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A Novel Metric for Corporate Environmental Responsibility and Its Impact on Investment Inefficiency

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ABSTRACT

This study aims to establish a new measurement standard for quantifying Corporate Environmental Responsibility (CER) information and activities disclosed by enterprises and to examine the relationship between CER and investment inefficiency (IIE), with a specific focus on the mediating role of information asymmetry (IA). By analysing how CER influences IIE through information asymmetry, the study provides insights into how transparency and responsible environmental practices can enhance investment decisions and overall corporate performance. Regression analysis of 22,413 firm-year observations from China A-shares (2011–2021) shows that active CER disclosure effectively reduces IIE by mitigating information asymmetry, particularly moral hazard (MH) and adverse selection (AS). Robustness tests, including instrumental variable analysis, the Heckman self-selection model, and Propensity Score Matching (PSM), consistently support these findings. The study also reveals that CER disclosures by non-state-owned enterprises (non-SOEs) and enterprises less sensitive to environmental concerns (NES) significantly diminish IIE by addressing information asymmetry. This research underscores the need for enterprises to embrace environmental responsibility actively, encouraging proactive engagement and transparent disclosure of environmental activities and information.

1 | Introduction

Climate change, carbon dioxide emissions, sea-level rise and global warming have emerged as prominent areas of academic inquiry in recent times, and all these subjects fall under environmental studies (Albitar, Borgi, et al. 2023a; Albitar, Al-Shaer, and Liu 2023b; Lu, Huang, Mo, Ye 2023; Hossain and Masum 2022; Zhang and Vigne 2021; Adomako, Ning, and Adu-Ameyaw 2021). As significant components of economic entities, companies play an important role in environmental protection (Liu, Xi, and Wang 2021). CER becoming a major component of corporate social responsibility (CSR) and is gaining attention from investors (Eding and Scholtens 2017; Lee 2021; Fukuda and Ouchida 2020; Cai, Cui, and Jo 2016). Studies have shown that environmental responsibility information disclosure significantly impacts investor response,

financial performance, risk management and social attention (Beji et al. 2020; Long et al. 2020). Therefore, CER, as vital non-financial information, helps investors better interpret financial indicators and offers them additional valuable insights (Meng and Zhang 2022). Although China has become the largest economy in the world, it is also facing increasingly serious environmental problems (Hu, Wu, and Ying 2022; Liu and Anbumozhi 2009). The Chinese government has also enacted many policies and measures in recent decades to protect the environment and to strengthen environmental protection requirements for companies (Long and Lin 2018). The government is working hard to promote mandatory environmental information disclosure according to the Guiding Opinions on Building a Green Financial System issued in 2016. The Ministry of Ecology and Environment of the People's Republic of China implemented the Measures for the Lawful Disclosure of

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Enterprise Environmental Information starting in 2022. Notice of the State Council on Issuing the '2024-2025 Action Plan for Energy Conservation and Carbon Reduction'. Moreover, the government of China has also issued a new commitment of carbon emission peak in 2030 and carbon neutrality in 2060. As China's capital market becomes more sophisticated, information disclosure about CER is increasingly valued by investors (Liu, Xi, and Wang 2021; Yu, Guo, and van Luu 2018; Yu et al. 2021). Therefore, it is imperative to establish a connection between CER and the economic outcomes of enterprises in China, highlighting the importance of CER. Drawing on the perspectives of 'eco-socio-economic man' and natural resource-based view (NRBV), environmental protection and economic development should go hand in hand (Liu, Xi, and Wang 2021; Wong et al. 2018; Hart and Dowell 2011; Li et al. 2017).

Previous studies have found the impact of CER-related activities and information disclosure on economic results, such as increasing firm value (Li, Liao, and Albitar 2020), reducing earning management (Chen et al. 2022), increasing operating or firm performance (Wang, Cui, and Liang 2015), increasing stock liquidity (Akrouf and Ben Othman 2016), reduces the cost of capital (Fonseka, Rajapakse, and Tian 2019; Gupta 2018). Zheng and Liu (2004) demonstrate that growth in business construction investment, such as investment in equipment and plant, will stimulate GDP growth compared to other types of investment. Qin et al. (2006) support that investment-driven growth has been considered as an important development strategy in China. Investment serves as one of the factors that contribute to microeconomic and macroeconomic development, therefore, IIE not only affects the growth of firm value but also damages macroeconomic growth (Jin and Yu 2018). IIE also reflects the going concern ability of firms (Dong, Dong, and Lv 2020). Therefore, the IIE, as a measurement of firm performance, of China enterprises needs to be studied.

The study aims to develop a novel measurement to quantify CER-related information and activities disclosed by enterprises, to better measure CER activities and disclosures. It also investigates the relationship between CER and IIE, examining IA's mediating role. This approach highlights CER's importance in profit generation. IA issues can trigger IE; for example, increased IA can lead to surplus management (MH problem) and over-investment, while IA can increase capital costs (AS problem), causing under-investment, thus triggering IIE (Biddle, Hilary, and Verdi 2009; Zhong and Gao 2017). Agency theory and empirical studies suggest CSR reduces IA and IIE (Benlemlih and Bitar 2018; Liu and Anbumozhi 2009; Samet and Jarboui 2017; Shahzad et al. 2018; Wong, Wong, and Boon-itt 2015). However, CSR disclosures might increase agency costs and opportunistic manager behaviour (Benabou and Tirole 2010; Fama and Jensen 1983; Preston and O'bannon 1997; Hossain and Masum 2022). The impact of CSR on IE is mixed, and CSR is not a complete proxy for CER. There are fewer studies on CER's effect on IIE or firm performance (Zeng, Qin, and Zeng 2019). Existing content analysis methods for quantifying CER have limitations (Du et al. 2016; Li et al. 2017; Montabon, Sroufe, and Narasimhan 2007; Wong, Wong, and Boon-itt 2015; Liu, Xi, and Wang 2021; Li, Liao, and Albitar 2020). This study will develop a new quantification strategy to support further research. Enhancing research on CER and economic outcomes is crucial for Chinese companies and government CER strategies (Long

and Lin 2018). This study aims to provide empirical evidence on whether CER can reduce IIE by reducing IA.

This study uses 22,413 firm-year observations between 2011 and 2021, and finds that CER can reduce IIE by reducing MH and AS, which prove the existence of partial mediating effects. The results of this study remain robust after a series of robustness tests, including alternative measures of CER and IIE, instrumental variables approach, Heckman two-stage model and PSM. Therefore, this study supports the agency theory, stakeholder theory, good manager theory, and obtains the same results as CSR research. This result is consistent with the previous empirical results (Cuadrado-Ballesteros, Garcia-Sanchez, and Martinez Ferrero 2016; Arco-Castro et al. 2020; Carey et al. 2021). Additional analysis finds that CER activities and information of non-SOE and NES can weaken IIE more effectively by weakening IA.

The study contributes to the literature in the following ways. First, this study provides strong empirical evidence on the transmission mechanism of CER on IIE by including MH and AS as mediating variables. Second, compared to previous studies (Cook et al. 2019; Li, Liao, and Albitar 2020; Rehman et al. 2021) that mainly focused on CSR, this study provides a new and comprehensive proxy to measure CER, which also contributes to the quantification of content analysis of CER. In this study, the method of content analysis was selected to quantify CER, thus eliminating the deficiencies of some third-party institutions' evaluations and index ratings; for example, the data provided by HeXun¹ did not consider the occurrence of environmental violations (Hu, Wang, and Xie 2018). Combined with previous research on content analysis related to environmental information disclosure and the main environmental information disclosure policies and guidelines in China, this study summarised and developed a new, more comprehensive and more suitable CER disclosure scoring method for content analysis of enterprises in China. This study provides a template for effective CER implementation, emphasises its importance to business leaders, guides governmental and managerial decision-making, advocates for government focus on CER by recognising its comprehensive economic benefits, and encourages investors to consider CER, indirectly spurring firms to adopt it.

The rest of the paper is structured as follows. Section 2 reviews previous research and theories on CSR, CER, IA and IIE and presents the hypotheses of this study. Section 3 presents the sample, variables and model settings of this study. In Section 4, the empirical results are presented and discussed. Section 5 provides some additional analysis, and Section 6 concludes the paper and presents the limitations of this study and suggestions for future research.

2 | Literature Review and Hypothesis Development

2.1 | Theoretical Framework

In the study of CER and its economic outcomes, particularly with respect to the IIE that is the focus of this study, the theories most often cited are the agency theory and the stakeholder

theory. According to agency theory, agency problems arise due to IA and divergent interests between principals and agents, and the main manifestations of agency problems are classified as MH and AS (Bosse and Phillips 2016; Cohen et al. 2007). MH and AS are referred to as concealed behaviour and concealed information, respectively (Arrow 1984). Modigliani et al. (1958) posited that the opportunity for investment is the sole factor determining whether an investment should be made. In an efficient capital market, firms can and should invest in every investment project with positive Net Present Value (NPV) until the marginal benefit of the investment equals the marginal cost (Hayashi 1982; Myers and Majluf 1984). AS and MH, resulting from IA will make enterprises deviate from the optimal investment level (Biddle, Hilary, and Verdi 2009; Hubbard 1997).

MH primarily refers to situations where an agent undertakes actions unbeknownst to the principal, and these actions generate value for the agent (Holmström 1979; Darrough and Stoughton 1986). Jensen (1986) states that managers will use free cash flow to overinvest in order to expand the company scale (empire building). Stein (2003) explained that managers' concerns about their reputation and career would not invest in new projects to cover up some bad capabilities, because investment would reveal these problems. Benlemlih and Bitar (2018) and Stein (2003) show that investors perceive the self-interest of managers and the waste of resources, thus increasing the cost of financing and causing firms to have no capital to invest. In a word, MH can lead to over-investment and under-investment, which depends on the form of behaviour and the availability of resources.

The AS problem arises mainly because the agent possesses more information (Darrough and Stoughton 1986). Managers will only issue shares when they believe that the shares will be overvalued, using their private information, but investors will find that the managers have concealed the information, so they will ask for a discount until the managers disclose their private information, and the managers will not accept this discount issuance, which will lead to no investment capital and eventually lead to insufficient investment (Chen et al. 2011; Dye 1985). If managers succeed in issuing stocks when they are overvalued, they will engage in overinvestment activities (Baker, Stein, and Wurgler 2003; Biddle, Hilary, and Verdi 2009). In summary, both MH and AS may lead to overinvestment and underinvestment. Overinvestment is mainly caused by the problem of empire building in MH and the excess income obtained by hiding information in AS. Underinvestment may be caused by the high financing cost caused by self-interested behaviour (MH problem) and hidden information (AS problem). Therefore, the way to reduce the inefficiency of investment is to restrict behaviour and expose information.

Appropriate supervision and incentive mechanism can effectively reduce hidden behaviours and information (Dalton et al. 2007; Healy and Palepu 2001). Agency theory proposes that principals can invest in a firm's information system to better monitor and expose behaviour and private information of agent (Eisenhardt 1989). Disclosure of information can effectively reduce IA (Fernando, Giboney, and Schneible 2018). CER-related information disclosure, can effectively reduce IA

and thus weaken the agency problem (Luo et al. 2022). However, agency theory also states that the monitoring of agents by principals incurs monitoring costs and residual losses, also known as agency costs (Fama and Jensen 1983), thus, CER can be considered, to some extent, as a cost impacting the firm's earnings. Moreover, regulation can also affect the incentives of agents, which may also exacerbate agency problems (Cohen et al. 2007). Krüger (2015) and Burke, Chen, and Lobo (2020) states that CSR, include CER, may help managers to conceal opportunistic behaviour, which in turn may exacerbate managers' opportunistic behaviour. According to agency theory, CER can reduce or increase IIE by reducing or increasing IA.

Stakeholder theory proposes that the company should consider all stakeholders when making decisions and formulating strategies (Freeman 2023). The enterprise can cater to the needs of multi-stakeholders through activities relevant to CER, which have witnessed an increase demand by stakeholders (Lee 2021; Fukuda and Ouchida 2020). Stakeholders believe that CER information can better reflect the performance of CSR (Meng and Zhang 2022). Dixon-Fowler, Ellstrand, and Johnson (2017) suggest that disclosure of environmental information also enables managers to establish good relationships with stakeholders. From the perspective of the good manager theory extended from the stakeholder theory, a responsible manager can enhance the company's relationship with key stakeholders by prioritising social and environmental responsibilities, leading to improved financial performance in the long run (Waddock and Graves 1997). From the perspective of stakeholder theory and good manager theory, CER can reduce IIE by reducing IA. This study employs a multi-theoretical framework to explain the relationships among CER, IA and IIE from various perspectives and mechanisms. Agency theory, primarily from the viewpoints of managers and principals, elucidates that IIE stems from IA and posits that CER can mitigate IA.

2.2 | CER and IIE

According to stakeholder theory and good manager theory, climate and environmental problems are concerned by many stakeholders. Therefore, compared with broader CSR issues, the disclosure of CER information can better meet the needs of many stakeholders at present, showing managers' concern and concern for stakeholders, so as to meet the needs of stakeholders and realise the economic performance and goals of enterprises. Previous empirical research about CER provided relevant evidence. Wang, Cui, and Liang (2015) study showed that the use of environmental labels by Chinese manufacturing enterprises can increase the operating performance of enterprises by reducing IA, increasing legitimacy and improving product differentiation. Benlemlih and Bitar (2018) found that higher CSR participation can improve the IE (reduce IIE) of US enterprises, while environmental information contributes more effect. Applying 496 A-share listed companies in China from 2008 to 2016, Li, Liao, and Albitar (2020) found that initially, CER negatively impacts firm value, but beyond a certain point, it begins to positively enhance firm value. Based on Chinese listed companies, Meng and Zhang (2022) found that environmental information disclosure can elicit a significant negative response from investors. Vestrelli, Colladon, and Pisello (2024) find that

the disclosure of climate information can significantly enhance firm value, using a sample of US companies. Some studies, while not directly examining the relationship between environmental protection and corporate performance, have indirectly highlighted the importance of environmental protection for corporate performance. Le and Nguyen-Phung (2024) found that GHG emission intensity significantly negatively impacts corporate financial performance (CFP), as measured by return on assets (ROA) and return on equity (ROE), based on a sample of African firms. Bose et al. (2024) found that, based on 22 countries over the period from 2007 to 2018, firms in regions with elevated economic policy uncertainty typically exhibit lower market value, which can be partly attributed to their higher levels of carbon emissions.

Hence, it can be seen that there is scant research on the relationship between CER and IIE as a measurement of firm performance. Moreover, the impact of CER-related information and activities on firm performance is not clearly defined; it could be either positive or negative. Considering the context of China, the Chinese government has issued numerous policies and initiatives to encourage enterprises to actively fulfil CER. Government officials' performance evaluations are often based on the level of local environmental protection. More importantly, the Chinese government has made significant efforts to enhance investors' environmental awareness and encourage environmentally friendly practices among listed companies in the current capital market. Additionally, enterprises that actively undertake CER can receive both upfront subsidies, such as environmental grants, and post-event incentives, such as tax reductions. Therefore, companies are more motivated to actively engage in CER, which in turn enables them to obtain more funds to achieve economic performance. Hence, the first hypothesis is as follows:

Hypothesis 1. *CER can reduce IIE.*

As mentioned above, agency problem, MH and AS can lead to the occurrence of IIE. Previous empirical studies have also provided relevant evidence. The empirical findings of Richardson (2006), Chen, Sun, and Xu (2016) and Zhang et al. (2016) found that overinvestment occurs more frequently in firms with higher free cash flows. Roychowdhury (2006) studied a sample of companies included in Compustat from 1987 to 2001 and shows that managers avoid reporting losses through sales discounts, overproduction and reduction of related investment expenditures. Moreover, the results of Lang and Lundholm (1996) indirectly confirm that IA increases the cost of capital. The increase of capital cost will eventually lead to the problem of insufficient investment.

Based on agency theory and stakeholder theory, the disclosure of CER information can effectively reveal managers' selfish behaviour and private information, subsequently alleviating IIE. Previous empirical research provides evidence that CER-related activities and information, can effectively curb managers' behaviour, which could solve MH problem. The research of Chen et al. (2022) shows that environmental regulation can reduce IA and agency cost, and then inhibits Chinese enterprises' real earnings management behaviour, but it has no such inhibitory effect in state-owned enterprises. The results from Gerged, Albitar,

and Al-Haddad (2021), based on 100 Jordanian firms listed from 2010 to 2014, indicate a negative correlation between environmental information disclosure and earnings management. CER information, can provide investors with more non-financial information to help them better understand the company and thus reduce financing constraints and financing costs (Luo et al. 2019), which could solve AS problem. The empirical findings of Kong et al. (2022), Gupta (2018), Fonseka, Rajapakse, and Tian (2019) and Yu et al. (2021) suggest that information and activities related to environmental responsibility are effective in attenuating financing constraints or financing costs.

Building on the preceding discussion, disclosing CER information can address the needs of stakeholders, enhance the understanding of management practices, and provide effective oversight by revealing managers' actions and private information, ultimately leading to a reduction in IIE. Considering the background of China, the importance of government agencies and their support for CER, as well as the guidelines and basis for the government to formulate various environmental protection policies and information disclosure, the quality and quantity of CER information should be steadily improved, and it can better meet the needs of stakeholders, therefore, following hypothesis is developed:

Hypothesis 2. *The impact of CER on IIE is mediated by MH and AS.*

3 | Data and Research Design

3.1 | Sample

This study is based on empirical analysis and panel data to test the hypothesis established above. Based on previous empirical studies, this study collects all financial and non-financial data from China Stock Market & Accounting Research Database (CSMAR). The range of years selected for this empirical study is 2012–2021. Firstly, the disclosure of environmental responsibility information of listed companies has only been specifically required in China since 2008, the initial year was decided to be after 2008 in view of its popularity and trial period. The importance of environmental issues is evident from the changes in environmental laws and the various slogans and policies has promulgated since 2013 (Li et al. 2017). The initial year is lagged to 2012 to consider that some data are lagged by one period. First, all A-share listed companies from 2012 to 2021 were downloaded from CSMAR, totally have 61,668 firm-year observations, after removing the financial sector (drop 861 firm-year observations) according to previous studies, and removing the missing data (drop 38,394 firm-year observations), such as missing data about CER and relevant dependent variables and control variables, the final sample of this study contains 22,413 firm-year observations between 2012 and 2021, representing 2241 Chinese listed companies. Table 1 shows the distribution of the sample by year and industry. The distribution of the sample by year shows that the closer to 2021, the more observations there are. The number of observations remains around 2000 firms in each year from 2012 to 2018, and rises to almost 3000 in 2019 and 2020. The decrease in the number of observations in 2021 may be due to the lack of timely data updates and the

TABLE 1 | Sample distribution by year and industry.

	Freq.	Percent	Cum.
Year			
2012-12-31	1875	8.37	8.37
2013-12-31	2166	9.66	18.03
2014-12-31	2288	10.21	28.24
2015-12-31	2197	9.80	38.04
2016-12-31	2058	9.18	47.22
2017-12-31	2151	9.60	56.82
2018-12-31	2338	10.43	67.25
2019-12-31	2781	12.41	79.66
2020-12-31	2954	13.18	92.84
2021-12-31	1605	7.16	100.00
Industry			
Agriculture, forestry, animal husbandry and fishery	337	1.50	1.50
Mining	557	2.49	3.99
Manufacturing	14,355	64.05	68.04
Electricity, heat, gas and water production and supply industry	777	3.47	71.50
Construction	605	2.70	74.20
Wholesale and retail trade	1259	5.62	79.82
Transportation, storage and postal services	728	3.25	83.07
Accommodation and catering	81	0.36	83.43
Information transmission, software and information technology services	1415	6.31	89.74
Real Estate Industry	1013	4.52	94.26
Rental and business services	274	1.22	95.48
Scientific research and technology services	185	0.83	96.31
Water, environment and public facilities management	281	1.25	97.56

(Continues)

TABLE 1 | (Continued)

	Freq.	Percent	Cum.
Residential services, repair and other services	1	0.00	97.57
Education	28	0.12	97.69
Health and social work	57	0.25	97.95
Culture, sports and entertainment	295	1.32	99.26
General	165	0.74	100.0
Total	22,413	100.00	

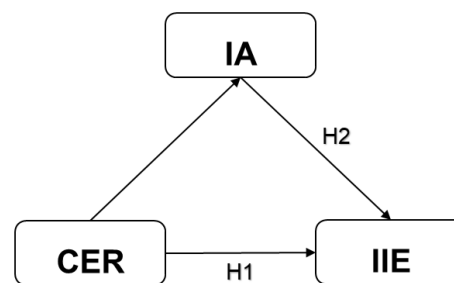


FIGURE 1 | Conceptual framework.

impact of the new Covid epidemic. Table 1 also shows the distribution of the sample in the industry, the latest industry classification released by the China Securities Regulatory Commission (CSRC), this study only focuses on the primary classification, a total of 19 primary industries, and the distribution of the data collected shows that the observations are distributed in each industry. The sample size of the manufacturing sector is the largest, accounting for 64% of the total sample, while the sample size of the residential services, repair, and other services sector is the smallest with only one observation.

3.2 | Model and Variables

This study follows the studies of MacKinnon, Cox, and Baraldi (2012), Li, Liao, and Albitar (2020), and Cook et al. (2019) on the mediating effect to set up the model. In this paper, we study the mediating effect of IA between CER and IIE, so the independent variable is CER, the mediating variable is IA, and the dependent variable is IIE, and then we estimate the mediating effect by setting up a three-stage model. Figure 1 shows the conceptual framework of this study.

3.2.1 | Independent Variable: CER

To enable a more precise quantification of CER information (Berelson 1952; Tangpong 2011), this study employs content analysis to measure CER, with the relevant disclosure data sourced from the CSMAR database. Compared to other quantitative approaches, such as reputation indices and scores provided

by third-party professional bodies (Xiong et al. 2016; Hu, Wang, and Xie 2018), content analysis is considered most suitable for quantitative studies of CSR or CER in China, as it better captures multi-stakeholder demands (Wong et al. 2018; Huang and Zhao 2016). When conducting content analysis, it is crucial to consider the guidelines or indicators used as reference bases.

By reviewing existing CER content analysis methods specific to China, this study refines previous quantitative guidelines. Unlike prior studies that focus solely on environmentally sensitive companies (Du et al. 2016; Li et al. 2017; Xu et al. 2020), this research encompasses all industries (except the financial sector), making the reference base and guidance more comprehensive. Existing quantitative content analysis guidelines and indicators have been updated (Liu and Anbumozhi 2009; Montabon, Sroufe, and Narasimhan 2007) to provide a more accurate comparison of CER-related disclosures and activities rather than a mere evaluation of CER (Li, Liao, and Albitar 2020). The disclosure scores in this study will more accurately reflect firms' actual commitment to CER.

Firstly, based on the five dimensions of CER proposed by Li, Liao, and Albitar (2020), the EID scoring index by Meng et al. (2014), the "Environmental Practice Matrix" by Montabon, Sroufe, and Narasimhan (2007), GRI guidelines, environmental information guidelines for listed companies issued by the Shanghai Stock Exchange, and the Management Measures for the Legal Disclosure of Corporate Environmental Information issued by the Ministry of Environmental Protection, this study compiles detailed disclosure criteria for CER. Supported by literature from Carey et al. (2021), Arco-Castro et al. (2020), Klassen and McLaughlin (1996) and Tan and Zhu (2022), five key sections are determined, and the disclosure criteria are systematically categorised, resulting in the final five sections as shown in Table 2. Among them, the Compliance section is designed to ensure that CER information disclosed by companies has a certain basis and standardisation that can guarantee the impartiality and authority of the information, and that authoritative information or information with guarantees is more effective (Carey et al. 2021; Arco-Castro et al. 2020). The Benefits component is intended to show that a company is recognised for its performance in terms of CERs. Environmental rewards imply that the company has achieved outstanding and recognised achievements in environmental management, which will bring benefits to the company, such as increased market value (Klassen and McLaughlin 1996). 'The Awareness section is designed to ensure that companies consider CER from a strategic development and ideological perspective, as integrating environmental awareness into company strategy, especially in the minds of managers, is an effective way to promote green innovation in companies and thus achieve the goals of CER (Tan and Zhu 2022)'. The Protection component investigates a range of efforts made by companies to protect the environment, and quantifying this component not only shows the actual behaviour of companies, but also some environmental performance, such as the type and amount of emissions and resource consumption reduced. The Damage section is designed to quantify the work done and penalties imposed on companies in terms of environmental damage, and in this

section, it is possible to observe the impact of companies on the environment, especially as the latter three can offset some of the greenwashing of environmental activities.

TABLE 2 | CER measurement.

Compliance
Compliance with the Guidelines on Environmental Disclosure for Listed Companies, the Global Reporting Initiative GRI Sustainability Reporting Guidelines, and a range of other CSR guidelines
Obtain relevant environmental certifications such as ISO14001Z or OHSAS18001
Have a third-party auditor
Benefits
Any Awards received from environmental authorities
Any Government funding, subsidies and tax rebates related to the environment
Awareness
Statement of values, philosophy and principles on environmental protection
The company's environmental policy, annual targets or plans
Protection
Staff training in environmental management and operations
A range of environmentally friendly activities
Facilities such as environmentally friendly products/energy saving technologies
Types of resource consumption reduced
Reduced resource consumption
Types of emissions reduced
Reduction in the amount of emissions
Environmental treatment of waste, pollutants, including but not limited to recycling/reuse
Surveys and audits of suppliers and consumers
Investment in environmental protection as described above
Damage
Type of resource consumption
Amount of resources consumed
Types of emissions
Amount of emissions
Investigation, criticism, penalty or seizure for violation of environmental regulations
Presence of construction projects with significant environmental impact
Complaints from local residents/communities

The quality of CER disclosed by an enterprise cannot be truly obtained solely by relying on the quantity and subject of disclosure (Anwar and Malik 2020). Moreover, the performance and implementation of environmental responsibility should be composed of actual performance and formal performance (Liu, Xi, and Wang 2021). Therefore, the specific quantitative measures according to the methods of Liu, Xi, and Wang (2021), Shvarts, Pakhalov, and Knizhnikov (2016), Wong et al. (2018) and Meng et al. (2014) are as follows. First, the content is assigned a score based on the location of the disclosure, if the content is disclosed in the annual report or CSR report alone, a score of 1 is assigned, and if it is disclosed in both reports, a score of 2 is assigned. According to the form of disclosure, the content can be classified into textual, quantitative and monetary descriptions. Monetary descriptions contain the most information and are the most accurate, while textual descriptions are the least. Therefore, textual, quantitative and monetized descriptions were assigned a value of 1, 2 and 3. Finally, the location score and the form score were aggregated to obtain the total CER score. The higher the score, the better the CER, but for the last three content in the ‘Damage’ plates when disclosed need subtract point which depends on the type and location of information were disclosed, if not disclosure give point 0.

Using one of the index as an example, let’s explain the quantification process. For the index ‘Government funding, subsidies, and tax rebates related to the environment’, the process begins

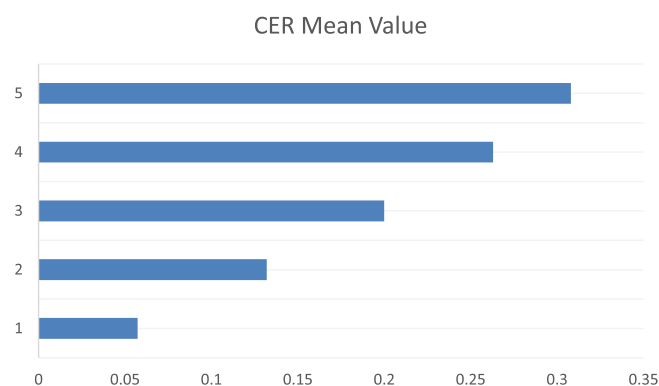


FIGURE 2 | Average CER distribution by ESG grade. [Colour figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com)]

by checking whether the enterprise has disclosed this information. If disclosed, it is marked accordingly. Next, the location of the disclosure is assessed: if it appears only in the CSR report or the annual report, the information receives 1 point; if disclosed in both reports, it receives 2 points. This completes the quantitative evaluation. For the qualitative evaluation, points are awarded based on the detail of the disclosed content: 1 point for a textual description, 2 points for numerical details (e.g., the number of subsidies received) and 3 points if the information is expressed in monetary terms (e.g., the amount of the grant).

In order to ensure the validity, two experts in the same research field were invited to review the newly created index for check validity. In order to double check validity of CER, following the previous study Karim et al. (2021), the mean value of CER was calculated based on the five ESG grades, with the expected result that the mean value of CER rises as the ESG grades increase (from the 1st grade to the 5th grade). Figure 2 illustrates the above results, and as expected, as the ESG rises, the mean value of CER also rises, therefore, our new measurement is valid.

3.2.2 | Dependent Variables: IIE

Firms are considered efficient if they invest at the expected level, over-invest if they invest more than the expected level, and conversely may under-invest if they invest less than expected (Wu et al. 2022). The current study quantifies IIE based on the investment function model used by Richardson (2006), Wu et al. (2022), Shi (2019) and Chen, Sun, and Xu (2016) with the following model 1:

$$\begin{aligned}
 Invest_{i,t} = & \beta + \beta_1 SaleGrowth_{i,t-1} + \beta_2 Leverage_{i,t-1} \\
 & + \beta_3 CFO_{i,t-1} + \beta_4 Age_{i,t-1} + \beta_5 Size_{i,t-1} \\
 & + \beta_6 Stockreturns_{i,t-1} + \beta_7 Invest_{i,t-1} + YearFixed \\
 & + IndustryFixed + \epsilon_{i,t} \quad (1)
 \end{aligned}$$

where $i = 1, \dots, N$ denotes the firm and $t = 1, \dots, T$ represents the time period. The variables in the model are quantified in the way shown in the Table 3. The above model is then estimated

TABLE 3 | Variables used to quantify IIE.

$Invest_i$	The sum of yearly growth in fixed assets, intangible assets, and construction in process, as scaled by total assets.
$SaleGrowth_{t-1}$	The growth rate of the operating income
$Leverage$	The sum of the book value of total debt divided by the sum of the book value of total debt and the book value of equity
CFO	The ratio of operating cash flow to total assets.
Age	The log of the number of years the firm has been listed as of the start of the year
$Size$	The log of total asset
$Stockreturns$	Stock returns are stock returns for the year prior to the year of investment, measured by the change in market capitalization of that company in the previous year

using ordinary least squares (OLS), controlling for year and industry by means of high-dimensional regression commands to achieve two-way fixed effects. The IIE is quantified by the residuals $\varepsilon_{i,t}$ from the above model. The residuals represent the difference between the actual investment and the expected investment, with a positive value indicating that the firm has overinvestment in the year and the expected investment is less than the actual investment. Negative values represent underinvestment in the current year, where the expected investment is greater than the actual investment. In this study, the negative values are taken as absolute values and then subjected to a mediating effect analysis for readability of the results. Therefore, the larger the residual value, the more the firm deviates from the optimal investment level.

3.2.3 | Control Variables

Following previous studies, some control variables (Benlemlih and Bitar 2018; Biddle, Hilary, and Verdi 2009; Cook et al. 2019; Dong, Dong, and Lv 2020; Zhao 2021; Zhong and Gao 2017) are also selected in this study in order to better isolate the effect of CER and IA on IE. CFO is the ratio of operating cash flow to total assets. Institutional Share is the percentage of company shares held by institutional investors. Leverage is the ratio of the book value of total debt to the book value of assets. Financial Slack is quantified by the ratio of cash holdings to PPE. Tangibility is measured by the ratio of PPE to total assets. Sale Sd is measured by the standard deviation of sales revenue over the previous 3 years, and ROA is the return on capital of a company quantified by the ratio of net income to total assets. Board Size measures the size of the board of directors. Independent Ratio measures the percentage of independent directors to the total number of board members. Gender Diversity measures the percentage of female members on the board. CEO Duality is a dummy variable, where a value of 1 means that the CEO serves as both president and chairman of the board, and vice versa.

3.2.4 | Mediating Variables

In the previous studies, the measurement of IA tends to use only a single quantification, but IA includes both MH and AS, so it should be quantified separately. Based on previous studies, MH will be measured using the firm's free cash flow, which is ((Net cash flows from operating activity – Cash paid for the purchase of fixed asset)/total asset). Free cash flow is the cash flow in excess of what is needed to finance all projects with positive net present value (Jensen 1986). Self-interested managers will waste company available resources (free cash flow) on empire building and value reduction projects, resulting in over-investment (Jensen 1986). Moreover, Drobetz, Grüniger, and Hirschvogel (2010) show that free cash flow can lead to MH. Therefore, free cash flow is the most appropriate measure for quantifying MH, as it can be observed both in terms of the availability of resources and the behaviour of managers. Based on previous studies (Cheng, Dhaliwal, and Neamtiu 2011; Cho, Lee, and Pfeiffer 2013), the AS problem is mainly measured by Bid and Ask spread, which is the ratio of the daily bid-ask spread to the closing price of a firm averaged

over the year. The Bid and Ask spread includes not only the cost of AS but also the order processing cost and inventory holding cost, but according to the previous literature and the results may be unreliable if AS is stripped out, so this study also follows the previous study and uses the actual value of Bid and Ask spread to quantify AS (Cheng, Dhaliwal, and Neamtiu 2011; Van Ness et al. 2001).

The most commonly used method to test the mediating effect involves a step-by-step regression coefficient analysis based on previous research (Li, Liao, and Albitar 2020; Cook et al. 2019). The first step is to test the influence of CER on IIE, and also test Hypothesis 1, the second step is to test the influence of CER on IA, and the third step is to test the influence of CER and IA on IIE. The criteria for judging whether there is mediation effect and the interpretation of the coefficient of key variables, the process begins with testing the coefficient α_1 in Model 2. If α_1 is not significant, the mediation analysis is halted. If α_1 is significant, the analysis proceeds to the second step, checking the β_1 coefficients in Models 3. If β_1 coefficients are significant, the analysis advances to the third step, which involves examining the coefficient δ_1 in Model 4. A significant δ_1 indicates a partial mediation effect, while an insignificant δ_1 suggests a full mediation effect. If β_1 in Model 3 and δ_2 in Model 4 are insignificant, a product coefficient test, including the Sobel test and Bootstraps, is conducted. If the results from these tests are significant, the mediating effect is confirmed; if not, the mediating effect is considered insignificant.

In this context, α_1 represents the total effect of CER on IIE, δ_1 represents the indirect effect of CER on IIE, and the $\beta_1 \times \delta_1$ represents the mediating effect of CER on IIE through its impact on IA. Model 2 was designed to investigate the effect of CER on IIE, with the first stage. Models 3 was designed to investigate the effects of CER on IA (MH; AS), and the second stage. Models 4 were designed to investigate the effects of CER and IA on IIE, and the third stage

$$\begin{aligned} Investeff_{i,t} = & \alpha_0 + \alpha_1 CER_{i,t-1} + \alpha_2 CFO_{i,t-1} \\ & + \alpha_3 InstitutionalShare_{i,t-1} + \alpha_4 Leverage_{i,t-1} \\ & + \alpha_5 FinancialSlack_{i,t-1} + \alpha_6 Tangibility_{i,t-1} \\ & + \alpha_7 SaleSd_{i,t-1} + \alpha_8 ROA_{i,t-1} + \alpha_9 BoardSize_{i,t-1} \quad (2) \\ & + \alpha_{10} IndependentRatio_{i,t-1} + \alpha_{11} GenderDiversity_{i,t-1} \\ & + \alpha_{12} CEODuality_{i,t-1} + YearFixedEffects \\ & + IndustryFixedEffects + \varepsilon_{i,t} \end{aligned}$$

$$\begin{aligned} IA_{i,t} = & \beta_0 + \beta_1 CER_{i,t-1} + \beta_2 CFO_{i,t-1} \\ & + \beta_3 InstitutionalShare_{i,t-1} + \beta_4 Leverage_{i,t-1} \\ & + \beta_5 FinancialSlack_{i,t-1} + \beta_6 Tangibility_{i,t-1} \\ & + \beta_7 SaleSd_{i,t-1} + \beta_8 ROA_{i,t-1} + \beta_9 BoardSize_{i,t-1} \quad (3) \\ & + \beta_{10} IndependentRatio_{i,t-1} + \beta_{11} GenderDiversity_{i,t-1} \\ & + \beta_{12} CEODuality_{i,t-1} + YearFixedEffects \\ & + IndustryFixedEffects + \varepsilon_{i,t} \end{aligned}$$

$$\begin{aligned}
\text{Investeff}_{i,t} = & \delta_0 + \delta_1 \text{CER}_{i,t-1} + \delta_2 \text{IA}_{i,t} + \delta_3 \text{CFO}_{i,t-1} \\
& + \delta_4 \text{InstitutionalShare}_{i,t-1} + \delta_5 \text{Leverage}_{i,t-1} \\
& + \delta_6 \text{FinancialSlack}_{i,t-1} + \delta_7 \text{Tangibility}_{i,t-1} \\
& + \delta_8 \text{SaleSd}_{i,t-1} + \delta_9 \text{ROA}_{i,t-1} + \delta_{10} \text{BoardSize}_{i,t-1} \quad (4) \\
& + \delta_{11} \text{IndependentRatio}_{i,t-1} + \delta_{12} \text{GenderDiversity}_{i,t-1} \\
& + \delta_{13} \text{CEODuality}_{i,t-1} + \text{YearFixedEffects} \\
& + \text{IndustryFixedEffects} + \varepsilon_{i,t}
\end{aligned}$$

4 | Empirical Results

4.1 | Descriptive Statistics

Panel A of Table 4 presents the results of descriptive statistics of the IIE data, including the initial IIE values (Investeff) and the substitution algorithm (Investeff-R), for the purpose of robustness testing, and which also includes both the overinvestment and the underinvestment sample groups. The number of underinvestment (underinvest) and overinvestment (overinvest) observations suggests that Chinese firms are more likely to underinvest, similar to the results of Chen et al. (2011), Liu and Tian (2021) and Zhong and Gao (2017). The number of observations of overinvestment and underinvestment is also identical for both methods, so the results are more robust. Based on the median, variance and minimum and maximum values, the fluctuations in IIE in all three groups are small and the means are almost equal, which further indicates the robustness of the IIE results. Panel B presents the descriptive statistics for MH and AS data. Panel C presents the descriptive statistics of CER data, including the overall CER score, the CER score calculated by principal component analysis (CER PCA). The median and minimum and maximum values of the total CER scores, indicate that Chinese firms do not take CER into account too much. Based on a standard deviation of 0.13, with a mean of 0.12 and the maximum and minimum values of 0.53 and 0, the overall CER score exhibits more volatility. The CER score collected based on five sections are generally consistent with the CER assumptions derived by Li, Liao, and Albitar (2020). Panel D presents the statistical results for some control variable data. Panel E shows the statistical results for two instrumental variables.

Table 5 shows the Pearson correlation coefficients between the variables. Consistent with expectations, CER score is negatively correlated with IIE, and both MH and AS are positively correlated with IIE. Moreover, IIE also has a strong correlation with the control variables as well. In addition, there is no strong correlation between the explanatory variables, so there is no problem of multicollinearity.

4.2 | Multivariate Analysis

Table 6 presents the results obtained using the OLS estimation model, incorporating fixed industry and year effects, and clustering at the firm level to address heteroskedasticity. The results in column (1) indicate a significant negative correlation between CER and IIE. Specifically, the study found that CER

is significantly negative with IIE, suggesting that CER can decrease IIE. These findings support a positive relationship between CER and firm performance and align with agency theory, stakeholder theory and good management theory. These theories propose that CER can reduce IA, fulfil stakeholders' needs and ultimately reduce IIE, thus supporting Hypothesis 1. The results in columns (2) and (3) demonstrate a statistically significant negative relationship between CER and both MH and AS. These findings indicate that CER information can reduce IA by curbing selfish behaviour and revealing information, as supported by Chen et al. (2022) and Gerged, Albitar, and Al-Haddad (2021). In terms of the magnitude of the coefficients, CER is more effective in inhibiting the occurrence of the MH problem compared to the AS problem. This outcome further supports agency theory and stakeholder theory. It implies that CER information can guide managerial behaviour and disseminate information while revealing the ethics of businesses through CER data disclosure. Consequently, this suggests that companies will provide information transparently, without concealment.

The results in columns (4) and (5) show that MH and AS are positively associated with IIE, indicating a significant positive relationship. Conversely, CER is negatively associated with IIE, and both associations are statistically significant. Therefore, it can be concluded that CER reduces IIE by reducing IA. Since the coefficients of CER and IIE are significantly negatively correlated in the third stage, only partial mediation is observed, supporting Hypothesis 2. These empirical results align with previous expectations and support agency theory and stakeholder theory. Furthermore, the findings confirm that CER provides valuable information to meet the needs of various stakeholders, aiding them in better regulation. This regulation, in turn, restricts managers' behaviour and reveals their private information, ultimately reducing IIE.

To delve deeper into specific IIE behaviours, we divide the IIE into two subsamples: overinvestment and underinvestment. Table 7 shows the estimation results using the subsample of overinvestment. The results in column (1) indicate a significant negative relationship between CER and overinvestment. The results in columns (2) and (3) confirm that CER is also significantly negatively related to both manifestations of IA. Columns (4) and (5) show that the two aspects of IA are positively associated with overinvestment, while CER is significantly negatively associated with overinvestment. Thus, integrating the coefficients and the statistical significance across the three stages, we can conclude that CER reduces overinvestment by mitigating IA. This result is also consistent with the findings of a previous study (Liu and Tian 2021).

Table 8 shows the results for underinvestment, which are also consistent with the previous IIE results in terms of positive and negative coefficients and significance. Firstly, the results in column (1) show a significant negative relationship between CER and underinvestment. In columns (2) and (3), CER is also negatively related to two manifestations of IA. In columns (4) and (5), the two aspects of IA are positively related to underinvestment, while CER is negatively related to underinvestment. Combining the coefficients and significance across the three stages, it can also be concluded that CER reduces underinvestment by

TABLE 4 | Descriptive statistics.

Variable	N	Mean	p50	SD	Min	Max
Panel A. Descriptive statistics for IE						
<i>Investeff</i>	22,413	0.027	0.018	0.032	0	0.183
<i>Investeff~R</i>	22,413	0.027	0.017	0.032	0	0.183
<i>Overinvest</i>	8554	0.036	0.019	0.046	0	0.239
<i>Underinvest</i>	13,859	0.022	0.017	0.020	0	0.111
<i>Overinvest~R</i>	8554	0.036	0.019	0.046	0	0.240
<i>Underinvest~R</i>	13,859	0.022	0.017	0.020	0	0.111
Panel B. Descriptive statistics for mediating variables						
MH	22,413	0.058	0.043	0.052	0.001	0.273
AS	22,413	0.039	0.037	0.011	0.018	0.072
Panel C. Descriptive statistics for corporate social responsibility scores						
CER	22,413	0.122	0.070	0.131	0	0.530
CER PCA	22,413	0.131	-0.050	1.246	-0.986	3.630
Panel D. Descriptive statistics for control variables						
Institutional share	22,413	0.438	0.456	0.240	0.00300	0.904
Financial slack	22,413	0.590	0.344	0.741	0.0200	4.649
Tangibility	22,413	0.444	0.431	0.201	0.0550	0.905
Board size	22,413	8.593	9.000	1.703	5.000	15.000
Independent ratio	22,413	0.376	0.364	0.0540	0.333	0.571
Gender Div	22,413	0.188	0.177	0.110	0	0.500
SALESD	22,413	1.356e+09	3.130e+08	3.471e+09	9.259e+06	2.508e+10
ROA	22,413	0.0290	0.0320	0.0730	-0.358	0.196
CEO duality	22,413	0.260	0	0.439	0	1
Leverage	22,413	0.456	0.441	0.502	0.00800	63.97
CFO	22,413	0.0460	0.0460	0.0840	-4.270	2.222
Panel E. Descriptive statistics for instrument variables						
Industry CER	22,413	0.108	0.0940	0.0530	0.0270	0.292
Regional CER	22,413	0.110	0.100	0.0500	0.0100	0.320

reducing IA. Therefore, the results of this part further confirm the previous hypothesis and related theories.

4.3 | Robustness Check

4.3.1 | Endogeneity

This study employs an instrumental variables approach, a Heckman two-stage model, and PSM to address potential endogeneity. Specifically, a two-step instrumental variables approach is used in each stage of the three-stage mediating effects estimation model. Instrumental variables, selected based on their relationship to endogenous variables and lack of correlation with disturbance terms, include the regional-year average CER

(Regional CER) and the industry-year average CER (Industry CER), both lagged (Bhandari and Javakhadze 2017; Benlemlih and Bitar 2018). Table 9 presents the results of the first stage using this approach. In the first step, both instrumental variables significantly positively relate to CER. In the second step, the fitted values of CER, substituted into the model and estimated using 2SLS, GMM and LIML, show a significant negative relationship with IIE, supporting Hypothesis 1 that CER reduces IIE.

Table 10 details the second and third stages of the mediating effects estimation with MH as a mediator. The second step of the second stage, using the same predictive variables as the first stage, shows a non-significant negative relationship between CER and MH across 2SLS, GMM and LIML models. In

TABLE 5 | Correlation.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
(1) Investeff.	1.000														
(2) MH	0.235*	1.000													
(3) AS	0.068*	0.036*	1.000												
(4) CER	-0.039*	-0.039*	-0.182*	1.000											
(5) CFO	0.042*	0.021*	-0.033*	0.123*	1.000										
(6) Institutional share	-0.013*	0.018*	-0.157*	0.257*	0.090*	1.000									
(7) Leverage	-0.027*	0.013	-0.027*	0.041*	-0.086*	0.069*	1.000								
(8) Financial slack	-0.086*	0.110*	0.059*	-0.143*	-0.008	0.014*	-0.046*	1.000							
(9) Tangibility	0.175*	-0.055*	-0.088*	0.185*	0.142*	0.106*	0.019*	-0.630*	1.000						
(10) Board size	-0.030*	-0.031*	-0.130*	0.180*	0.047*	0.240*	0.040*	-0.047*	0.130*	1.000					
(11) Independent ratio	0.005	0.013	0.037*	-0.010	-0.015*	-0.062*	0.005	0.002	-0.027*	-0.491*	1.000				
(12) Gender Div	0.022*	0.031*	0.054*	-0.154*	0.001	-0.169*	-0.051*	0.043*	-0.054*	-0.166*	0.066*	1.000			
(13) SALESD	-0.012	-0.013*	-0.127*	0.290*	0.034*	0.288*	0.117*	0.003	-0.012	0.119*	0.055*	-0.139*	1.000		
(14) ROA	0.063*	0.059*	-0.058*	0.070*	0.313*	0.110*	-0.228*	0.135*	-0.093*	0.040*	-0.030*	-0.002	0.020*	1.000	
(15) CEO Duality	0.059*	0.031*	0.086*	-0.109*	-0.007	-0.200*	-0.049*	0.027*	-0.071*	-0.183*	0.121*	0.127*	-0.053*	0.009	1.000

*p < 0.05.

TABLE 6 | Regression result of IE.

	(1)	(2)	(3)	(4)	(5)
	First stage Investeff	Second stage MH	Second stage AS	Third stage Investeff	Third stage Investeff
CER	-0.019*** (0.00)	-0.014*** (0.00)	-0.009*** (0.00)	-0.017*** (0.00)	-0.016*** (0.00)
MH				0.139*** (0.00)	
AS					0.315*** (0.00)
CFO	-0.003 (0.29)	0.006 (0.69)	0.000 (0.59)	-0.004 (0.23)	-0.003 (0.27)
Institutional share	0.001 (0.30)	0.004* (0.07)	-0.002*** (0.00)	0.001 (0.53)	0.002 (0.13)
Leverage	0.000 (0.82)	0.003 (0.28)	0.000 (0.65)	-0.000 (0.14)	0.000 (0.86)
Financial slack	0.001*** (0.00)	0.007*** (0.00)	0.000 (0.35)	0.000 (0.22)	0.001*** (0.00)
Tangibility	0.034*** (0.00)	0.002 (0.68)	-0.001 (0.12)	0.034*** (0.00)	0.034*** (0.00)
Board size	-0.001*** (0.00)	-0.001** (0.04)	-0.000*** (0.00)	-0.001*** (0.01)	-0.010*** (0.01)
Independent ratio	-0.009 (0.14)	0.001 (0.95)	-0.004** (0.01)	-0.009 (0.11)	-0.007 (0.20)
Gender Div	0.007*** (0.01)	0.010** (0.03)	0.002*** (0.00)	0.006** (0.02)	0.006** (0.01)
SALESD	0.000*** (0.00)	-0.000 (0.38)	-0.000*** (0.00)	0.000*** (0.00)	0.000*** (0.00)
ROA	0.033*** (0.00)	0.036*** (0.00)	-0.004*** (0.00)	0.028*** (0.00)	0.034*** (0.00)
CEO duality	0.003*** (0.00)	0.003*** (0.00)	0.001*** (0.00)	0.003*** (0.00)	0.003*** (0.00)
Constant	0.024*** (0.00)	0.060*** (0.00)	0.049*** (0.00)	0.016*** (0.00)	0.009* (0.09)
Year fixed	Yes	Yes	Yes	Yes	Yes
Industry fixed	Yes	Yes	Yes	Yes	Yes
N	22,412	22,412	22,412	22,412	22,412
R ²	0.090	0.050	0.554	0.141	0.095
Adjusted R ²	0.086	0.045	0.552	0.137	0.091

Note: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

TABLE 7 | Regression result of overinvestment.

	(1)	(2)	(3)	(4)	(5)
	First stage overinvestment	Second stage MH	Second stage AS	Third stage overinvestment	Third stage overinvestment
CER	-0.032*** (0.00)	-0.021*** (0.00)	-0.008*** (0.00)	-0.026*** (0.00)	-0.027*** (0.00)
MH				0.300*** (0.00)	
AS					0.581*** (0.00)
CFO	-0.003 (0.69)	-0.147*** (0.00)	0.000 (0.75)	0.041*** (0.00)	-0.003 (0.66)
Institutional share	0.004 (0.11)	-0.004 (0.22)	-0.001*** (0.00)	0.006** (0.03)	0.005* (0.06)
Leverage	0.009*** (0.00)	0.018*** (0.00)	0.001*** (0.01)	0.003 (0.22)	0.008*** (0.01)
Financial slack	0.004*** (0.00)	0.009*** (0.00)	0.000 (0.61)	0.001 (0.26)	0.004*** (0.00)
Tangibility	0.062*** (0.00)	0.038*** (0.00)	-0.003*** (0.00)	0.051*** (0.00)	0.064*** (0.00)
Board size	-0.001** (0.05)	-0.001** (0.03)	-0.000*** (0.00)	-0.001* (0.09)	-0.001* (0.08)
Independent ratio	-0.017 (0.15)	-0.022 (0.14)	-0.004** (0.05)	-0.011 (0.32)	-0.015 (0.22)
Gender Div	0.011** (0.02)	0.013* (0.06)	0.003*** (0.00)	0.008* (0.10)	0.010** (0.05)
SALESD	0.000*** (0.00)	-0.000 (0.22)	-0.000*** (0.00)	0.000*** (0.00)	0.000*** (0.00)
ROA	0.080*** (0.00)	0.068*** (0.00)	0.003 (0.10)	0.059*** (0.00)	0.078*** (0.00)
CEO duality	0.005*** (0.00)	0.005*** (0.00)	0.001*** (0.00)	0.004*** (0.00)	0.005*** (0.00)
Constant	0.018 (0.10)	0.065*** (0.00)	0.050*** (0.00)	-0.002 (0.88)	-0.011 (0.34)
Year fixed	Yes	Yes	Yes	Yes	Yes
Industry fixed	Yes	Yes	Yes	Yes	Yes
N	8550	8550	8550	8550	8550
R ²	0.107	0.101	0.571	0.226	0.116
Adjusted R ²	0.097	0.091	0.566	0.218	0.106

Note: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

TABLE 8 | Regression result of underinvestment.

	(1)	(2)	(3)	(4)	(5)
	First stage underinvestment	Second stage MH	Second stage AS	Third stage underinvestment	Third stage underinvestment
CER	-0.013*** (0.00)	-0.010** (0.02)	-0.009*** (0.00)	-0.012*** (0.00)	-0.011*** (0.00)
MH				0.026*** (0.00)	
AS					0.125*** (0.00)
CFO	-0.005** (0.01)	0.065** (0.01)	0.000 (0.94)	-0.007*** (0.00)	-0.005** (0.01)
Institutional share	-0.001* (0.08)	0.006** (0.02)	-0.002*** (0.00)	-0.002* (0.06)	-0.001 (0.16)
Leverage	-0.001* (0.07)	0.003 (0.30)	-0.000 (0.64)	-0.001* (0.08)	-0.001* (0.07)
Financial slack	0.001*** (0.00)	0.007*** (0.00)	0.000 (0.12)	0.001*** (0.00)	0.001*** (0.00)
Tangibility	0.013*** (0.00)	-0.020*** (0.00)	-0.000 (0.99)	0.013*** (0.00)	0.013*** (0.00)
Board size	-0.001*** (0.00)	-0.001 (0.10)	-0.000*** (0.00)	-0.001*** (0.00)	-0.001*** (0.00)
Independent ratio	-0.004 (0.31)	0.014 (0.24)	-0.004** (0.04)	-0.004 (0.26)	-0.003 (0.37)
Gender diversity	0.007*** (0.00)	0.011** (0.04)	0.002*** (0.01)	0.006*** (0.00)	0.006*** (0.00)
SALESD	0.000 (0.60)	-0.000 (0.49)	-0.000*** (0.00)	0.000 (0.56)	0.000 (0.40)
ROA	0.006*** (0.01)	0.025** (0.03)	-0.007*** (0.00)	0.006** (0.01)	0.007*** (0.00)
CEO duality	0.002*** (0.00)	0.001 (0.37)	0.001*** (0.00)	0.002*** (0.00)	0.002*** (0.00)
Constant	0.028*** (0.00)	0.057*** (0.00)	0.048*** (0.00)	0.027*** (0.00)	0.022*** (0.00)
Year fixed	Yes	Yes	Yes	Yes	Yes
Industry fixed	Yes	Yes	Yes	Yes	Yes
N	13,859	13,859	13,859	13,859	13,859
R ²	0.107	0.081	0.554	0.111	0.109
Adjusted R ²	0.101	0.074	0.551	0.104	0.103

Note: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

TABLE 9 | Instrument variable test for first stage.

Variables	(1) First step CER	(2) 2SLS Investeff	(3) GMM Investeff	(4) LIML Investeff
Industry CER	0.614*** (0.00)			
Regional CER	0.814*** (0.00)			
CER		-0.020*** (0.00)	-0.020*** (0.00)	-0.020*** (0.00)
CFO	0.051*** (0.00)	-0.003 (0.32)	-0.003 (0.32)	-0.003 (0.32)
Institutional share	0.071*** (0.00)	0.001 (0.28)	0.001 (0.28)	0.001 (0.28)
Leverage	0.003 (0.38)	0.000 (0.81)	0.000 (0.83)	0.000 (0.81)
Financial slack	-0.006*** (0.00)	0.001*** (0.00)	0.001*** (0.00)	0.001*** (0.00)
Tangibility	0.030*** (0.00)	0.034*** (0.00)	0.034*** (0.00)	0.034*** (0.00)
Board size	0.008*** (0.00)	-0.001*** (0.00)	-0.001*** (0.00)	-0.001*** (0.00)
Independent ratio	0.138*** (0.00)	-0.008 (0.16)	-0.008 (0.17)	-0.008 (0.16)
Gender Div	-0.042*** (0.00)	0.007*** (0.01)	0.007*** (0.01)	0.007*** (0.01)
SALESD	0.000*** (0.00)	0.000*** (0.00)	0.000*** (0.00)	0.000*** (0.00)
ROA	0.054*** (0.00)	0.033*** (0.00)	0.033*** (0.00)	0.033*** (0.00)
CEO duality	-0.012*** (0.00)	0.003*** (0.00)	0.003*** (0.00)	0.003*** (0.00)
Constant	-0.273*** (0.00)			
Year fixed	Yes	Yes	Yes	Yes
Industry fixed	Yes	Yes	Yes	Yes
<i>N</i>	22,412	22,412	22,412	22,412
<i>R</i> ²	0.387	0.035	0.035	0.035
Adjusted <i>R</i> ²	0.384	0.031	0.031	0.031

Note: ****p* < 0.01; ***p* < 0.05; **p* < 0.1.

TABLE 10 | Instrument variable test.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	2SLS	GMM	LIML	Third stage	2SLS	GMM	LIML	2SLS	GMM	LIML	Third stage	2SLS	GMM	LIML
Variables	MH	MH	MH	CER	Investeff	Investeff	Investeff	AS	AS	AS	CER	Investeff	Investeff	Investeff
Industry CER				0.613*** (0.00)							0.600*** (0.00)			
Regional CER				0.814*** (0.00)							0.806*** (0.00)			
CER	-0.002 (-0.84)	-0.002 (-0.84)	-0.002 (-0.84)		-0.020*** (0.00)	-0.020*** (0.00)	-0.020*** (0.00)	-0.007*** (0.00)	-0.007*** (0.00)	-0.007*** (0.00)		-0.018*** (0.01)	-0.018*** (0.01)	-0.018*** (0.01)
MH				-0.065*** (0.00)	0.139*** (0.00)	0.139*** (0.00)	0.139*** (0.00)							
AS											-1.661*** (0.00)	0.312*** (0.00)	0.313*** (0.00)	0.312*** (0.00)
Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Industry Fixed	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
N	22,412	22,412	22,412	22,412	22,412	22,412	22,412	22,412	22,412	22,412	22,412	22,412	22,412	22,412
R ²	0.017	0.017	0.017	0.388	0.089	0.089	0.089	0.054	0.055	0.054	0.396	0.041	0.041	0.041
Adjusted R ²	0.012	0.012	0.012	0.385	0.085	0.085	0.085	0.05	0.05	0.05	0.394	0.037	0.037	0.037

Note: ***p < 0.01; **p < 0.05; *p < 0.1.

TABLE 11 | Heckman self-selection model.

	(1)	(2)	(3)	(4)	(5)	(6)
	First CER Dummy	First stage Investeff	Second stage MH	Third stage Investeff	Second stage AS	Third stage Investeff
Industry CER	6.265*** (0.00)					
Regional CER	8.274*** (0.00)					
CER		-0.014*** (0.00)	-0.006 (0.18)	-0.013*** (0.00)	-0.004*** (0.00)	-0.012*** (0.00)
MH				0.140*** (0.00)		
AS						0.314*** (0.00)
imr		0.001*** (0.01)	0.002*** (0.00)	0.001** (0.04)	0.001*** (0.00)	0.001* (0.05)
CFO	0.383* (0.05)	-0.002 (0.39)	0.009 (0.55)	-0.003 (0.26)	0.001 (0.25)	-0.003 (0.34)
Institutional share	0.437*** (0.00)	0.002 (0.14)	0.005** (0.02)	0.001 (0.33)	-0.001*** (0.00)	0.002* (0.07)
Leverage	0.028** (0.05)	0.000 (0.73)	0.003 (0.27)	-0.000 (0.17)	0.000 (0.52)	0.000 (0.79)
Financial slack	-0.070** (0.04)	0.001*** (0.00)	0.007*** (0.00)	0.000 (0.34)	0.000 (0.89)	0.001*** (0.00)
Tangibility	0.286** (0.02)	0.034*** (0.00)	0.002 (0.58)	0.034*** (0.00)	-0.001 (0.21)	0.034*** (0.00)
Board size	0.098*** (0.00)	-0.001*** (0.01)	-0.001* (0.09)	-0.001** (0.02)	-0.003*** (0.00)	-0.001** (0.02)
Independent ratio	0.824** (0.01)	-0.008 (0.20)	0.002 (0.82)	-0.008 (0.16)	-0.003** (0.05)	-0.007 (0.26)
Gender_Div	-0.286* (0.07)	0.007*** (0.01)	0.010** (0.03)	0.005** (0.03)	0.002*** (0.00)	0.006** (0.02)
SALESD	0.000*** (0.00)	0.000*** (0.00)	-0.000 (0.56)	0.000*** (0.00)	-0.000*** (0.00)	0.000*** (0.00)
ROA	-0.177 (0.41)	0.033*** (0.00)	0.037*** (0.00)	0.028*** (0.00)	-0.004*** (0.00)	0.034*** (0.00)
CEO duality	-0.109*** (0.00)	0.003*** (0.00)	0.003** (0.00)	0.003*** (0.00)	0.001*** (0.00)	0.003*** (0.00)
Constant	-4.520*** (0.00)	0.019*** (0.00)	0.051*** (0.00)	0.012** (0.03)	0.044*** (0.00)	0.005 (0.36)
Year fixed	Yes	Yes	Yes	Yes	Yes	Yes

(Continues)

TABLE 11 | (Continued)

	(1)	(2)	(3)	(4)	(5)	(6)
	First CER Dummy	First stage Investeff	Second stage MH	Third stage Investeff	Second stage AS	Third stage Investeff
Industry fixed	Yes	Yes	Yes	Yes	Yes	Yes
<i>N</i>	22,292	22,292	22,292	22,292	22,292	22,292
<i>R</i> ²	0.26	0.090	0.050	0.141	0.556	0.095
Adjusted <i>R</i> ²		0.086	0.046	0.138	0.554	0.092

Note: ****p* < 0.01; ***p* < 0.05; **p* < 0.1.

the third stage, re-estimating the first step with CER, mediating variables and control variables, the fitted values of CER substituted into the second step confirm CER's significant negative association with IIE and MH's significant positive association with IIE, validating the mediation effect. For AS as the mediator, the procedures mirror those in the MH section. Columns (8) to (10) in Table 10 show the second stage results, with a significant negative relationship between CER and AS. Columns (11) to (14) present the third stage results, confirming CER's significant negative relationship with IIE and AS's significant positive association with IIE. These findings affirm the mediation effect, reinforcing the robustness of the results.

Table 11 presents the results of the Heckman self-selection model, addressing endogeneity from self-selection bias. This model is executed in two steps. First, a probit model regresses the dependent dummy variable, CER_Dummy (defined as 1 if the firm's CER score is in the fifth quartile, and 0 otherwise, as per Li et al. 2018), on the two instrumental variables and all control variables, generating the inverse Mills ratio. In the second step, this ratio is included in the three-stage mediating effects model, which is re-run. The first column of Table 11 shows the probit model results, where both instrumental variables significantly positively relate to CER Dummy. The second column shows the first stage of the mediating effects, indicating a significant negative relationship between CER and IIE. Columns three and four display the second and third stages of the mediation effect with MH as the mediator, using Heckman's method. While CER is not significantly negatively related to MH, CER remains negatively related to IIE, and MH remains positively related to IIE in the third stage. The Sobel test confirms the mediating effect of MH, aligning with previous results. The last two columns report the second and third stages of the mediating role of AS, also estimated using Heckman's method. These results confirm that higher CER participation effectively reduces both the AS problem and IIE, consistent with prior expectations.

Similarly, in line with prior studies (Benlemlih and Bitar 2018; Cook et al. 2019), this research also employs PSM to address the self-selection issue. To implement PSM, the CER dummy variable used in the Heckman two-step method is taken as the dependent variable. Three key matching methods are utilised: 1-to-1 replacement matching, 1-to-1 matching within callipers, and kernel matching. Table 12 separately displays the results of the third-stage model following the use of the

1-to-1 replacement matching method, the 1-to-1 matching within callipers method, and the kernel matching method. Appendix shows the complete results of the first and second stages (see Supporting Information), the findings indicate that CER persistently reduces IIE by mitigating MH and AS issues. Consequently, the results that demonstrate the mediating effect are still valid, thereby further affirming the robustness of the results.

5 | Additional Analysis

5.1 | SOEs and Non-SOEs

Based on previous studies, this study also investigates the difference between SOEs and non-SOEs. Previous research suggests that SOEs are policy-oriented in undertaking CER, while non-SOEs are market-oriented (Kao et al. 2018). Therefore, the CER of non-SOEs may be more likely to reduce IIE. However, this study hypothesizes that both SOEs and non-SOEs will foster the implementation and adoption of CER, thereby reducing IIE by reducing IA.

Table 13 shows the regression results for the sample of SOEs, while Table 14 shows the regression results for non-SOEs. The total effect of CER is -0.02 for SOEs and -0.013 for non-SOEs. The direct effect of CER is -0.018 for SOEs and -0.01 for non-SOEs. The indirect effect of CER with MH as a mediating variable is -0.0011 for SOEs and -0.0016 for non-SOEs. The indirect effect of CER with AS as a mediating variable is -0.0026 for SOEs and -0.0031 for non-SOEs.

The results indicate that CER reduces IA and IIE for both SOEs and non-SOEs, with the mediating effect of CER being more pronounced in non-SOEs. This finding aligns with previous research (Kao et al. 2018), which indicates that CER information disclosed by non-SOEs is more responsive to stakeholders' needs and more effective in reducing IA issues compared to SOEs.

5.2 | Environmentally Sensitive (ES) Industries and NES Industries

Based on previous studies, this research also divides the sample into ES firms and NES firms for discussion. Table 15 presents the regression results for the ES sample group, while Table 16 shows the regression analysis results for the NES sample group.

TABLE 12 | PSM TEST.

Variables	One-to-one		One to one within calliper		Kernel	
	Third stage Investeff	Third stage Investeff	Third stage Investeff	Third stage Investeff	Third stage Investeff	Third stage Investeff
CER	-0.019*** (0.00)	-0.022*** (0.00)	-0.019*** (0.00)	-0.022*** (0.00)	-0.017*** (0.00)	-0.016*** (0.00)
MH	0.137*** (0.00)		0.137*** (0.00)		0.139*** (0.00)	
AS		0.361*** (0.00)		0.361*** (0.00)		0.316*** (0.00)
CFO	-0.006 (0.40)	-0.002 (0.80)	-0.006 (0.40)	-0.002 (0.80)	-0.004 (0.23)	-0.003 (0.40)
Institutional share	0.001 (0.69)	0.002 (0.49)	0.001 (0.69)	0.002 (0.49)	0.001 (0.53)	0.002 (0.13)
Leverage	0.000 (0.99)	-0.000 (0.94)	0.000 (0.99)	-0.000 (0.94)	-0.000 (0.14)	0.000 (0.87)
Financial slack	-0.001* (0.05)	0.002*** (0.01)	-0.001* (0.05)	0.002*** (0.01)	0.000 (0.21)	0.001*** (0.00)
Tangibility	0.029*** (0.00)	0.031*** (0.00)	0.029*** (0.00)	0.031*** (0.00)	0.034*** (0.00)	0.034*** (0.00)
Board size	-0.000*** (0.00)	-0.001 (0.25)	-0.000*** (0.00)	-0.001** (0.03)	-0.001*** (0.01)	-0.001*** (0.01)
Independent ratio	-0.001 (0.92)	0.001 (0.88)	-0.001 (0.92)	0.001 (0.88)	-0.009 (0.12)	-0.007 (0.21)
Gender_Div	0.006 (0.17)	0.009** (0.04)	0.006 (0.17)	0.009** (0.04)	0.006** (0.02)	0.006** (0.01)
SALESD	0.000*** (0.00)	0.000*** (0.00)	0.000*** (0.00)	0.000*** (0.00)	0.000*** (0.00)	0.000*** (0.00)
ROA	0.029*** (0.00)	0.029*** (0.00)	0.029*** (0.00)	0.029*** (0.00)	0.028*** (0.00)	0.034*** (0.00)
CEO duality	0.003** (0.01)	0.003*** (0.00)	0.003** (0.01)	0.003*** (0.00)	0.003*** (0.00)	0.003*** (0.00)
Constant	0.023*** (0.01)	0.004 (0.67)	0.023*** (0.01)	0.004 (0.67)	0.016*** (0.00)	0.009* (0.10)
Year fixed	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed	Yes	Yes	Yes	Yes	Yes	Yes
N	6398	6454	6398	6454	22,400	22,400
R ²	0.143	0.118	0.143	0.118	0.140	0.095
Adjusted R ²	0.131	0.105	0.131	0.105	0.137	0.091

Note: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

TABLE 13 | Regression result for state-owned enterprises (SOEs).

Variables	(1) First stage Investeff	(2) Second stage MH	(3) Second stage AS	(4) Third stage Investeff	(5) Third stage Investeff
CER	-0.020*** (0.00)	-0.014** (0.01)	-0.008*** (0.00)	-0.018*** (0.00)	-0.018*** (0.00)
MH				0.111*** (0.00)	
AS					0.262*** (0.00)
CFO	-0.006** (0.03)	0.014 (0.49)	-0.000 (0.68)	-0.008** (0.02)	-0.006** (0.04)
Institutional share	0.006** (0.01)	-0.003 (0.49)	-0.002*** (0.01)	0.006*** (0.01)	0.006*** (0.01)
Leverage	-0.001 (0.56)	0.016*** (0.00)	0.001 (0.14)	-0.002** (0.04)	-0.001 (0.48)
Financial slack	0.001*** (0.00)	0.010*** (0.00)	-0.000 (0.25)	0.000 (0.46)	0.001*** (0.00)
Tangibility	0.028*** (0.00)	-0.002 (0.78)	-0.003*** (0.00)	0.028*** (0.00)	0.029*** (0.00)
Board size	-0.001 (0.79)	-0.005 (0.56)	-0.007*** (0.00)	-0.001 (0.88)	0.001 (0.90)
Independent ratio	-0.001 (0.86)	0.013 (0.32)	-0.007*** (0.00)	-0.003 (0.69)	0.001 (0.94)
Gender Div	0.010*** (0.01)	0.012* (0.09)	0.002** (0.03)	0.009** (0.02)	0.010** (0.01)
SALESD	0.000*** (0.01)	-0.000* (0.06)	-0.000*** (0.00)	0.000*** (0.00)	0.000*** (0.00)
ROA	0.026*** (0.00)	0.057*** (0.00)	-0.006*** (0.00)	0.020*** (0.00)	0.028*** (0.00)
CEO duality	0.002* (0.08)	0.002 (0.23)	0.000 (0.40)	0.001 (0.12)	0.002* (0.09)
Constant	0.009 (0.18)	0.043*** (0.00)	0.050*** (0.00)	0.004 (0.50)	-0.004 (0.57)
Year fixed	Yes	Yes	Yes	Yes	Yes
Industry fixed	Yes	Yes	Yes	Yes	Yes
N	11,034	11,034	11,034	11,034	11,034
R ²	0.102	0.077	0.583	0.137	0.106
Adjusted R ²	0.094	0.069	0.579	0.130	0.098

Note: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

TABLE 14 | Regression result for non-state-owned enterprises (non-SOEs).

Variables	(1) First stage Investeff	(2) Second stage MH	(3) Second stage AS	(4) Third stage Investeff	(5) Third stage Investeff
CER	-0.013*** (0.00)	-0.012** (0.03)	-0.009*** (0.00)	-0.011*** (0.00)	-0.010*** (0.00)
MH				0.163*** (0.00)	
AS					0.310*** (0.00)
CFO	-0.000 (0.99)	-0.007 (0.71)	0.000 (0.77)	0.001 (0.84)	-0.000 (0.97)
Institutional share	0.004** (0.01)	0.010*** (0.00)	-0.001** (0.03)	0.003* (0.10)	0.005*** (0.01)
Leverage	0.000 (0.67)	0.002 (0.39)	-0.000 (0.83)	-0.000 (0.89)	0.000 (0.65)
Financial slack	0.002*** (0.00)	0.005*** (0.00)	0.001*** (0.00)	0.001** (0.05)	0.002*** (0.00)
Tangibility	0.041*** (0.00)	0.005 (0.42)	0.002*** (0.00)	0.041*** (0.00)	0.041*** (0.00)
Board size	-0.018*** (0.01)	-0.024** (0.02)	-0.004** (0.02)	-0.014** (0.02)	-0.016*** (0.01)
Independent ratio	-0.010 (0.28)	-0.008 (0.66)	0.002 (0.32)	-0.009 (0.31)	-0.011 (0.24)
Gender Div	0.001 (0.83)	0.006 (0.28)	0.001 (0.11)	-0.000 (0.93)	0.000 (0.93)
SALESD	0.000*** (0.00)	0.000 (0.31)	-0.000 (0.40)	0.000*** (0.00)	0.000*** (0.00)
ROA	0.030*** (0.00)	0.034*** (0.00)	-0.003** (0.01)	0.024*** (0.00)	0.030*** (0.00)
CEO duality	0.003*** (0.00)	0.002* (0.06)	0.001*** (0.00)	0.002*** (0.00)	0.003*** (0.00)
Constant	0.028*** (0.00)	0.072*** (0.00)	0.042*** (0.00)	0.017** (0.03)	0.015* (0.08)
Year fixed	Yes	Yes	Yes	Yes	Yes
Industry fixed	Yes	Yes	Yes	Yes	Yes
N	11,378	11,378	11,378	11,378	11,378
R ²	0.090	0.047	0.531	0.155	0.095
Adjusted R ²	0.083	0.039	0.527	0.148	0.087

Note: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

TABLE 15 | Regression result for environmental sensitive industry.

Variables	(1) First stage Investeff	(2) Second Stage MH	(3) Second Stage AS	(4) Third Stage Investeff	(5) Third Stage Investeff
CER	-0.02*** (0.00)	-0.02*** (0.00)	-0.01*** (0.00)	-0.02*** (0.00)	-0.02*** (0.00)
MH				0.15*** (0.00)	
AS					0.36*** (0.00)
CFO	-0.01** (0.05)	0.00 (0.79)	-0.00 (0.63)	-0.01* (0.07)	-0.01** (0.05)
Institutional share	0.00* (0.07)	0.01*** (0.00)	-0.00*** (0.00)	0.00 (0.26)	0.00** (0.03)
Leverage	0.00 (0.81)	0.00 (0.33)	0.00 (0.83)	-0.00 (0.17)	0.00 (0.82)
Financial slack	0.00*** (0.00)	0.01*** (0.00)	-0.00 (0.86)	0.00 (0.66)	0.00*** (0.00)
Tangibility	0.03*** (0.00)	0.00 (0.39)	0.00 (0.97)	0.03*** (0.00)	0.03*** (0.00)
Board size	-0.02*** (0.00)	-0.02* (0.06)	-0.01*** (0.00)	-0.01*** (0.00)	-0.02*** (0.00)
Independent ratio	-0.00 (0.55)	0.00 (0.86)	-0.00 (0.13)	-0.00 (0.50)	-0.00 (0.65)
Gender Div	0.01** (0.02)	0.01* (0.08)	0.00*** (0.00)	0.01* (0.05)	0.01** (0.04)
SALESD	0.00*** (0.01)	0.00 (0.34)	-0.00*** (0.00)	0.00*** (0.01)	0.00*** (0.00)
ROA	0.04*** (0.00)	0.04*** (0.00)	-0.00*** (0.01)	0.03*** (0.00)	0.04*** (0.00)
CEO duality	0.00*** (0.00)	0.00*** (0.01)	0.00*** (0.00)	0.00*** (0.00)	0.00*** (0.00)
Constant	0.03*** (0.00)	0.06*** (0.00)	0.05*** (0.00)	0.02*** (0.00)	0.01* (0.07)
Industry FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
N	15,689	15,689	15,689	15,689	15,689
R ²	0.069	0.042	0.536	0.123	0.076
Adjusted R ²	0.065	0.038	0.534	0.120	0.072

Note: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

TABLE 16 | Regression result for non-environmental sensitive industry.

Variables	(1) First stage Investeff	(2) Second stage MH	(3) Second stage AS	(4) Third stage Investeff	(5) Third stage Investeff
CER	-0.01*** (0.00)	-0.02** (0.03)	-0.01*** (0.00)	-0.01** (0.01)	-0.01*** (0.01)
MH				0.12*** (0.00)	
AS					0.18*** (0.00)
CFO	0.00 (0.36)	0.01 (0.80)	0.00 (0.20)	0.00 (0.48)	0.00 (0.40)
Institutional share	-0.00 (0.30)	-0.01* (0.06)	-0.00*** (0.00)	-0.00 (0.50)	-0.00 (0.39)
Leverage	-0.00 (0.93)	0.02*** (0.00)	0.00 (0.58)	-0.00 (0.21)	-0.00 (0.90)
Financial slack	0.00*** (0.01)	0.01*** (0.00)	0.00 (0.37)	0.00 (0.21)	0.00*** (0.01)
Tangibility	0.03*** (0.00)	0.00 (0.94)	-0.00** (0.04)	0.03*** (0.00)	0.03*** (0.00)
Board size	-0.00 (0.65)	-0.01 (0.25)	-0.01*** (0.00)	-0.00 (0.81)	-0.00 (0.84)
Independent ratio	-0.02* (0.06)	-0.00 (0.95)	-0.01** (0.03)	-0.02** (0.05)	-0.02* (0.08)
Gender Div	0.01 (0.12)	0.01 (0.14)	0.00 (0.12)	0.01 (0.21)	0.01 (0.14)
SALESD	0.00*** (0.01)	-0.00** (0.03)	-0.00** (0.02)	0.00*** (0.00)	0.00*** (0.01)
ROA	0.02*** (0.00)	0.04*** (0.00)	-0.01*** (0.00)	0.02*** (0.00)	0.02*** (0.00)
CEO duality	0.00*** (0.00)	0.00 (0.24)	0.00*** (0.00)	0.00*** (0.00)	0.00*** (0.00)
Constant	0.02* (0.07)	0.06*** (0.00)	0.05*** (0.00)	0.01 (0.26)	0.01 (0.42)
Industry FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
N	6723	6723	6723	6723	6723
R ²	0.132	0.076	0.622	0.174	0.134
Adjusted R ²	0.125	0.068	0.618	0.167	0.126

Note: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

The regression results for both groups indicate that CER can reduce IIE by mitigating IA.

However, after comparing the proportion of the mediating effect, it was found that the proportion of the mediating effect in the ES group is 0.15 (MH: (0.020.15)/0.02) and 0.18 (AS: (0.010.36)/0.02), whereas in the NES group, the proportions are 0.24 (MH: (0.020.12)/0.01) and 0.18 (AS: (0.020.12)/0.01). Therefore, overall, the CER of the NES group is more effective in reducing IIE by mitigating IA. This also verifies that the information provided by the NES group is more effective. To some extent, the quantitative method developed in this study can mitigate greenwashing, as firms in the ES group cannot better mitigate IA by conveying environmental scores.

6 | Discussion

This study demonstrates the agency theory, stakeholder theory and good manager theory from the perspective of CER, a specific level. The results of this empirical study support the agency theory that CER as an effective information system can effectively reduce IA and also help external investors to monitor managers' behaviour (Jensen et al. 1976; Fama and Jensen 1983; Burke, Chen, and Lobo 2020). The results of the current study also support the stakeholder and good manager theories that active commitment to CER can satisfy stakeholders' needs and lead to good firm performance (Preston and O'bannon 1997; Liu, Xi, and Wang 2021). The results of the current empirical study also echo the findings of previous CER, IA and firm performance studies, such as Li, Liao, and Albitar (2020), Albitar, Borgi, et al. (2023a), Albitar, Al-Shaer, and Liu (2023b), Meng and Zhang (2022), Chen et al. (2022), Gerged, Albitar, and Al-Haddad (2021), Yu et al. (2021), Zamir, Shailer, and Saeed (2022) and Zeng, Qin, and Zeng (2019), which there are also studies in the context of China. In particular, it echoes the findings of Samet and Jarbouli's (2017a) and Bilyay-Erdogan et al. (2024) study testing the mechanisms of CSR and IIE with agency problems and IA, this study verifies the transmission mechanism between CER information, IA and IIE.

The additional analysis results suggest that the CER of non-SOEs is more effective in reducing IA and, consequently, IIE compared to SOEs. This finding further confirms that CER information from non-SOEs aligns better with market demands, which result support previous statement (Kao et al. 2018). Similarly, within the sample groups, the CER of NES firms is more effective in mitigating IA and IIE compared to ES firms. This is likely because ES firms may engage in greenwashing through CER.

7 | Conclusion

Due to growing environmental issues, research on CER and its economic outcomes needs deepening. China's focus on environmental responsibility provides a suitable backdrop for this study. IIE affects both enterprise performance and macroeconomic development, making it crucial for Chinese enterprises. Therefore, examining the relationship between CER, IA and IIE is essential.

Analysing 22,413 firm-year observations from 2011 to 2021, we find that CER can reduce IIE by mitigating MH and AS problems, confirming a partial mediating effect with statistically significant results. Robustness tests, including instrumental variables, the Heckman model and PSM, confirm the reliability of these findings. The mediating effect of AS is more significant than that of MH. The study supports agency theory, stakeholder theory and good manager theory, showing that active CER participation satisfies stakeholders and provides transparency, reducing IIE. The study also finds that non-SOEs' CER is more effective in reducing IA and IIE than that of SOEs, aligning better with market demands. Similarly, the NES group shows more effective CER in reducing IA and IIE compared to the ES group.

This study contributes to the literature by providing empirical evidence on CER's impact on IIE through MH and AS. It introduces a novel index for CER disclosure measurement, improving quantification in content analysis and addressing third-party evaluation defects. Additionally, it develops a comprehensive CER disclosure scoring method suitable for Chinese enterprises based on existing policies and guidelines.

The study has several implications. Firstly, it provides a practical template for companies to disclose and implement CERs, effectively reducing IA, resolving stakeholder conflicts and achieving economic benefits. Secondly, it helps managers understand the importance of CER practice and highlights credibility as its crucial aspect. Managers can recognise CER's substantial economic benefits, meeting stakeholder, shareholder and potential investor's needs, and should consider CER in corporate strategies. The results and theoretical framework highlight CER's impact on economic performance, underscoring its importance to shareholders and stakeholders. Investors can appreciate CER's importance in decision-making, encouraging active corporate CER engagement. Thirdly, this study offers new policy, strategy and decision-making directions for governments and relevant institutions. It encourages governments to prioritise CER to achieve dual benefits for both corporate and national economies. The study suggests formulating policies that promote the implementation of CER, along with supportive measures, considering that CER is inherently a high-cost activity. Furthermore, given the government's authority, it can more effectively supervise the implementation of CER by enterprises. The study also encourages third-party institutions to develop guidelines for CER information disclosure and performance measurement methods. These measures would assist companies in improving CER disclosure while ensuring the quality and authenticity of the information provided. Additionally, the study provides a template for future research on CER and corporate performance, suggesting a comprehensive and updated quantitative approach. It encourages researchers to explore specific areas within CER, such as climate change and carbon emissions, beyond broad topics like CSR or ESG. The study also offers a template for future research on CER and corporate performance, suggesting a comprehensive and updated quantitative approach. Future research could expand the sample to multiple countries, exploring cultural and institutional impacts on CER and IIE. Additionally, researchers can investigate other variables affecting the mediating effect, such as moderating or interactive mediating effects. Specific areas within CER, like climate change and carbon emissions, offer new research avenues.

However, this study has limitations. It focuses only on Chinese listed companies, making the sample homogeneous. It does not consider other factors that might affect the mediating effect. Future research should expand the sample and explore how culture and institutional context influence CER and IIE, and investigate other variables affecting the mediating effect, providing new insights into specific CER topics.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Endnotes

¹ Hexun is a leading financial information portal in China, established in 1996 and headquartered in Beijing. Hexun provides comprehensive financial and economic information, covering areas such as stocks, funds, futures, forex, bonds, insurance, banking, and real estate. The site has over 60 million page views daily, making it one of the most visited financial websites in China.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.