation enhances the effects of relevant policies to generate strong incentives to achieve the goals of the corresponding industrial policy, the influence of investment on environment protection in the aspect of green innovation of carbon capture of listed enterprises, and other internal and external factors on carbon capture listed companies green innovation influence.

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