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Article

The Impact of Institutional Investors on Firm Carbon Information Disclosure: Evidence from Chinese Industrial Listed Firms

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Abstract

In recent years, climate change mitigation and sustainable development have gradually become an important consideration in global economic and social governance. Firms' carbon information disclosure is of great significance in global warming alleviation, drawing widespread attention from stakeholders, including institutional investors. However, limited attention has been devoted to how institutional investors in China affect such disclosure practices. This paper aims to explore the influence and underlying mechanisms of institutional investors on the quality of firms' carbon information disclosure by employing fixed effect regression and mediating effect analysis on panel data that covers industrial firms traded on the A-share markets of the Shanghai and Shenzhen stock exchanges (SSE and SZSE) over the period from 2013 to 2023. The results suggest that institutional investors contribute to higher-quality firm carbon information disclosure, with analyst following serving as a mediating channel. Heterogeneity analysis further indicates that institutional investors' positive influence is stronger among state-owned firms. Overall, the study highlights the role of institutional investors in advancing firms' low-carbon development and offers practical guidance for improving carbon information disclosure.

Keywords: institutional investors; carbon information disclosure; analyst following; firm governance

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1. Introduction

Global warming poses serious threats to human survival, such as sea-level rises, glacier collapses, and extreme weather. The emissions of greenhouse gases (GHGs), including carbon dioxide (CO₂), are key factors causing global climate change [1]. These challenges have increasingly drawn attention to the broader agenda of sustainable development. Firms hold a pivotal position in achieving the Sustainable Development Goals (SDGs), and the SDG project emphasizes their involvement in this global agenda [2,3]. Firms' disclosures in the areas of climate and environment not only contribute to reducing regional carbon emissions [4] but also promote green technologies [5]. Moreover, since firms are also major sources of carbon emissions, their carbon information disclosure quality is of great significance for carbon reduction. In China, after more than two decades of development, institutional investors have grown into key forces within the financial system,

exerting a progressively greater impact on firms' sustainability governance. Notions like environmental, social, and governance (ESG); eco-friendliness; biodiversity; and corporate social responsibility (CSR) have garnered considerable attention from investors, prompting institutional investors to incorporate factors of sustainable development into their decision-making processes. In this context, whether or not Chinese institutional investors can fulfill a role of enhancing firms' disclosure quality of carbon information has developed into a topic of significant concern.

Addressing global warming requires long-term efforts. According to the Emissions Gap Report 2024 by the United Nations Environment Programme (UNEP), in 2023, global GHG emissions reached 57.1 Gt of CO₂ equivalent, an increase of 1.3% from the 2022 level. Firms' performance in areas of environment and social responsibility has drawn attention from investors. Stakeholder groups are exerting pressure on corporations to promote environmental responsibility [6]. Compared with individual investors, institutional investors possess more sophisticated skills for information acquisition and analysis, alongside greater proficiency in investment and risk management. Institutional investors can exert influence on firms through shareholder proposals and executive compensation [7,8] and are considered to be a mechanism of moving corporations to reduce their climate risk exposures and carbon footprints [9]. Given the severe threat that the greenhouse effect poses to ecological systems and human survival, the pursuit of carbon reduction has gained wide recognition. Existing research generally notes that institutional investors contribute to the advancement of firm sustainability and ESG practices. Given this established role, their function in the narrower context of firms' low-carbon practice presents a significant need for a further investigation. This study therefore focuses on how institutional investors influence carbon information disclosure and has the following objectives:

- To reveal the effect of institutional investors on the quality of firms' disclosure of carbon information;
- To analyze the channel through which firm carbon information disclosure is influenced by institutional investors.

This research employs a fixed effect model on a panel data, covering industrial firms from the A-share markets of SSE and SZSE from 2013 to 2023. The model incorporates firm-level and year-level fixed effects. The dependent and independent variables capture firms' carbon information disclosure quality and institutional investors' shareholding ratio, respectively, and the mediating variable captures analyst following. Furthermore, a set of robustness checks is conducted, including alternative measurement of the dependent variable, inclusion of industrial or provincial fixed effects, and the use of the dependent variable of the t+1 periods. The results demonstrate a positive impact of institutional ownership on the quality of carbon information disclosure, with analyst following serving as a mediating channel. The results of heterogeneity analysis suggest that institutional investors' positive influence holds across firms with different ownership types. Compared with non-state-owned firms, institutional investors exhibit a greater influence on state-owned firms. This may occur because state-owned firms typically possess richer resources and are more expected to align with regulatory and societal priorities, making them more capable and motivated to respond to institutional investors' expectations and demands regarding high-quality disclosure of carbon information.

The organization of this study proceeds in the following manner. Section 2 delivers a review of pertinent literature and develops hypotheses. The data, variables, and regression model are presented in Section 3. Section 4 includes descriptive statistics, correlation analysis, baseline regression, mediating effect analysis, heterogeneity analysis, and robustness tests. Finally, the main findings and future research topics are summarized and proposed in Section 5. Figure 1 displays the research framework.

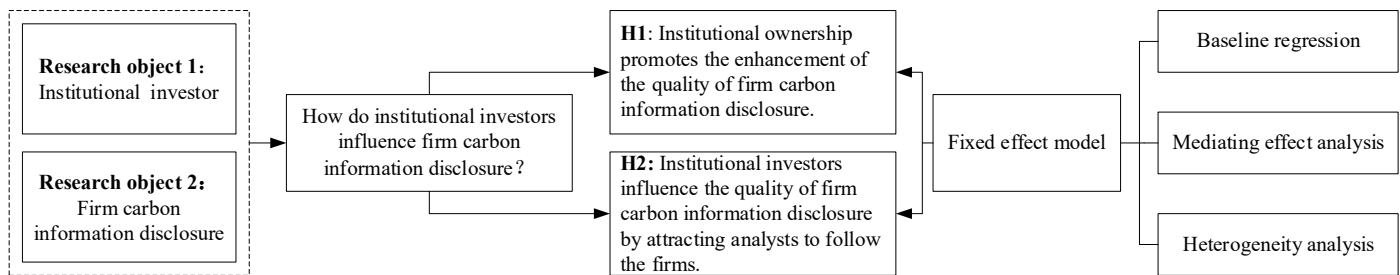


Figure 1. The research framework of this study.

2. Literature Review and Hypotheses Development

2.1. Institutional Investors and Firm Governance

Institutional investors possess a relative advantage in gathering and processing information [10]. In contrast to individual investors, institutional investors own more substantial financial resources, a greater tolerance for the costs of information acquisition, and advanced analytical skills. As a result, they are better positioned and more motivated to develop a deeper understanding of firms and influence firm governance. The “exit threat” is generally considered a mechanism through which firms are influenced by institutional investors. Some institutional investors choose to exit portfolio firms because of dissatisfaction [11]. Nevertheless, exiting a firm by selling stocks is not costless: such divestment can drive down share prices [12], thereby imposing financial losses on the investors themselves. These potential losses substantially raise the costs associated with relying on exit as a mechanism to influence firms. Therefore, institutional investors have a rationale to pursue more proactive avenues of engagement in order to influence firm governance and bring about desired changes.

A considerable number of studies note that institutional investors tend to engage in practices of shareholder activism. For instance, they monitor and impose constraints on managers’ opportunistic and self-serving behavior [13]. Aggarwal et al. [14] develop an index to measure firm governance, reporting a positive linkage between institutional ownership and this index. Their work further indicates that ownership by institutions acts as a disciplinary tool for removing chief executive officers (CEOs) who perform poorly. Lin and Fu [15] show that institutional ownership can positively influence firm performance. Additionally, institutional investors are seen as key figures in reducing information asymmetry. Ajinkya et al. [16] note that a firm with higher institutional ownership releases forecasts that are both more precise and detailed. An elevated degree of voluntary disclosure is also linked to firms that have significant institutional ownership [17]. Tan and Lin [18] argue that institutional investors’ visits promote firm information disclosure. Although due to the potential free-rider problem [19], institutional investors may not be inclined to engage in firm governance, they are willing to spend resources monitoring and engaging with firms if they expect that engagement could generate at least a modest impact on value [20].

2.2. Factors Affecting Carbon Information Disclosure

Act mandating GHG emissions disclosure by firms is associated with emission reductions [21]. Against the backdrop of global warming, on the one hand, a series of environmental disclosure requirements have been implemented, such as in Denmark, Norway, and Sweden [22]; on the other hand, stakeholders are placing increasing emphasis on firms’ efforts toward low-carbon practices and emission reduction. Shareholder reactions are positive toward announcements of eco-friendly initiatives but negative toward eco-

harmful firm behaviors [23]. He et al. [24] suggest a positive relationship between external pressure faced by a firm and its level of carbon information disclosure. According to stakeholder theory, managers' decision-making should take account of the interests of stakeholders [25]; legitimacy theory, meanwhile, emphasizes that firms' survival depends not only on financial outcomes but also on its conformity to prevailing social values. Therefore, firms disclose carbon information in response to the demands from stakeholders, shaping a favorable image of engaging in efforts to mitigate global warming for maintaining stakeholder relations and gaining legitimacy. Building on the perspective of Hooghiemstra [26], such disclosures aid in building a positive reputation and establishing a competitive edge. Through carbon information disclosure, firms demonstrate accountability to stakeholder demands. Firms exhibiting superior carbon performance are more inclined to provide high-quality disclosures, which helps identify themselves from those with poor performance and increase firm valuation [27,28].

Firms' disclosures in areas related to the climate or environment can generate a range of beneficial outcomes. For instance, it is beneficial for the improvement of firm profitability and value [29–31]. Wan-Hussin et al. [32] find that analysts tend to release more favorable recommendations for those delivering greater CSR disclosures. Moreover, carbon information disclosure is associated with firms' commitment to addressing climate change and constitutes a practice in line with social morality. According to views from Godfrey [33], carbon information disclosure can help protect firms' relational wealth by mitigating assessments of bad mind. In general, it suggests that carbon information disclosure is consistent with interests of both investors and firms themselves. Therefore, even from a purely financial perspective, firms have incentives to disclose carbon information.

2.3. Measurement of Carbon Information Disclosure

Given the rising emphasis on sustainable development, firms' information disclosure related to low carbon, environment, and ESG has become a focus of academic research. Differentiated measures of relevant performance and information disclosure quality have been proposed. Some scholars set dummy variables according to whether or not firms disclose relevant information [34–36]. Some studies introduce data from third-party data. Cheng and Wu [37] and Duan et al. [38] use the Huazheng ESG rating to assess ESG disclosure quality. Some studies utilize data from Hexun.com—a leading Chinese financial information and investment service platform that has long been committed to serving the middle class and enhancing investor wealth—to measure corporate carbon reduction engagement and CSR performance [39,40]. Several scholars employ data from Bloomberg and Thomson Reuters [41–43]. Furthermore, a considerable number of studies adopt self-designed indicator systems to assess the quality of firm carbon information disclosure [44–46].

2.4. Summary and Research Gaps

Existing research has laid a foundation for understanding the link between institutional investors and firm's disclosure of carbon information. With their informational and resource advantages, institutional investors possess the capability and the motivation to influence firm governance, thereby enhancing information transparency. However, several research gaps remain. First, theoretically, while prior studies have explained firms' carbon information disclosure motivations from perspectives such as stakeholder theory and legitimacy theory, there is room for further exploration into the specific drivers of carbon information disclosure. Second, methodologically, although a significant body of research has focused on broad categories such as ESG and CSR, it is valuable to narrow the focus to the influence of institutional investors on carbon information disclosure, which is a more targeted dimension, to clarify their role in the specific context of low-

carbon development. Third, empirically, there remains scope to explore potential mediating mechanisms on how institutional investors influence firm carbon information disclosure. Taking institutional investors as a starting point, this study examines how firms' carbon information disclosure is driven by such investors, thereby contributing to a clearer understanding of their impact on firms' sustainable development.

2.5. Theoretical Hypotheses

The result of a survey carried out by Ilhan et al. [47] shows that institutional investors value the information disclosure corresponding to climate risk. Their role in promoting firm sustainability is well-documented in the literature, encompassing positive influences on CSR, ESG, and green governance [48–50]. Dyck et al. [51] provide evidence that institutional investors push for firm environmental and social performance. Benlemlih et al. [52] suggest institutional investors significantly contribute to reducing GHG emissions of their investees. Liu and Wang [53] contend that a higher shareholding ratio enable institutional investors to leverage their capital and informational advantages for effective oversight and improvement in sustainable development performance. The survey conducted by Solomon and Solomon [54] shows that institutional investors have a demand for information on social, ethical, and environmental matters. Bae et al. [55] identify a significantly positive link between institutional shareholding and sustainability disclosure. Wu and Memon [56] consider institutional investors as one of the forces driving improvements in firm environmental information disclosure. According to Clarkson [57], corporation cannot survive as a going concern without the continuing participation of primary stakeholders. Moreover, when such stakeholders, including shareholders and investors, become dissatisfied and withdraw, the corporation is likely to experience significant setbacks. Given that institutional investors constitute one of the key stakeholder groups, stakeholder theory implies that firms are expected to respond to their demands for carbon information.

Institutional investors have a demand for analyst reports, and their willingness to pay for research may motivate analysts to follow firms [58]. Frankel et al. [59] consider institutional ownership as a possible factor that increases the demand for analyst research. Analysts play a role in information distribution and information asymmetry reduction [60]. Liesen et al. [61] offer support for the view that firms' reports on GHG emissions is a response to pressures from external stakeholders. With stakeholders' rising attention to firm carbon information, providing comprehensive disclosure enables firms to release favorable signals, thereby serving their long-term interests. Therefore, firms would have incentives to enhance their disclosure quality of carbon information in consequence of being followed by analysts. Accordingly, the following hypotheses are proposed:

H1. *Institutional ownership promotes the enhancement of the quality of firm carbon information disclosure.*

H2. *Institutional investors influence the quality of firm carbon information disclosure by attracting analysts to follow the firms.*

3. Data and Research Design

3.1. Data Sources and Sample Selection

Panel data covering industrial firms listed on A-share markets of SSE and SZSE during 2013 to 2023 are selected for analysis. The data are sourced from the Wind and CSMAR databases, as well as from annual reports and CSR-related reports released by firms. Appendix A contains the data cleaning content and observation characteristics.

3.2. Measurement of Firm Carbon Information Disclosure Quality

A system of indicators based on methods of Chi et al. [45] and Zou et al. [46], which is reported in Table 1, is constructed to measure firms' carbon information disclosure quality. The entropy weight method is employed to derive a score based on the indicators in Table 1, which serves as the overall measure of carbon information disclosure quality. A higher value of this score corresponds to carbon information disclosure of higher quality.

Table 1. Indicators for carbon information disclosure quality.

Indicator	Indicator Meaning
Environmental Objectives	Disclosure of information related to strategies, objectives related to environment protection = 1, otherwise = 0
Environmental Publicity	Disclosure of information related to publicity activities related to environmental protection = 1, otherwise = 0
Environmental Management	Disclosure of information related to management related to environmental protection = 1, otherwise = 0
Low-carbon Operation	Disclosure of information related to low-carbon operations = 1, otherwise = 0
Low-carbon Technology	Disclosure of information related to low-carbon technologies = 1, otherwise = 0
Carbon Emission and Carbon Reduction	Disclosure of information related to carbon emission or carbon reduction = 1, otherwise = 0
Negative Information	Disclosure of negative information related to environmental protection = 1, otherwise = 0
ISO 14001 Certification [62]	Disclosure of information related to ISO 14001 certification = 1, otherwise = 0

3.3. Model Construction

Following Wei et al. [63] and Liu et al. [64], Model (1) is constructed for baseline regression.

$$CD_{i,t} = \alpha_0 + \alpha_1 IO_{i,t} + \alpha_2 Size_{i,t} + \alpha_3 Lev_{i,t} + \alpha_4 Age_{i,t} + \alpha_5 Roa_{i,t} + \alpha_6 Board_{i,t} + \alpha_7 Dual_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t}, \quad (1)$$

where firm and year are denoted by i and t , respectively. The dependent variable $CD_{i,t}$ captures the quality of firm carbon information disclosure using a score derived from the entropy weight method. Institutional investors' shareholding ratio is captured by the independent variable $IO_{i,t}$. Firms' disclosure of carbon information can be affected by multiple factors, including firm size, profitability, and other characteristics [65–67]. Therefore, control variables are composed of firm size ($Size_{i,t}$), debt capacity ($Lev_{i,t}$), firm age ($Age_{i,t}$), profitability ($Roa_{i,t}$), board size ($Board_{i,t}$), and duality ($Dual_{i,t}$). The model specification incorporates firm-level and year-level fixed effects, which are represented by μ_i and λ_t , respectively. Definitions for variables used in Model (1) are provided in Table 2.

Table 2. Definitions of variables.

Variable	Name	Definition
Dependent Variable	CD	The score of firm carbon information disclosure quality
Independent Variable	IO	The proportion of institutional investors' shareholdings in firm's outstanding A-shares
Control Variables	Size	The natural logarithm (NL) of total assets at the end of the period
	Lev	Ratio of total liabilities to total assets at the end of the period
	Age	The NL of 1 plus the number of years since establishment
	Roa	Ratio of net profit to total asset balance
	Board	The NL of the number of the members on firm's board of directors
	Dual	A dummy variable equal to 1 if firms' chairman and general manager are the same person, and to 0 otherwise

4. Empirical Analyses

4.1. Descriptive Statistics

An overview of the main variables is provided in Table 3 to illustrate their descriptive characteristics. The independent variable CD has a mean of 0.3237 and a median of 0.2549, which indicates that the firms selected have disclosed carbon information with a certain level of quality. A standard deviation of 0.2765 for CD further points to considerable cross-firm heterogeneity in disclosure practices. The mean and median of IO are both approximately 40.50%. Size ranges from 20.3194 to 26.2582, with a standard deviation of 1.2609, reflecting variation in firm size. The average level of Lev is 0.3759, with a median of 0.3699. The minimum value of Age is 2.0794, indicating that the firms have undergone at least 7 years of development since their establishment. Most firms exhibit a positive Roa. Board has a mean of 2.1096 and a median of 2.1972, reflecting that a board size of 8 to 9 members is typical among the firms. Dual has a median of 0.0000, suggesting that more than half of the firms do not exhibit duality, meaning the roles of chairman and general manager are occupied by different individuals.

Table 3. Descriptive statistics.

Variable	N	Mean	SD	Min	Median	Max
CD	9523	0.3237	0.2765	0.0000	0.2549	1.0000
IO	9523	0.4036	0.2392	0.0036	0.4106	0.8893
Size	9523	22.4553	1.2609	20.3194	22.2673	26.2582
Lev	9523	0.3759	0.1777	0.0549	0.3699	0.7516
Age	9523	2.9189	0.3070	2.0794	2.9444	3.5264
Roa	9523	0.0622	0.0517	−0.0955	0.0571	0.2183
Board	9523	2.1096	0.1975	1.6094	2.1972	2.6391
Dual	9523	0.3786	0.4851	0.0000	0.0000	1.0000

4.2. Correlation Analysis

The correlation results for the variables included in Model (1) are summarized in Table 4. The correlation coefficient between IO and CD is positive, which is consistent with hypothesis H1. CD is positively correlated with Size, possibly because larger firms possess more resources to bear the costs of collecting and organizing data for carbon information disclosure, enabling them to provide carbon information with higher quality. All correlation coefficients have absolute values below 0.8, suggesting that the data do not exhibit signs of serious multicollinearity. Additionally, the variance inflation factor (VIF) is computed as a supplementary diagnostic for multicollinearity. All VIF values are below 10, providing additional evidence that multicollinearity does not constitute a serious problem.

Table 4. Correlation analysis.

	CD	IO	Size	Lev	Age	Roa	Board	Dual
CD	1							
IO	0.1760 ***	1						
Size	0.3636 ***	0.4445 ***	1					
Lev	0.1508 ***	0.2126 ***	0.5715 ***	1				
Age	0.2084 ***	0.1499 ***	0.2795 ***	0.1410 ***	1			
Roa	−0.0447 ***	0.1059 ***	−0.1001 ***	−0.3968 ***	0.0223 **	1		
Board	0.0471 ***	0.1943 ***	0.2621 ***	0.1350 ***	0.1234 ***	−0.0466 ***	1	
Dual	−0.0007	−0.1652 ***	−0.2095 ***	−0.1081 ***	−0.0990 ***	0.0212 **	−0.2088 ***	1

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

4.3. Regression Analyses

4.3.1. Verification of Hypothesis H1

Presented in Table 5 are the results of baseline regression estimated from Model (1). Results shown in Column (1) are based on specifications without control variables, whereas those in Column (2) include both the independent and control variables. The significant coefficient on IO establishes an underlying positive association with CD, thereby leading support to Hypothesis H1. This finding implies that institutional ownership fosters improvements in the firms' disclosure quality of carbon information. As climate change garners increasing concern among stakeholders, institutional investors' reputation and portfolio return are increasingly exposed to firms' climate change risks, motivating them to urge firms toward higher carbon transparency to protect investments and reputation. Furthermore, a significantly positive coefficient for Size implies that large firms are more inclined to disclose carbon information with higher quality, a finding consistent with Trotman and Bradley [68]. Larger firms are likely to face thorough external analysis [69], which in turn exposes them to higher levels of public scrutiny. Moreover, large firms may have lower information production costs [70]. Therefore, compared to their smaller counterparts, larger firms possess stronger motivations to provide higher-quality carbon information.

Table 5. Empirical results.

	(1)	(2)	(3)	(4)	(5)	(6)
	CD	CD	Analyst	CD	CD	CD
					State-Owned Firms	Non-State-Owned Firms
IO	0.0593 *** (0.0139)	0.0503 *** (0.0136)	1.0859 *** (0.0736)	0.0428 *** (0.0136)	0.0922 ** (0.0373)	0.0463 *** (0.0146)
Analyst				0.0069 ** (0.0028)		
Size		0.0579 *** (0.0097)	0.6483 *** (0.0406)	0.0534 *** (0.0100)	0.0627 *** (0.0207)	0.0597 *** (0.0111)
Lev		−0.0429 (0.0276)	−0.3104 ** (0.1402)	−0.0407 (0.0276)	−0.1465 ** (0.0742)	−0.0098 (0.0299)
Age		0.0414 (0.0658)	0.0822 (0.3018)	0.0408 (0.0655)	0.1092 (0.1607)	0.0674 (0.0775)
Roa		0.0952 (0.0587)	5.2845 *** (0.2895)	0.0585 (0.0599)	−0.0109 (0.1611)	0.0897 (0.0632)
Board		−0.0226 (0.0241)	0.0205 (0.1208)	−0.0227 (0.0240)	0.0473 (0.0456)	−0.0399 (0.0286)
Dual		0.0100 (0.0086)	0.0390 (0.0423)	0.0097 (0.0086)	−0.0139 (0.0229)	0.0144 (0.0093)
_cons	0.1053 *** (0.0077)	−1.1954 *** (0.2582)	−12.8703 *** (1.0968)	−1.1060 *** (0.2613)	−1.6192 ** (0.6678)	−1.2715 *** (0.2924)
Firm	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
N	9523	9523	9523	9523	2028	7495
adj. R ²	0.6148	0.6204	0.1872	0.6208	0.6238	0.6196

Note: The reported values in parentheses represent standard errors, which are clustered at the firm level. ** $p < 0.05$, *** $p < 0.01$.

4.3.2. Verification of Hypothesis H2

To test the channel through which firm carbon information disclosure is influenced by institutional investors, this study follows Baron and Kenny [71] and Zhou et al. [72]. We build analysis on Model (1) used above and Models (2) and (3) specified as follows:

$$\text{Analyst}_{i,t} = \beta_0 + \beta_1 \text{IO}_{i,t} + \beta_2 \text{Size}_{i,t} + \beta_3 \text{Lev}_{i,t} + \beta_4 \text{Age}_{i,t} + \beta_5 \text{Roai}_{i,t} + \beta_6 \text{Board}_{i,t} + \beta_7 \text{Dual}_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t} \quad (2)$$

$$\text{CD}_{i,t} = \gamma_0 + \gamma_1 \text{IO}_{i,t} + \gamma_2 \text{Analyst}_{i,t} + \gamma_3 \text{Size}_{i,t} + \gamma_4 \text{Lev}_{i,t} + \gamma_5 \text{Age}_{i,t} + \gamma_6 \text{Roai}_{i,t} + \gamma_7 \text{Board}_{i,t} + \gamma_8 \text{Dual}_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t} \quad (3)$$

where the mediating variable Analyst represents the analyst following level, measured by the NL of the number of analysts or analyst teams following the firm within a year.

The results from Model (1), as presented in Column (2) of Table 5, provide support for the view that institutional ownership promotes firm's disclosure quality of carbon information. Column (3) in Table 5 displays the results of Model (2), where a positive and statistically significant coefficient on IO reveals that ownership of institutional investors is linked to higher analyst following level. The regression results of Model (3), which are shown in Column (4) of Table 5, reveal significantly positive coefficients of both IO and Analyst, implying that analyst following serves as a partial mediating factor in the relationship between institutional ownership and firms' carbon information disclosure quality, which supports Hypothesis H2. The demand for information production can be influenced by the existence of institutional investors, and firms with higher institutional ownership are associated with greater analyst following [73]. With growing attention on firms' engagement in low-carbon practice, firms face pressure to promote their disclosure of carbon information as a response.

4.3.3. Heterogeneity Analysis

Firms are classified according to their ownership type into state-owned and non-state-owned groups for a comparative analysis based on Model (1). The corresponding results are presented in Column (5) and (6) of Table 5, showing that institutional ownership enhances carbon information disclosure quality within both groups of firms. Furthermore, the positive effect of institutional ownership is stronger in state-owned firms, which might be because these firms would respond to low-carbon policies or initiatives more actively, thereby giving greater consideration to institutional investors' demands for carbon information.

4.4. Robustness Tests

Checks for robustness are conducted by adopting alternative measurement of the dependent variable, inclusion of industrial or provincial fixed effects, and using the dependent variable of the t+1 period.

4.4.1. Alternative Measurement of Dependent Variable

An alternative measurement of firm carbon information disclosure quality, denoted by CD_{II} , is calculated in Equation (4) based on the methods of Yang et al. [74], García-Meca and Pucheta-Martínez [75] and Chau and Gray [76].

$$\text{CD}_{\text{II}} = \sum S_j / \sum S_{j,\max} \quad (4)$$

In Equation (4), S_j represents the score of a firm on indicator j in the indicator system displayed in Table 1, and $S_{j,\max}$ denotes the maximum score for indicator j .

The original dependent variable CD in Model (1) is subsequently replaced with CD_{II} . As reported in Columns (1) and (2) of Table 6, the coefficients of IO remain statistically significant and positive, aligning with those observed in baseline regression. This outcome

reinforces the robustness of the finding that institutional ownership contributes to improved quality in firm carbon information disclosure.

Table 6. Robustness tests.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	CD _{it}	CD _{it}	CD	CD	CD	CD	CD _{t+1}
IO	0.0675 *** (0.0145)	0.0558 *** (0.0140)	0.0582 *** (0.0138)	0.0491 *** (0.0136)	0.0586 *** (0.0138)	0.0496 *** (0.0135)	0.0413 *** (0.0151)
Size		0.0689 *** (0.0093)		0.0569 *** (0.0097)		0.0563 *** (0.0096)	0.0607 *** (0.0107)
Lev		−0.0187 (0.0284)		−0.0359 (0.0279)		−0.0403 (0.0275)	−0.0339 (0.0315)
Age		0.1497 ** (0.0644)		0.0439 (0.0652)		0.0503 (0.0655)	−0.0136 (0.0763)
Roa		0.0095 (0.0597)		0.0977 * (0.0588)		0.1016 * (0.0581)	0.1300 * (0.0690)
Board		−0.0317 (0.0249)		−0.0244 (0.0242)		−0.0207 (0.0242)	−0.0121 (0.0281)
Dual		0.0099 (0.0082)		0.0102 (0.0086)		0.0097 (0.0086)	0.0186 ** (0.0092)
_cons	0.1628 *** (0.0087)	−1.6396 *** (0.2503)	0.3762 *** (0.0608)	−0.9596 *** (0.2725)	0.2121 *** (0.0119)	−1.0714 *** (0.2562)	−1.1383 *** (0.2893)
Firm	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry	No	No	Yes	Yes	No	No	No
Province	No	No	No	No	Yes	Yes	No
N	9523	9523	9523	9523	9523	9523	7901
adj. R ²	0.6425	0.6511	0.6171	0.6226	0.6174	0.6228	0.6145

Note: The reported values in parentheses represent standard errors, which are clustered at the firm level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

4.4.2. Inclusion of Industrial Fixed Effects

Industrial firms can be further classified into specific sectors, such as furniture manufacturing and textiles. Therefore, industrial fixed effects are additionally incorporated in Model (1). As shown in Columns (3) and (4) of Table 6, the coefficients of IO maintain their statistical significance and positive sign, suggesting that the findings are robust when industrial fixed effects are additionally controlled for.

4.4.3. Inclusion of Provincial Fixed Effects

Natural conditions and environmental regulations in different regions may influence firm's disclosure practices. Therefore, in addition to firm-level and year-level fixed effects, we incorporate provincial fixed effects in Model (1). Evidence from Columns (5) and (6) of Table 6 indicates that institutional ownership remains positively associated with firm carbon information disclosure. After the inclusion of provincial fixed effects, the conclusion remains robust.

4.4.4. Using the Dependent Variable of Period t+1

Following the approach employed by Jiang et al. [77], Model (1) is re-estimated with CD in period t+1 as the dependent variable, while other variables remain measured at period t. As presented in Column (7) of Table 6, the empirical findings still reveal a

significantly positive coefficient on IO, confirming the favorable impact of institutional ownership on firms' disclosure of carbon information.

5. Discussion

Amid rising concerns about climate change, institutional investors have shown an increasing emphasis on long-term value creation, directing their attention toward areas related to sustainability [78–80]. A growing body of research supports institutional investors' influence on advancing sustainable development [81–86]. The present analysis demonstrates a positive association between institutional investors' influence and firms' carbon information disclosure, which aligns with the arguments of Huang et al. [87], Bedi and Singh [88], and Singhania and Bhan [89]. Similarly, Li et al. [90] find that the institutional ownership contributes to enhanced environmental disclosure practices, while Jaggi et al. [91] report that institutional investors of some Italian listed firms can promote firms' carbon disclosure. Institutional investors possess professional expertise and resource advantage, enabling more effective communication with firms. Driven by concerns such as reputation protection and portfolio risk mitigation, institutional investors have incentives to incorporate climate risks into their investment decisions [92] and thereby act as a significant force in promoting firms' information disclosure in the field of sustainability.

6. Conclusions and Implications

6.1. Conclusions

Firm transparency on climate-related issues forms an important component of SDGs. Given their essential role in both economic development and carbon emissions, firms' disclosure of carbon information has attracted increasing attention from stakeholders. Firms' disclosure of carbon information not only enables authorities to monitor carbon emissions in economic activities but also assists investors in assessing climate change risks and helps firms build a positive image of environmental responsibility and sustainability. Institutional investors, as one of the key stakeholders of firms, are equipped with professional skills in collecting and analyzing information, show concern for climate risk disclosure [47], and thus have the motivation and capacity to drive enhancements in firms' carbon information disclosure practices. Using panel data covering industrial firms listed on A-share markets of SSE and SZSE during 2013 to 2023, the present work investigates the association between institutional investors and firms' disclosure of carbon information.

The empirical analysis of this study demonstrates a significantly positive influence of institutional ownership on firm's disclosure quality of carbon information, and this conclusion remains robust after being tested with an alternative measurement of the dependent variable, inclusion of industrial or provincial fixed effects, and the introduction of the dependent variable measured at period $t+1$. The results imply that institutional investors can drive firms' carbon information disclosure, thereby providing support for tackling the challenges of global warming. The mediating effect analysis indicates that analyst following serves as a channel through which institutional ownership influences firm carbon information disclosure. One possible interpretation is that institutional ownership increases analyst attention to firms, which puts pressure on firms to disclose more comprehensive carbon information. Heterogeneity analysis shows a more pronounced favorable impact of institutional ownership on carbon information disclosure quality within state-owned firms.

Theoretically, this paper highlighted how institutional investors exert a significant influence on firm low-carbon practices and examined the channels of their influence by introducing analyst following as a mediating mechanism, broadening the perspectives of stakeholder and legitimacy theories to encompass the domain of carbon information

disclosure. By illustrating how this type of financial market participant influences firms' sustainable behavior, this study contributes a perspective for understanding the function of the financial market in advancing sustainable development and enhancing firm carbon transparency through market-based mechanisms.

6.2. Implications

Grounded in the empirical evidence presented, several implications are derived to provide guidance for strengthening firm's sustainable practices. First, the empirical results support market forces as a potential channel to advance sustainable development. It is advisable to encourage institutional investors to appropriately participate in firm governance, which can help convey stakeholders' demands for carbon information to firms. Regulatory authorities could, to some extent, increase the weight assigned to low-carbon factors when assessing institutional investors' performance, thereby guiding institutional investors to adopt a long-term perspective on portfolio profitability and promoting their commitment to firm sustainability governance. Second, considering the identified mediating effect of analyst following, this finding suggests that information channels and market attention can serve as avenues for improving firms' low-carbon practices. A concrete step forward would be the adoption of more standardized content and format for firms' disclosure practice. Regulators could play a facilitating role by developing unified disclosure frameworks and encouraging greater interaction between institutional investors, analysts, and firms. Such measures would help embed environmental sustainability into analysts' assessment processes and enable investors to efficiently assess firms' engagement in low-carbon practices. In turn, the heightened transparency would sharpen market focus on carbon information, creating a long-term incentive for firms to strengthen their disclosures. Third, the heterogeneity analysis indicates that the institutional investors' favorable influence is more pronounced among state-owned firms, suggesting that differentiated strategies should be adopted to promote sustainable development across diverse types of firms, taking into account variations in their resource endowments and governance characteristics. State-owned firms could be positioned as positive models of sustainable development, enabling them to serve as a demonstration effect. A promising approach involves channeling institutional investors' expertise and influence to bridge the gap between non-state-owned and state-owned firms. Given their demonstrated effectiveness within state-owned firms, institutional investors could be encouraged to interact with firms and extend their influence by facilitating the diffusion of improved approaches to carbon information disclosure. This cooperation would help build an ecosystem of shared learning and accountability, reinforcing market-based incentives for firms to adopt and sustain low-carbon practices.

6.3. Limitations and Future Research Directions

The present work inevitably has its limitations, which also suggest potential directions for future research. First, institutional investors might exert a long-term effect on carbon information disclosure. In addition, this relationship may also be influenced by firm characteristics such as capital and number of employees. Subsequent studies, granted the availability of more comprehensive datasets, could further investigate the lagged and multidimensional nature of this relationship. Second, the impacts on carbon disclosure may be affected by factors that are difficult to quantify, such as investment preferences, potential misleading practices, and prevailing social values. As relevant data becomes more accessible, future research could incorporate softer indicators to capture these dimensions. Third, while this study examined the channel of analyst following, future research could further investigate other mechanisms underlying the relationship between institutional investors and firms' disclosure practices of carbon information.

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Appendix A

Drawing on Ding et al. [93] and Ren et al. [94], the following procedures are implemented for the accuracy of the empirical analysis. First, observations from firms marked with ST or *ST are excluded, as those firms have abnormal financial conditions that may distort a firm's operation and disclosure behavior. Second, firms with missing variables or discontinuous records over the sample period are removed. Third, firms with fewer than two years of observations are omitted. The usable sample comprises 9523 firm-year observations. The distribution of the observations across industries is presented in Table A1. Furthermore, in order to alleviate the impact of outliers, continuous variables are processed via winsorization at the 1% and 99% levels.

Table A1. Distribution of observations by industry.

Industry	N
Coal Mining and Washing	90
Petroleum and Natural Gas Extraction	13
Ferrous Metal Mining and Dressing	3
Non-Ferrous Metal Mining and Dressing	98
Mining Support Service Activities	67
Agricultural and Sideline Food Processing	189
Food Manufacture	220
Liquor, Beverages and Refined Tea	168
Textiles	148
Textile, Apparel and Accessories	189
Leather, Fur, Feather and Related Products and Footwear	36
Wood Processing and Wood, Bamboo, Rattan, Palm and Straw Products	35
Furniture	138
Paper and Paper Products	115
Printing and Reproduction of Recording Media	43
Cultural, Educational, Arts, Sports and Entertainment Products	80
Petroleum, Coal and Other Fuel Processing	69
Chemical Raw Materials and Chemical Products	873
Medicines	810
Chemical Fibers	62
Rubber and Plastic Products	274
Non-Metallic Mineral Products	408
Ferrous Metal Smelting and Rolling	116

Non-Ferrous Metal Smelting and Rolling	271
Metal Products	249
General Machinery	439
Specialized Machinery	819
Automobiles	489
Railway, Ship, Aerospace and Other Transportation Equipment	152
Electrical Machinery and Apparatus	848
Computers, Communication and Other Electronic Equipment	1500
Measuring Instruments and Machinery	208
Other Manufacturing	56
Comprehensive Utilization of Waste Resources	22
Repair of Metal Products, Machinery and Equipment	1
Electricity and Thermal Power Production and Supply	129
Gas Production and Supply	51
Water Production and Supply	45
Total	9523

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