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Empirical Analysis of the Carbon Accounting Information Disclosure (CAID) Affecting R&D Investment and Sustainable Development in State-Owned and Non-State-Owned Enterprises

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Abstract: As a topic of interest, the quality of Carbon Accounting Information Disclosure (CAID) provides necessary support to enhance sustainability and investment in Research and Development (R&D). Does improving the quality of CAID have an impact on the R&D investment? Does the sustainability of enterprises play a moderating role in the quality of CAID and R&D investment? These are questions that deserve attention and discussion. This paper extracted 1407 samples from China's markets from 2019–2021, carried out descriptive statistical analysis, analyzed the impact of CAID on R&D investment using multiple linear regression, verified the moderating effect of sustainability on the role of both, and finally conducted a robustness test. The study showed that the higher the quality of CAID, the greater the R&D investment of listed companies; the stronger the sustainability, the stronger the promotion of CAID quality on R&D investment. The findings were also applicable in State-Owned Enterprises (SOEs), while the effect is not significant in non-State-Owned Enterprises. This paper made several recommendations. First, to enhance the company's R&D investment, listed companies should enhance their CAID capability. Second, listed companies should improve their sustainability to ensure the effective performance of CAID. Third, the government should strengthen supervision and policy guidance to promote the continuous improvement of the CAID system to guide listed companies on the road to developing a low-carbon economy.

Keywords: carbon accounting information disclosure (CAID); enterprises R&D investment; sustainable development; state-owned enterprises (SOEs); low-carbon economy

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1. Introduction

The rapid increase of GDP growth rates in the world brings high consumption of various types of energy and natural resources, especially widespread water and air pollution. According to the current state of CO_2 emissions in the world, the World Bank survey found that China is the country that emits the most CO_2. China, as a developing country, is under extreme pressure to actively promote economic development and take measures to reduce low carbon emissions [1]. The need to ensure high economic development and reduce carbon emissions at the same time has become a problem that China must face. In addition to strengthening the control of harmful emissions, China is further reducing energy losses and increasing forest accumulation, using the power of nature to consume CO_2 and reduce carbon emissions to build a low-carbon emission reduction and green economy [2,3]. In addition, China has started to build a carbon emissions trading market and has taken practical measures to promote the gradual improvement of the carbon emissions trading mechanism. This is a matter of whether China can achieve sustainable development and whether the common home of humankind can continue to exist.

In February 2021, China stated that it will gradually promote the realization of high-efficiency and high-quality environmental protection and establish a new system for China's economic development to ensure the achievement of the carbon peak and carbon neutrality goals. According to the relevant deployment, China is striving to achieve the carbon peak

by 2028 [4]. It must be said that carbon accounting is an important component of achieving carbon peaking and carbon neutrality. Through researching the articles published in the research field in the past ten years at home and abroad, it was found that fewer studies used empirical methods to study the influence of CAID [5]. At this stage, China has no relevant theoretical system to effectively guide and constrain Chinese listed companies, resulting in low overall disclosure level. It is very important and meaningful to study the influencing factors of CAID [6]. Therefore, this paper focused on the theme of "sustainability, R&D investment and carbon accounting information disclosure". This paper collected data from target companies, proposed hypotheses and used multiple regression models to analyze them [7]. That is, CAID is positively related to R&D investment, and sustainability plays an important moderating role in regulating the relationship between CAID and R&D investment.

Research contributions. Existing research mainly focuses on theoretical and system specification, and very few studies adopt empirical research methods to investigate the influencing factors of CAID. Therefore, this paper adopts an empirical research method to investigate the influencing factors of CAID and the impact on R&D investment to further enrich the theoretical research in this field. This study points out the influence of company characteristics on the disclosure level to improve the disclosure level of companies. In addition, the study points out which company characteristics have an impact on CAID, which provides a reference basis for governmental departments to formulate laws and regulations, which provides information support and investment suggestions for enterprise stakeholders, and also provides references for strategic decisions on enterprise innovation and R&D investment.

Section 1 is the Introduction, which discusses the innovation points. Section 2 describes the background issues related to CAID, R&D investment and sustainability. Section 3 provides a Literature Review and Research Hypotheses, which discuss the theoretical and practical literature strongly related to the research context and furthermore, combine both to obtain the research hypotheses of this study. Section 4 discusses the Research Design. The data sample is described; the CAID system is constructed using the equivalence assignment method, the research variables are designed, and the empirical research models are established. Section 5 is Empirical Analysis, wherein descriptive statistical analysis and correlation statistics are conducted, multiple regressions are performed and the research hypotheses are tested for validity, robustness tests are conducted to verify the empirical results and further analysis is carried out. Sections 6 and 7 present the Discussion and Conclusions, respectively. Finally, the research limitations of this study and the outlook for future research are provided.

2. Background

Foreign scholars have conducted studies on how enterprises should carry out CAID and what the specific scope involves. In their study, Wu, D. [8] suggested that carbon accounting information is not the same as carbon accounting, but the former has a broader scope and includes information on climate change. Wang, Y. [9] also pointed out that, considering the unique accounting information environment in the low-carbon economy, non-financial information, such as carbon reduction targets, should not be ignored while presenting financial information. Barbosa, F. [10] believed that the CAID is more diversified—the first is the way to disclose the information alone, the second is the way to disclose the information and other information at the same time, and the third is the disclosure at the social responsibility report. Hsieh, H.Y.S. [11] stated that disclosing this information provides the stakeholders with the information they need and can also contribute to the sustainable development of enterprises. Vittorio, A. [12] introduced the disclosure approach that can be taken, arguing that the behavior can be disclosed through a combination of quantitative and qualitative disclosure. Yang, S. [13] explored the specific content of CAID, which includes auditing in addition to measurement and management, and the three are complementary to each other. The current academic community has not yet formed a standardized disclosure

approach that can be adopted for carbon accounting information. The first view is that a special low-carbon report should be established for disclosure instead of traditional financial reports. The second view is to continue to use traditional financial reporting for CAID and simply create supplementary items on the report.

From a global perspective, the Climate Risk Disclosure Guidelines, the Draft Weather Reporting Framework, and the International Framework on Climate Risk Disclosure are more influential globally [14]. The CDP project (Carbon Disclosure Project) conducted in the UK has received significant attention and results. The project encourages large international investors to actively participate in addressing environmental change and provides a basis for large enterprises to formulate development strategies [15]. Foreign scholars generally believe that enterprises participating in the CDP project will actively balance different interests and can include environmental protection when making production, operational and investment decisions to promote the healthy development of enterprises.

3. Literature Review and Research Hypotheses

3.1. Carbon Accounting Information Disclosure and R&D Investment

In recent years, scholars have started to study which factors mainly affect research investment at the macro, micro and industry levels.

Macro factors. First, tax policies: Li, W. et al. [16] point out that the introduction of tax credits in Canada has had a large impact on companies' R&D investment. For multinational companies, Li, H. [17] argues that the introduction of tax policies affects companies' ability to conduct R&D activities. Second, multinational R&D: Yang, R. [18] studied 904 manufacturing companies in Japan and argued that the introduction of income tax credits would have an impact on the technological research conducted by companies. Mei, Z. [19] argued that the implementation of a tax credit policy can activate companies to conduct R&D. Third, preferential policy: Nandy, M. [20] conducted a study on Small and Medium Enterprises (SMEs) in more than fifty developed countries around the world, and through research, Dong, Q. [21] found that government investment in R&D activities is often more leveraged.

Micro factors. First, technology innovation: Xp, A. et al. [22] showed that small companies have a "behavioral advantage" and tend to be more efficient in introducing new products or new designs, as well as more efficient in technological innovation. Garrido-Prada, P. [23] found that increased R&D investment and the focus on technological competitiveness indirectly contributed to the increase in company scale. When the company scale increases, R&D investment also increases along with sales. Second, the concentration of shareholders' power: Zhu, Z. et al. [24] pointed out that when the equity of a company is more concentrated, the willingness for R&D of the company is weaker, while when the private gain of control is elevated, the investment in technological innovation also increases. Third, controlling party: Zhong, J. et al. [25] showed that large companies generally maintain a positive attitude toward ongoing R&D activities, believing that conducting R&D investment is extremely beneficial in promoting the company's development, not only by improving the research level but also by helping to raise visibility. Liu, Y. [26] pointed out that if there is a lack of sufficient financial support, it is difficult to implement the R&D activities carried out by the company. Fourth, the personal background of the CEO: Innocenti, N. [27] pointed out that among the many factors that influence R&D investment, the personal background of the CEO is more significant. Their study analyzed 94 large high-technology companies in terms of R&D efforts and found that the major shareholders' enhanced investment in technological innovation aimed at obtaining more profit returns. Fifth, the debt ratios: Some scholars pointed out that companies with high debt ratios should enhance their R&D investment to improve long-term profitability and thus promote healthy enterprise development, while some scholars held the opposite view.

Industry factors. First, market concentration: Researchers have shown that enterprises have the ability to continuously invest in technological innovation only after they have accumulated and developed and have a monopoly position. Some scholars have

found that although market concentration helps to increase the R&D intensity, the effect is not significant. Second, market demand: Industry demand and technology gaps would have a greater impact on companies' R&D investments. Li, Z.'s study [28] on the U.S. pharmaceutical market found that growing product demand would also play a role in promoting product innovation. Third, industry competition: Tahat, Y.A. [14] shows that if full imitation can be achieved quickly, companies will tend to choose copycat products and reduce the R&D investment that can achieve innovation. Gao, Y. [29] points out that the outflow of technological knowledge will have a strong grip on companies to reduce the cost of innovation but will also weaken the incentive to invest in research and development. According to Lu, B. [30], innovation and competition are not always positively correlated. In other words, the overall relationship is an "inverted U". Fourth, the level of industrial development: Dong, J. [7] focus on external factors: First, higher market demand for new products will activate enterprises to strengthen their R&D investment, but the impact of such promotion is relatively small; second, in general, competition among industries does not play an important role in enterprises' efforts to improve R&D investment; and third, an external financing environment has a small impact on R&D investment.

On the one hand, there is a positive relationship between CAID and R&D investment. At present, most financial institutions tend to focus on the quality of CAID when screening and lending. For enterprises, high-quality information disclosure can bring about more economic benefits for themselves, gain the trust of banks, and have advantages, such as low-cost and adequate financing, than other enterprises in financing [31]. As one of the essential elements of enterprise financial information disclosure, CAID can help investors understand the enterprise environment and social responsibility fulfillment, and then form an understanding of the enterprise image and make investment decisions [32]. Therefore, proper CAID can help enterprises to obtain external financial support and maximize their interests and profits.

On the other hand, Signaling Theory states that investors usually interpret the meaning embedded in management's behavior and use it as a basis to reduce information asymmetry between the two parties. For companies, high-quality accounting disclosure helps drive investment in technological innovation. The involvement of outside capital allows investors to have a more comprehensive understanding of the company's current operations, finances, social compliance and future development and to assess the value of the company in a comprehensive manner [33]. In addition, high-quality information disclosure helps external monitoring, restrains management's behavior, and effectively prevents management from taking advantage of information asymmetry to take advantage of investors' interests. Good environmental information will help companies to gain more investors' goodwill and help them to obtain more external financial benefits. Therefore, good quality carbon accounting information disclosure will help companies obtain more capital to invest in R&D. Therefore, research hypothesis H1 is proposed.

H1: *All other things being equal, the higher the level of carbon accounting information disclosure, the higher the intensity of enterprises' R&D investment.*

3.2. Carbon Accounting Information Disclosure, Sustainability and R&D Investment

The heavily-polluting industries need to undertake more environmental obligations due to the special characteristics of their industries; thus, their level of Carbon Accounting Information Disclosure (CAID) is higher. Harussani, M.M. [34] showed that the higher the level of CAID of companies in heavy pollution industries, the more comprehensive, detailed and standardized the disclosure of companies with worse financial status. Li, Z. [28] showed that the level of CAID varies across industries, especially in heavily polluting industries. The heavily polluting industries were subject to stricter regulation by the environmental authorities, with greater penalties and costs, so the degree of disclosure was higher in the heavily polluting industries. The annual reports of listed companies in Singapore show that the level of CAID of enterprises is positively related to the Company Scale. Using the information of 100 companies in China as a sample, it is also concluded that the

level of CAID of enterprises is positively related to the Company Scale [35]. By collecting information on the financial status of the chemical industry for empirical research, it was found that the Development Capacity and debt level were both negatively related to the level of CAID; and positively related to the Company Scale [36]. An empirical analysis of the social responsibility reports of listed companies in the heavy pollution industry was conducted, and it was concluded that the Company Scale, Sustainability and Development Capacity are directly related to the level of information disclosure of the company [37].

The results of the sample of companies with H shares show that the company is influenced to some extent by the company's debt ratio. If the company has a higher debt ratio, it will increase the disclosure of the environment, thus gaining the ability to keep stakeholders abreast of the actual situation of the company and increase their trust in the company [38]. In addition, the level of CAID is positively related to the Concentration of Shareholders' Power, so the supervision of the company's board of directors can be enhanced by establishing an audit committee and introducing independent directors. Some scholars have examined the Nature of the Controlling Party in Chinese manufacturing listed companies by classification, and through the study, it is concluded that the degree of disclosure of state-owned enterprises is higher than that of non-state-owned enterprises. He, R. [39] conducted a classification analysis of listed companies in China and empirically analyzed the disclosure ratio of state-owned and non-state-owned enterprises separately. The results showed that state-owned enterprises had a higher level of disclosure. Lu, B. [30] also reached similar conclusions. Borghei, Z. [40] studied the role of the public as well as government management. From the perspective of social pressure, the public is extremely concerned about major news reports, especially negative environmental information about enterprises, so negative news forces enterprises to strengthen environmental protection and increase the level of CAID [41]. In addition, the management of environmental information by local governments facilitates the public monitoring of their environment, and the regulation of the media is the regulation of the government. Gao, Y. [29] studied manufacturing enterprises and found that under government pressure, enterprises face increased pressure from shareholders and creditors to pay attention. It was found that under certain political pressure, the CAID of enterprises is greatly affected, and if the policy requirements are violated, it will cause an increase in political costs, the removal of tax benefits, and even environmental penalties [42].

Based on the findings and results of the above literature, this paper categorizes the main influencing factors of Carbon Accounting Information Disclosure (CAID) as Industry Characteristics, Company Scale, Concentration of Shareholders' Power, Nature of Controlling Party and Sustainability and Development Capacity.

Sustainability is not only a measure of an enterprise's ability to continue operating but also a key indicator of an enterprise's level of operation. Sustainability is a gold-sucking stone, and its good or bad determines whether an enterprise can enter the vision of investors. The return on the net assets metric provides a broad picture of the return on shareholders' equity, which is a key indicator for judging the efficiency of a company's capital utilization [43]. A high return on net assets means a high return on the investment of assets and the company receives more net income from its investments. Generally speaking, this indicator helps to judge the operating efficiency of a certain enterprise or even the whole industry.

A consistently high level of sustainability can ensure the quality of CAID, enhancing investors' understanding of the invested company. Sustainability requires not only the management's governance but also the participation of all employees [44]. An efficient and strong sustainability capability can realize the relative fairness of the internal management system of the enterprise and guarantee the independence of the financial information processing by ensuring that the enterprise is not constrained by certain links or powerful people when making CAID. Sustainable development capability ensures the quality of CAID so that the function of investors to understand the low-carbon development of enterprises can be implemented, thus enhancing investors' confidence in enterprises [45].

With sufficient financial support, enterprises are bound to increase R&D investment to achieve better development in the context of high-quality internal control and gradually realize low-carbon development and green innovation of enterprises while maintaining their sustainable profitability.

The basic goal of efficient and strong sustainability is to guarantee the truthfulness and reliability of carbon accounting disclosure [46]. Theoretically, well-established and effective controls can use scientific segregation of duties and appropriate authorization and approval to create a moderating effect between carbon accounting disclosure and R&D investment and reduce the possibility of ineffective, inefficient, and false carbon accounting disclosure information. Therefore, research hypothesis H2 is proposed.

H2: *Other things being equal, the sustainability of listed companies as a moderating variable helps to strengthen the driving effect of carbon accounting information disclosure level on R&D investment.*

3.3. Policy Norms of Carbon Accounting Information Disclosure in China

Chinese companies aim to promote the joint development of environmental, economic and social benefits. Three of the five development concepts advocated by China are inextricably linked to the environment and must always be the goal of corporate environmental disclosure. In recent years, China has placed a high priority on pollution control, which requires companies to focus on research and development, not only to develop innovative production lines and products but, more importantly, to upgrade the industrial structure and deepen the recycling of waste at the end of the industry. It is still forward-looking for China to link CAID with corporate R&D investment for research.

According to the requirements of Chinese finance authorities, the carbon emission rights granted by the government to enterprises without fees shall not be considered assets, and only the carbon emission rights acquired by trading shall belong to the category of assets. However, on the issue of carbon accounting measurement, almost all scholars at home and abroad have reached a consensus on the measurement scale and the criteria of measurement attributes, making it clear that the former is mainly monetary measurement, supplemented by physical measurement. The latter agrees with the coexistence of historical cost and fair value, which is the measurement model of carbon emission rights.

As an indispensable and important part of the reporting information, CAID plays an important reference role in the decision-making of top management and the determination of the future development direction of the enterprise. The CAID must strictly follow four important principles: first, the effectiveness of information disclosure; second, the comprehensiveness of information disclosure; third, considering the balance of cost–benefit; and fourth, the balance of resources and mandatory. In his book, *China's Road to Low Carbon Economy: Theory and Policy,* Chinese scholar Wang Mingxi refers to the study of how China can effectively reduce the pollution caused by carbon emissions to the environment to ensure economic growth. This book combines theoretical knowledge with Chinese policies and raises questions about the model of energy saving and emission reduction for Chinese enterprises and the game model for developing a low-carbon economy. At the same time, the responsibilities and roles of different subjects in building a low-carbon society and developing a low-carbon economy are studied, and the carbon reduction policies of the government at both international and domestic levels are considered. Therefore, in the process of designing and constructing the carbon accounting information disclosure system, we also consider whether the enterprises use clean energy when carrying out the relevant work.

4. Research Design

4.1. Data Sample

This paper selects 2076 listed companies in A-shares from 2019–2021 as the target. The exclusion was carried out according to the following conditions: First, companies under the two major industry categories of finance and insurance were screened out based on the industry classification of the 2012 edition of the Securities and Futures Commission. Second, in view of the going concern accounting assumption, companies under the PT, ST

and *ST categories were excluded. Third, after screening and excluding the sample, and after manual collection and collation, 1407 companies were finally included in the study as valid observations. The data for this study was obtained from all companies listed in China A-shares that fit the theme of the study, and the data can be used directly without being disaggregated by year, allowing for a comprehensive analysis.

Note: PT (Particular Transfer) companies are listed companies that provide a "special transfer service" for the circulation of suspended stocks. ST (Special Treatment) companies are listed companies with unusual financial or other conditions. If a company's stock bears the ST mark, the company is warned by the market that there is an investment risk; if it bears the *ST mark, the company is at risk of delisting.

Most of the data related to carbon accounting disclosure indicators and control variables were obtained from China Stock Market & Accounting Database (CSMAR), and the data on R&D investment and sustainability measures were mainly obtained from Directory Information Base (DIB). The data were processed with the help of Excel and Stata 16.0. In addition, to ensure that the data are subject to extreme values, the Winsorization method is used to reduce the tails of key continuous variables at the front and back percentiles.

4.2. Carbon Accounting Information Disclosure System Construction

We adopt the content analysis method by referring to the Carbon Disclosure Project (CDP) and collect useful information from different companies' annual reports and screening the content related to CAID to score it as a standard to measure the level of CAID. A score of 1 is given to companies that disclose carbon reduction strategies, risk opportunities, management accounting, assurance, and performance in their reports, while no score is given to those that do not. In this paper, a total of 19 carbon accounting information disclosure points in seven categories are selected, referred to as "score" ($0 \leq$ score ≤ 19, score $\in$ N), which can reflect the information disclosure situation of enterprises in a relatively detailed and comprehensive way. Examples of specific scoring criteria are shown in Table 1.

Table 1. Carbon Accounting Disclosure Level Assignment.

Projects	Information	Instructions
Carbon Reduction Strategy	Climate change issues integrated into strategic planning Emission reduction targets	Disclosure is taken as 1, otherwise 0
Carbon Reduction Risks and Opportunities	Carbon risks from climate change Development opportunities arising from climate change	
Carbon Emission Reduction Management	Emission reduction administrative function institutions and personnel settings Emission reduction assessment, incentive and other related management systems Low-carbon publicity, education and training for employees Participation in carbon emissions trading Low-carbon project investment and technology research and development Emissions and treatment methods Emission fees and fines paid	
Accounting for Carbon Emission Reduction	Accounting Methodology Emissions saving tonnage Emission reduction tonnage Emission targets and completion status	
Carbon Emission Reduction Forensics	Third-Party Independent Authentication	
Carbon Emission Reduction Performance	Energy-saving and emission-reduction subsidies and incentive funds Economic and social benefits and honors of energy-saving and emission reduction	
Carbon Recycling	Carbon-gas-recycling-related initiatives	

4.3. Variable Design

The empirical study of this paper involves four categories of variables: (1) Predicted Variable: research and development investment (***RD***); (2) Explanatory Variable: Carbon Disclosure Level (***CDL***); (3) Moderating Variable: Sustainability development rate (***Sdr***); and (4) Control Variables. The definitions of Predicted Variable, Explanatory Variable, Moderating Variable and Control Variables are explained in Table 2.

Table 2. Variable Definition Table.

Category	Name	Symbol	Definition
Predicted Variable	R&D Investment	***RD***	R&D investment/total assets at the beginning of the period
Explanatory Variable	Carbon Disclosure Level	***CDL***	Index system constructed by the questionnaire
Moderating Variable	Sustainability Development Rate	***Sdr***	Measured by DIB index
Control Variables	Investor Confidence	***XINXIN***	Market price per share/net assets per share
	Asset–Liability Ratio	***Lev***	Liabilities/Assets
	Company Scale	***SCALE***	Natural logarithm of total enterprise assets
	Board Size	***BS***	Natural logarithm of the actual number of board members
	Ratio of Independent Directors	***Indep***	Ratio of independent directors to the total number of board members
	Dual Directorship	***Dual***	Dummy variable, the value of 1 for the combination of chairman and general manager, otherwise the value of 0

4.3.1. Predicted Variable

The predicted variable is denoted by ***RD***. Since the size of different enterprises varies, the intensity cannot be judged and identified by selecting the annual amount of money invested into the field of R&D by the enterprises in the study process. We measure the R&D intensity by the proportion of the enterprise's investment in R&D to the entire business revenue.

4.3.2. Explanatory Variable

In this paper, the CAID level carried out by enterprises externally is taken as the explanatory variable, which is expressed by ***CDL***. The current CAID guidelines and system have not yet formed a unified paradigm, and the disclosure information varies among listed companies. The disclosure information differs greatly in terms of content and quality, and the relevant information is too fragmented, unorganized and comparable, so it is difficult to sort out a more uniform disclosure content. To address this situation, this paper refers to China's report on the Carbon Disclosure Project (CDP), collects useful information about the sample companies' annual reports, sustainability reports and other related materials, and finally divides them into seven categories with a total of 19 items (Table 1).

4.3.3. Moderating Variable

In this paper, the sustainability of the enterprise is chosen as the moderating variable, which is expressed by the sustainability development rate (***Sdr***). Regarding the measurement of the enterprise's sustainability, there are generally several methods: First, measurement by accounting information after the completion of the audit under the system of internal control. Second, measurement using the questionnaire method. Third, measurement using the internal control system. Fourth, measurement using both internal and external variables. Through comparison, the third method to measure the sustainability of enterprises is chosen to use the enterprise profitability index from the DIB database to indicate the level of sustainability of enterprises.

4.3.4. Control Variables

Factors affecting the R&D investment of listed companies include various aspects such as company characteristics and enterprise governance, in addition to the level of CAID and sustainability. To better verify the relationship between CAID and R&D investment and make it more accurate, this paper selects the control variables shown in Table 2.

(1) Investor Confidence (***XINXIN***)

Investors' decisions depend, to a large extent, on their confidence, according to the theory of investor sentiment. It can be said that investor information plays an irreplaceable and important role in both capital markets and enterprise development. Investors' perception of investment had subtly changed since the economic crisis in 2008 when social responsibility and environmental disclosure started to be taken into account by investors. Investor confidence and psychological expectations are constantly linked to the level of the environmental performance of the company, which means that the environmental performance of the company is increasingly becoming a knock on the door of investors' decisions. Investor confidence is difficult to measure as a psychological factor, and current measures of investor confidence are primarily based on the stock exchange market. In this paper, the annual turnover rate of stocks is used as a proxy for investor confidence and is expressed as ***XINXIN***.

(2) Asset–Liability Ratio (***Lev***)

The measure of enterprise solvency is mainly reflected in the Asset–liability Ratio indicator. From the data selection, the solvency of enterprises can be reflected by the ratio of total liabilities to total assets of enterprises. The higher the Asset–liability Ratio, the more the business operator is bound to take up part of the company's capital to pay off the debt. Limited resources are squeezed, and accordingly, the funds invested in R&D of the enterprise will be curtailed to a certain extent. This paper predicts that the asset–liability ratio (***Lev***) is inversely related to its R&D intensity.

(3) Company Scale (***SCALE***)

This paper uses the scale of assets to replace the company scale, and the total number of assets is used as the basis for calculation. Usually, the larger the company scale, its working business, operating conditions and internal management staff structure tend to be more complex, profitable and is more likely to increase their R&D investment. As a result, this paper predicts a significant positive correlation between the company scale of listed companies and the intensity of R&D investment. Company Scale is represented by ***SCALE***, and the data was obtained from the CSMAR database.

(4) Board Size (***BS***)

Board size refers to the actual number of board members of a company. In general, the size of the board is closely related to the efficiency of governance, and the smaller the size, the more efficient the governance. In this paper, the Board Size is represented by ***BS***.

(5) Ratio of Independent Directors (***Indep***)

This paper reflects the independence of the board of directors through the proportion of independent directors, and the independence of the board of directors will promote the R&D investment of the company. The proportion of independent directors is the proportion of independent directors to all directors. This paper predicts that the ratio of independent directors is positively associated with its R&D investment. ***Indep*** is used to denote the proportion of independent directors, and the data is obtained from CSMAR database.

(6) Dual Directorship (***Dual***)

Dual directorship refers to the situation where one person is both the chair and the manager of the same company, equivalent to "supervising oneself". This is obviously an institutional weakness, which may lead to serious problems, i.e., the company's major decisions are often made by the "dictator"—the chair, thus aggravating the phenomenon of companies reducing R&D investment. Therefore, this paper predicts there is a negative relationship between dual role and R&D investment. Dual directorship is denoted by ***Dual***.

4.4. Model Construction

To explore whether the level of CAID will have an impact on R&D investment of listed companies, model (1) is constructed:

$$RD = \alpha_0 + \alpha_1 \cdot CDL + \alpha_2 \cdot \sum control + \alpha_3 \cdot Year + \mu_0$$

RD represents the R&D investment in 2019–2021, and the coefficient of ***CDL***, which refers to the level of CAID, indicates the correlation between the level of CAID and the R&D investment. The coefficient is expected to be positive, which means a positive correlation exists between the level of CAID and R&D investment.

To verify the moderating role of enterprise sustainability in CAID and R&D investment, model (2) is constructed:

$$RD = \alpha_0 + \alpha_1 \cdot CDL + \alpha_2 \cdot Sdr + \alpha_3 \cdot CDL \cdot Sdr + \alpha_4 \cdot \sum control + \alpha_5 \cdot Year + \mu_0$$

Sdr denotes the firm's sustainability rate, which is measured by the internal control index in the DIB database. $\boldsymbol{\alpha_2} \times$ ***Sdr*** denotes the interaction term of carbon accounting information disclosure level and R&D investment. This paper concludes that carbon accounting information disclosure has a stronger contribution to R&D investment for listed companies with high-quality sustainability.

5. Empirical Analysis

5.1. Descriptive Statistical Analysis

In order to understand the basic characteristics of the variables in question, descriptive statistical analysis is conducted in this paper, as shown in Table 3. The ***mean*** of R&D is 0.0193, the ***max*** is 0.0786, the ***min*** is 0, and the ***Std.*** is 0.0159. This indicates that the difference in R&D intensity exists among different companies listed in China. The ***max*** CAID level score is 16, the ***min*** is 1, and the ***Std.*** is 3.144; the size difference is more obvious. The ***max*** of ***score*** (CAID level score) is 16, the ***min*** is 1, and the ***Std.*** is 3.144; the size difference is more obvious. This reflects that there has been a large gap in the level of CAID among listed companies. The ***Sdr*** has a ***mean*** of 0.0590 and a ***Std.*** of 0.0969, with a ***max*** of 0.402 and a ***min*** of −0.358. This indicates that there are still listed companies with a large gap in sustainability rate in China, and there is a large gap in sustainability capability between companies.

Table 3. Descriptive Statistics Results.

		(1)	(2)	(3)	(4)	(5)
Category	**Variables**	**Sample Size**	***Mean***	***Std.***	***Min***	***Max***
Predicted Variable	***RD***	1406	0.0193	0.0159	0	0.0786
CAID Level Score	***score***	1406	6.085	3.144	1	16
Moderating Variable	***Sdr***	1406	0.059	0.0969	−0.358	0.402
Control Variables	***XINXIN***	1406	0.0487	0.177	−0.193	0.633
	SCALE	1405	22.8	1.344	20.50	26.41
	Lev	1406	0.428	0.182	0.0773	0.882
	Dual	1406	0.263	0.441	0	1
	Indep	1406	0.374	0.0519	0.308	0.556
	BS	1406	8.706	1.76	5	15

Among the control variables, the ***max*** of ***SCALE*** is 26.41, and the ***min*** is 20.50 with a ***Std.*** of 1.344. This means that the disparity in ***SCALE*** exists among our listed companies, with a ***mean*** of 22.80. The ***max*** of investor confidence is 0.633, the ***min*** is −0.193, and the ***Std.*** is 0.177. This indicates that the level of investor confidence in listed companies varies widely, with an overall ***mean*** on 0.0487. The ***max*** of ***Dual*** is 1, the ***min*** is 0, the ***Std.*** is 0.441, and the ***mean*** is 0.263. This indicates that the overall difference of ***Dual*** in the sample companies is not very big. The ***max*** of ***BS*** is 15, the ***min*** is 5, the ***Std.*** is 1.760, and the ***mean*** is 8.706. This indicates that the difference of ***BS*** among listed companies in China is not significant, and the management structure of enterprises is reasonable. The ***max*** of the ***Indep*** is 0.556, the ***min*** is 0.308, the ***Std.*** is 0.0519, and the ***mean*** is 0.374. The ***mean*** of the ***Lev*** is 0.428, the ***Std.*** is 0.182, and the overall difference is large.

5.2. Correlation Analysis

In order to test whether there are multiple co-linearities between the independent variables, this paper conducted correlation tests on each variable, and Table 4 shows the correlation analysis. For the control variables, the correlation coefficients between ***XINXIN***, ***SCALE***, ***Lev***, ***Indep*** and ***BS*** and ***RD*** are −0.095, −0.312, −0.276 and −0.015, respectively, indicating that all the above variables have a negative impact on R&D investment. The correlation coefficients between ***Sdr*** and ***Dual*** and ***RD*** are 0.145 and 0.171, respectively, indicating that these two variables will positively promote R&D investment. Secondly, there is no multiple co-linearity problem among the variables.

Table 4. Correlation Analysis Results.

	RD	***Score***	***Sdr***	***XINXIN***	***SCALE***	***Lev***	***Dual***	***Indep***	***BS***
RD	1								
Score	−0.003	1							
Sdr	0.145 ***	0.044 *	1						
XINXIN	−0.095 ***	0.126***	0.199 ***	1					
SCALE	−0.312 ***	0.218 ***	0.074 ***	0.387 ***	1				
Lev	−0.276 ***	0.045 *	−0.157 ***	0.227 ***	0.481 ***	1			
Dual	0.171 ***	−0.090 ***	0.088 ***	−0.097 ***	−0.272 ***	−0.121 ***	1		
Indep	−0.015	0.010	0.012	−0.010	0.006	0.022	0.022	1	
BS	−0.127 ***	0.156 ***	−0.007	0.175 ***	0.369 ***	0.163 ***	−0.146	−0.468 ***	1

***, * indicate significant correlation at 0.01 and 0.1 levels, respectively.

5.3. Regression Analysis

5.3.1. Regression Analysis of the Effect of Carbon Accounting Information Disclosure on R&D Investment

Table 5 shows the results of the regression analysis of model (1). The regression result of Model (1) shows that the regression coefficient of CAID is 0.030, and the t-value is 2.34. This indicates a significant positive correlation between CAID and R&D investment within the 5% confidence interval. The higher the level of CAID, the greater the R&D investment intensity of listed companies, and hypothesis H1 holds. On the one hand, the high quality and level of CAID makes investors know more about the enterprise, improves investors' confidence in the invested enterprise, and improves the enterprise's financing ability, thus prompting the enterprise to have more capital to invest in R&D. On the other hand, the higher the level of CAID, the more transparent the earnings structure and the more reasonable the division of labor, which represents the stronger the company's internal control ability. To improve sustainable development, the company's proprietors are more stringent in disclosing the financial accounting information, which increases the intensity of the R&D investment.

Table 5. Regression Results of CDL and R&D investment and Moderating Role of Sustainability in CDL and R&D investment.

	Model (1)		**Model (2)**
Variables	***RD***	**Variables**	***RD***
score	0.030 **	***score***	0.030 **
	(2.34)		(2.36)
		Sdr	0.023 ***
			(4.21)
		α_2***Sdr***	0.265 *
			(1.91)
XINXIN	0.003	***XINXIN***	0.001
	(1.23)		(0.33)
SCALE	−0.003 ***	***SCALE***	−0.003 ***
	(−7.48)		(−8.28)
Lev	−0.014 ***	***Lev***	−0.011 ***
	(−5.56)		(−3.93)
Dual	0.003 ***	***Dual***	0.003 ***
	(3.36)		(2.91)
Indep	−0.009	***Indep***	−0.008
	(−1.03)		(−0.93)
BS	0	***BS***	0
	(−1.17)		(−0.83)
Constant	0.088 ***	Constant	0.091 ***
	(10.85)		(11.23)
Year	Control	Year	Control
Industry	Control	Industry	Control
Observations	1405	Observations	1405
R-squared	0.134	R-squared	0.153
F test	0	F test	0
r2_a	0.129	r2_a	0.146
F	27.34	F	28.19

***, **, * indicate significant correlation at 0.01, 0.05 and 0.1 levels, respectively.

5.3.2. Regression Analysis of the Moderating Effect of the Companies' Sustainability

Table 5 shows the results of the linear regression analysis of model (2). The regression result of Model (2) shows that the regression coefficient of CAID is 0.030, and the t-value is 2.36. This shows that CAID and R&D intensity significantly correlate within a 5% confidence interval. At the same time, the coefficient of the cross-product term of carbon accounting disclosure level and sustainability ($\alpha_2 \times Sdr$) is 0.265, and the t-value is 1.91. This indicates that there is a significant positive correlation between CAID and R&D investment within the 10% confidence interval. That is, the Sdr as the adjusting variable will enhance the positive effect of CAID on R&D investment; that is, the adjusting variable strengthens the main effect, and hypothesis H2 holds.

5.4. Robustness Tests

The paper will use the following two ways to conduct robustness tests. One is to change the carbon accounting disclosure score to do the robustness test; the other is to use the lagged period as the instrumental variable to test its endogeneity in order to avoid the possible endogeneity problem between carbon accounting disclosure and R&D investment.

5.4.1. Changing Carbon Accounting Disclosure Scores

To exclude the influence of differences in R&D investment measures on the study findings, this paper changes the carbon accounting disclosure scores and conducts robustness tests. This is because the higher the score of carbon accounting disclosure issued by a company, the heavier and stronger the disclosure, and the higher the intensity of prior R&D investment. Therefore, the score of carbon accounting disclosure is divided by a fixed

number as a proxy measure of carbon accounting disclosure score, defined as ***E***. The higher this indicator is, the stronger the intensity of R&D investment. The results are shown in Table 6. The regression coefficient between the level of carbon accounting disclosure score and R&D investment is 0.006, and the t-value is 2.40. This indicates that the level of CAID is significantly and positively correlated with R&D investment at a 5% confidence interval, further testing hypothesis H1. The regression coefficient of the cross-product term between sustainability and carbon accounting disclosure is 0.051 and the t-value is 1.94. It can be learned that the sustainability rate as a moderating variable can still promote a positive relationship between the two, further testing hypothesis H2. After changing the variables, the conclusion still shows that the model is robust.

Table 6. Robustness Test of CAID Score, Changing CAID Score and R&D Investment.

(1) CAID Score		(2) Changing CAID Score	
Variables	***Sdr***	**Variables**	***Sdr***
E	0.006 **	***E***	0.006 **
	(2.40)		(2.44)
		Sdr	0.023 ***
			(4.21)
		E* × *Sdr	0.051 *
			(1.94)
XINXIN	0.003	***XINXIN***	0.001
	(1.23)		(0.34)
SCALE	−0.003 ***	***SCALE***	−0.003 ***
	(−7.49)		(−8.29)
Lev	−0.014 ***	***Lev***	−0.011 ***
	(−5.57)		(−3.94)
Dual	0.003 ***	***Dual***	0.003 ***
	(3.36)		(2.92)
Indep	−0.009	***Indep***	−0.008
	(−1.03)		(−0.92)
BS	0	***BS***	0
	(−1.17)		(−0.82)
Year	Control	Year	Control
Industry	Control	Industry	Control
Constant	0.088 ***	Constant	0.091 ***
	(10.86)		(11.24)
Observations	1405	Observations	1405
R-squared	0.134	R-squared	0.153
F test	0	F test	0
r2_a	0.129	r2_a	0.147
F	27.41	F	28.27

***, **, * indicate significant correlation at 0.01, 0.05 and 0.1 levels, respectively.

5.4.2. Endogeneity Test with One-Period Lag as an Instrumental Variable

Table 7 shows the regression results with ***score*-1** instead of ***score*** as an instrumental variable. The sample size becomes 782 because the carbon accounting disclosure score lagged by one period. Column (1) is the endogeneity test for the first stage of the model, while column (2) is the endogeneity test for the second stage of the model. The regression coefficient between the lagged one-period carbon accounting disclosure score (***score*-1**) and the original explanatory variable (***score***) in column (1) is 0.858, with a *z*-value of 53.91. This indicates that the lagged one-period carbon accounting disclosure score of the instrumental variable is significantly and positively related to the original explanatory variable at the 1% level. Moreover, the first stage ***F***-value is 457.09, which indicates that the score of carbon accounting disclosure with one period lag can be used as an instrumental variable in this paper. In the second stage of the endogeneity test, this explanatory variable is replaced with an instrumental variable, and the regression coefficient between the score of carbon accounting disclosure and R&D investment is 0.0603, with a ***t***-value of 3.04. This

indicates there is still a significant positive relationship between the replaced predicted variable and the explanatory variable R&D investment. The results obtained from the two regressions are consistent with the previous paper, the main findings remain unchanged, and the instrumental variable approach test indicates that the research model in this paper is not endogenous.

Table 7. Endogeneity Test with One-Period Lag as An Instrumental Variable.

	(1) the First Stage	(2) the Second Stage
Variables	***Score***	***RD***
score		0.0603 ***
		(3.04)
***score*-1**	0.858 ***	
	53.91	
XINXIN		0.0039
		(1.02)
SCALE		−0.0028 ***
		(−5.91)
Lev		−0.0125 ***
		(−3.87)
Dual		0.0034 **
		(2.42)
Indep		−0.0065
		(−0.61)
BS		−0.0006 **
		(−2.09)
Constant		0.0906 ***
		(8.19)
Year	Control	Control
Industry	Control	Control
Observations		782
R-squared		0.138
F-value of the first stage	457.09	

***, ** indicate significant correlation at 0.01, 0.05 levels, respectively.

5.5. Further Analysis

Enterprises are the providers and disclosers of carbon accounting information. Due to the differences in various aspects such as organizational structure, system scale, role significance and social status of enterprises, there are some differences in the quality and level of CAID by enterprises with different natures. The share of State-Owned Enterprises (SOEs) in the total assets of national enterprises and financial assets in 2021 is 58.72% and 81.55%, respectively, both exceeding 50%. The revenue and profit of SOEs have exceeded that of non-SOEs in the past ten years, indicating the dominant role of SOEs in China's corporate assets. In terms of the situation of A-share listed companies, as of December 8, 2021, the number of listed companies of SOEs was 541, accounting for 29.01% of all A-share listed companies; the number of listed companies of non-SOEs was 1324, accounting for 70.99%. The total market value of SOEs listed companies was 63.74 trillion yuan, accounting for 47.98% of the total market value of all A-shares listed, almost half of the total market value. As of December 31, 2021, the total revenue and profit of SOEs were 44.05 trillion yuan and 4.98 trillion yuan, accounting for 66.39% and 73.18%, respectively.

SOEs are the backbone of China's market economy, and the ultimate controller of SOEs is a Chinese government department, representing the overall image of Chinese government departments. Therefore, it is more logical for SOEs to fulfill more social responsibilities and disclose environmental information in a timely manner in order to improve their enterprise image. When SOEs are the actual controllers, the level of CAID is better than that of non-SOEs. This paper further speculates that the effect of CAID of SOEs on R&D investment is stronger. As seen from the data in Table 8, the regression coefficient

of the CAID of SOEs is 0.064 and the t-value is 3.30. This indicates that the CAID of SOEs has a significant positive relationship with R&D investment at a 1% confidence interval, which indicates that the CAID of SOEs has a significant contribution to R&D investment.

Table 8. Regression Results of CAID and R&D Investment in SOEs.

	(1)
Variables	
score	0.064 ***
	(3.30)
XINXIN	0.014 ***
	(3.31)
SCALE	−0.003 ***
	(−5.83)
Lev	−0.011 ***
	(−3.83)
Dual	0.002
	(0.83)
Indep	0.005
	(0.45)
BS	0
	(−0.48)
Year	Control
Industry	Control
Constant	0.077 ***
	(6.84)
Observations	498
R-squared	0.15
F test	0
r2_a	0.134
F	11.53

*** indicates significant correlation at 0.01 levels.

Technological innovation brings about the market inducement of excessive monopoly profits and coupled with various government policies to guide them, the investment mechanism and operation mechanism of technological innovation take root in SOEs, thus achieving higher sustainability. As shown in Table 9, the regression coefficient of CAID score is 0.059, and the ***t***-value is 2.65, indicating that it is significantly and positively correlated with R&D investment within a 1% confidence interval. The coefficient of the cross-product term between the level of CAID and the sustainability of SOEs is 0.024, and the ***t***-value is 2.97. It can be concluded that the sustainability of SOEs as a moderating variable enhances the positive effect of SOEs' carbon accounting disclosure level on R&D investment.

Non-SOEs are an important part of China's economy, but compared with SOEs, non-SOEs have weaker supervision and responsibility affiliation, smaller system size, and less timely implementation of regulations, so their CAID has a weaker impact on R&D investment. As shown in Table 10, the regression coefficient of CAID is 0.006, and the ***t***-value is 0.35, which indicates that the effect of CAID of non-SOEs on R&D investment is not significant.

From the data in Table 11., the regression coefficient of the CAID score of non-SOEs is −0.021, and the ***t***-value is −1.08, which indicates that its relationship with R&D investment is not significant. The coefficient of the cross-product term between the level of CAID and the sustainability of non-SOEs is 0.489, and the ***t***-value is 2.51. It can be concluded that the relationship between the level of CAID and R&D investment of non-SOEs is not significant, and the relationship between sustainability as a moderating variable on the level of CAID and R&D investment of non-SOEs is also not significant.

Table 9. Moderating Effect of SOEs' Sustainability Capability in CAID and R&D Investment.

	(1)
Variables	
score	0.059 ***
	(2.65)
Sdr	0.022 *
	(1.78)
$\alpha_2 \times Sdr$	0.024 ***
	(2.97)
XINXIN	0.011 ***
	(2.83)
SCALE	−0.003 ***
	(−6.10)
Lev	−0.008 **
	(−2.46)
Dual	0.001
	(0.59)
Indep	0.005
	(0.49)
BS	0
	(−0.27)
Year	Control
Industry	Control
Constant	0.081 ***
	(6.96)
Observations	498
R-squared	0.177
F test	0
r2_a	0.158
F	10.99

***, **, * indicate significant correlation at 0.01, 0.05 and 0.1 levels, respectively.

Table 10. Regression Results of CAID and R&D Investment of non-SOEs.

	(1)
Variables	
score	0.006
	(0.35)
XINXIN	−0.001
	(−0.35)
SCALE	−0.002 ***
	(−4.21)
Lev	−0.016 ***
	(−4.05)
Dual	0.003 **
	(2.55)
Indep	−0.022
	(−1.51)
BS	0
	(−0.77)
Year	Control
Industry	Control
Constant	0.089 ***
	(6.35)
Observations	907
R-squared	0.086
F test	0
r2_a	0.0768
F	10.63

***, ** indicate significant correlation at 0.01, 0.05 levels, respectively.

Table 11. Moderating Effect of Sustainability Capability of non-SOEs in CAID and R&D Investment.

	(1)
Variables	
score	−0.021
	(−1.08)
Sdr	(0.014)
	(−1.00)
$\alpha_2 \times$ ***Sdr***	0.489 **
	(2.51)
XINXIN	−0.003
	(−0.73)
SCALE	−0.003 ***
	(−4.97)
Lev	−0.013 ***
	(−3.02)
Dual	0.003 **
	(2.39)
Indep	−0.022
	(−1.49)
BS	0
	(−0.63)
Year	Control
Industry	Control
Constant	0.097 ***
	(6.70)
Observations	907
R-squared	0.102
F test	0
r2_a	0.0911
F	10.22

***, **, indicate significant correlation at 0.01, 0.05 levels, respectively.

6. Discussion

The modernization of economic and social construction is developing at high speed, and the modernization of enterprise management systems is accelerating. The climate crisis is becoming more severe, and carbon emissions are receiving widespread attention from all over the world, which has put forward higher requirements for green and sustainable enterprises. The role of CAID in enterprises has long been not only limited to the daily financial work but also to the overall planning and strategic layout of enterprises. To better play the role of carbon accounting disclosure in enhancing R&D investment, promoting green practices and sustainability, and reducing the occurrence of high pollution and high consumption behaviors of enterprises, we propose relevant countermeasures and suggestions.

First, strengthening and improving relevant laws and regulations. First of all, we found that most listed companies do not actively disclose carbon accounting information, accounting for less than 20% of the total, and the carbon accounting information with insufficient comparability is extremely detrimental to the healthy development of the ecological economy. In this regard, relevant government departments should formulate unified disclosure standards and guidelines to reflect the comparability of disclosure information. Moreover, some enterprises actively develop in the low-carbon economy, but the government does not provide enough incentives and subsidies to support them, which tends to weaken the enthusiasm for CAID. In this regard, the government should introduce preferential policies in line with the actual development, such as enterprises can obtain corresponding preferential support in terms of loans and taxes if they meet the requirements in disclosing complete carbon accounting information.

Second, strengthening the enhancement of supervision. The study shows a positive correlation between the size of the company, the proportion of independent directors and the level of CAID, and it is positively correlated with the level of CAID in terms of sustainability. In order to promote companies to actively undertake environmental missions, emphasis should be placed on improving supervision. In terms of government supervision, it should be clarified how companies should implement carbon accounting information disclosure. In terms of strengthening social supervision, the role of accounting firms should be brought into play to form a joint effort to promote the level of CAID.

Thirdly, continuously improving governance mechanisms. Research shows that the higher the concentration of companies' shareholding, the lower the level of evaluation of their carbon accounting information—the two are significantly negatively correlated. In contrast, State-Owned Enterprises (SOEs) focus on carbon accounting information disclosure and have a relatively high level in this regard. From this perspective, the enterprise governance structure also affects the level of CAID. Therefore, the government needs to adopt practical and feasible initiatives to improve the enterprise governance system.

For enterprise governance, it should enhance the awareness of CAID, consciously assume social and environmental responsibilities, and build a good image to lay the foundation for the company to achieve healthy development. The enterprise governance should give the internal audit department the authority to audit the CAID and send the report directly to the audit and strategic development committees to avoid the manipulation of the audit report by insiders as much as possible to protect the development of the ecological economy.

7. Conclusions

This paper investigated the relationship between enterprise sustainability, carbon accounting information disclosure (CAID) and R&D investment. This paper extracted 1407 data samples from China's A-share markets from 2019–2021, carried out descriptive statistical analysis, analyzed the impact of CAID on R&D investment using multiple linear regression, verified the moderating effect of enterprise sustainability on the role of both, and finally conducted a robustness test.

When the listed companies are higher in terms of CAID, the intensity of R&D investment is greater. On the one hand, there is a relationship between investors' high trust in listed companies. Specifically, the company's financing capacity is relatively stronger, and the company is more affluent to invest in R&D investments. There is a relationship between high levels of CAID and high transparency. The role of the CFO's financial supervision function gets full play, and its professionalism can be utilized more effectively, thus maximizing the company's financial efficiency.

Sustainability can significantly moderate the relationship between CAID and R&D investments. High-quality sustainability can ensure that the ability of CAID's effectiveness can develop; therefore, enterprises are free from the interference of other factors when conducting R&D innovation and increasing R&D investment, thus increasing the R&D investment of enterprises. High-quality sustainability can also effectively enhance investors' confidence, strengthen enterprises' financing ability, improve enterprises' capital reserve, and thus increase enterprises' R&D investment ability.

The nature of the enterprises can also significantly affect the CAID, R&D investment and sustainability. The stronger the sustainability of SOEs, the stronger the promotional effects of CAID on R&D investment. On the contrary, there is no significant correlation between CAID and R&D investment in non-SOEs, and the effect of sustainability as a moderating variable on the relationship between CAID and R&D investment is not significant.

8. Research Limitations and Future Prospects

This paper conducted an empirical analysis of the relationship between CAID and enterprise R&D investment and the moderating role of sustainability in the relationship between CAID and R&D investment and provided corresponding strategic opinions in response to the research results. However, the research process of this paper still suffers from the following shortcomings.

The selection of data samples and variables is not comprehensive enough. The main companies listed in the paper are mainly A-share main board companies in Shanghai and Shenzhen from 2019–2021. Other listed companies, such as B-shares and H-shares, as well as unlisted companies, are not involved, which may cause the research findings to lack generalizability. In the selection of the variables of CAID characteristics, considering the availability of data, only a portion of the carbon accounting information was selected as a variable, which presented certain limitations. In the subsequent study, the sample data should be improved as much as possible, and other characteristics of CAID should be fully considered.

The selection of control variables may have limitations. There are many factors affecting R&D investment in practice, and although this paper includes as many factors affecting R&D investment as possible as control variables, there may be a problem in that the selection of control variables is not comprehensive. In future research, more variables that may affect R&D investment should be included in the range of control variables to make the research findings more comprehensive.

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