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Mechanisms of investor attention in enhancing ESG performance: evidence from Chinese listed companies

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Abstract

In the context of China's "Dual Carbon" goals and regulatory requirements, listed companies in China are actively engaging in ESG (Environmental, Social, and Governance) practices, and the improvement of ESG performance has become a hot topic in the academic community. This study aims to clarify the impact of investor attention on the ESG performance of listed companies in China and its mechanism of action, depicting a more comprehensive analytical framework compared to existing similar studies. The results show that there is a significant positive correlation between external investor attention and company ESG ratings. Investor attention can positively affect a company's ESG performance by alleviating financial constraints, increasing R&D spending, and strengthening customer relationships, among other ways. In addition, factors such as the company's ownership structure, digitalization process, separation of the chairman and CEO positions, and audit quality also play a moderating role in this relationship. Finally, this study provides profound policy recommendations for stakeholders such as investors, companies, and policymakers, aiming to promote companies to effectively enhance ESG performance and promote sustainable development.

Keywords ESG performance, Investor attention, Listed companies, Mechanism

1 Introduction

Amid the surge of economic globalization, the concept of ESG (Environmental, Social, and Governance) was introduced by the United Nations Principles for Responsible Investment (UN-PRI) in 2006. Since then, the notion of sustainable development has garnered widespread acknowledgment from the global investment community [1]. According to Bloomberg, the global scale of ESG assets reached \$37.8 trillion in 2021 and is expected to exceed \$53 trillion by 2025. The philosophy of ESG advocates that companies should commit to achieving long-term sustainable development and create value for shareholders and society. Over the past few decades, listed companies have increasingly adopted ESG disclosure [2]. For investors, ESG emphasizes a company's social performance and shareholder returns, helping investors to quantitatively measure



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the sustainability of a company's development, making it a focus of their attention. In China, although ESG investment started late, in the past three years, the annual growth rate of the ESG investment market has reached an impressive 56%¹, making it a hot topic in the Chinese market. In China's capital market, the China Securities Regulatory Commission (CSRC) is gradually strengthening the ESG disclosure requirements for listed companies. Although there are some guidelines and recommendations encouraging listed companies to disclose ESG information, it has not yet become a mandatory legal requirement. However, with the Chinese government increasingly emphasizing corporate environmental and social responsibilities and the ongoing implementation of the "dual carbon" goals², the scenario of ESG information becoming a mandatory requirement for listed companies and their active fulfillment of ESG practices may come soon. Despite the annual growth of ESG investment in China, there are still many challenges and issues [3], such as the low number of companies participating in ESG disclosure, low investor attention, and uneven quality of company ESG reports. These issues are of great significance to investors, companies, and the sustainable development of the entire market.

Previous academic studies have demonstrated that companies implementing ESG practices not only effectively reduce potential financial risks [4], enhance investment attractiveness [5], but also strengthen the company's image and reputation [6], bringing multifaceted benefits. In corporate finance, academic research surrounding ESG is extensive. However, most studies focus on the economic consequences of ESG performance, such as the impact of ESG on company performance [5, 7, 8], company value [9–12], and cost of capital [13], but the conclusions remain controversial. Literature on factors driving companies to improve their ESG performance is sparse. Existing research primarily focuses on internal factors driving a company's ESG performance, such as corporate governance [14], industry characteristics [15], financial constraints [16], company size [17], board composition [18] or institutional quality of the company [19]. However, external factors like government policies [20], analysts, or external investors are rarely discussed.

External investors of the company play a pivotal role in the stock market, and the significance of their attention cannot be overstated. Previous studies have pointed out its pivotal role in various market dynamics such as stock prices, trading volume, and market liquidity [21, 22]. As an essential field of behavioral finance, research on investor attention is primarily based on limited attention theory and information dissemination theory, exploring a series of economic consequences of investor attention, such as asset price volatility [23], asset returns [24, 25] and corporate-level issues like corporate innovation [26] and equity capital costs [27]. Some of these conclusions are also topics of debate. In China, on April 16, 2022, the China Securities Regulatory Commission issued the "Guidelines on Investor Relations Work of Chinese A-share Listed Companies", explicitly requiring Chinese A-share listed companies to consider ESG information as a key component of interacting with investors.

¹ The data is sourced from the 'Insights into the Development of Sustainable Finance in China' white paper shared by KPMG China during the Carbon Expo in June 2023.

² China has pledged to reach peak carbon emissions before 2030, meaning that by 2030, the total amount of carbon emissions in China will no longer increase but will instead start to gradually decrease. Additionally, China has committed to achieving carbon neutrality by 2060, meaning that by 2060, China will achieve net-zero carbon emissions, i.e., the amount of carbon emitted by China will be balanced by the amount of carbon that can be absorbed.

This study will explore whether investor attention can enhance the ESG performance of Chinese listed companies, as well as the transmission mechanisms and influencing factors. Currently, academic research on this topic is relatively limited. For example, studies have analyzed the impact of investor attention on stock prices, trading volume, and market liquidity [22, 28]. The existing literature on the relationship between investor attention and ESG performance is scarce. Amir and Serafeim [29] found that an increasing number of investors in global financial markets use ESG information to assess the future value of companies, encouraging firms to improve their ESG performance to meet investor demands. Zhang et al. [30] corroborated that, in the context of social media, the social and governance aspects of ESG significantly increase investor attention, though the environmental factor has less influence. As for whether investor attention can enhance ESG performance, Xie and Cao [31] demonstrated that in the Chinese capital market, investor attention significantly boosts corporate ESG performance, especially in highly market-oriented and competitive industries. Gu [32] also confirmed that investor attention has a positive impact on the ESG performance of listed manufacturing companies in China.

The potential contributions of this paper are threefold. First, this study addresses a notable gap in the existing literature by examining the impact of investor attention on ESG (Environmental, Social, and Governance) performance from a behavioral finance perspective, an angle that remains underexplored. While prior studies [31–33] have established a direct association between investor attention and ESG performance, they often overlook the underlying mechanisms and contextual factors. In contrast, our study introduces a more integrated conceptual framework that incorporates both mediating variables (e.g., financial constraints) and moderating factors (e.g., audit quality, ownership structure). This enables a deeper understanding of not only whether but also how and under what conditions investor attention influences ESG outcomes—thus sharpening the theoretical and empirical contributions. Second, the study innovates methodologically by employing the Baidu Search Index as a proxy for investor attention. Unlike conventional measures such as trading volume or social media sentiment, the Baidu Index reflects proactive and voluntary information-seeking behavior from a wide spectrum of the Chinese public. This real-time, large-scale behavioral indicator provides a more representative and nuanced measure of investor sentiment in China's unique digital environment, offering new empirical insights beyond the scope of prior studies. Third, the study contributes practical and policy insights by connecting investor attention not only to ESG performance but also to firms' governance structures, financial constraints, and strategic decision-making processes. By highlighting how external market perceptions can influence internal ESG practices, our findings offer actionable implications for policymakers, corporate managers, and investors aiming to foster sustainable development through improved information transparency and stakeholder engagement.

2 Literature review and theoretical analysis

2.1 Investor attention and ESG

Dimson et al. [34] employed a longitudinal study of shareholder activism across global markets and demonstrated that active ownership—particularly through shareholder proposals and engagements—can significantly improve firms' socially responsible investment performance. Barko et al. [35] adopted a quasi-experimental design using

panel data on European firms and found that institutional investor dialogues with management lead to notable improvements in ESG ratings, especially in governance-related dimensions. In a similar vein, Dyck et al. [36] analyzed a large sample of firms across multiple countries to examine the impact of institutional ownership on corporate social responsibility (CSR), finding that foreign institutional investors are key drivers of improved CSR disclosure and performance [37]. These studies share a common emphasis on the role of institutional engagement, but vary in terms of geographic focus and the specific ESG dimensions emphasized.

In the Chinese context, research directly linking investor attention to ESG outcomes remains limited but is gradually emerging. Zhang et al. [30] utilized Baidu Search Index data to measure investor attention and found a positive association with ESG ratings, particularly in the social and governance domains, highlighting the impact of social media-driven attention. Xie and Cao [31] focused on listed firms in China and employed a fixed-effects regression approach; their findings indicated that investor attention significantly enhances ESG practices, especially in provinces with higher marketization levels [38]. Zhang and Zhang [33], using industry-level heterogeneity tests, further confirmed that investor attention boosts ESG performance but acknowledged the absence of clear mediating mechanisms. Compared to these studies, our research builds upon and extends the existing literature by not only reaffirming the positive effect of investor attention on ESG performance but also by empirically investigating the internal mechanisms—such as managerial behavior and strategic alignment—through which attention exerts its influence.

The influence of investor attention on corporate ESG performance can be explained through a synthesized framework combining Attention Allocation Theory, Behavioral Finance Theory, and Institutional Responsibility Theory. According to Attention Allocation Theory, investors are subject to cognitive constraints and tend to allocate more attention to firms in which they hold economic interests [39]. This focused attention enhances the visibility of ESG-related information, leading to greater information processing and monitoring. Building upon this, Behavioral Finance Theory posits that investor attention amplifies the effects of investor sentiment and market perceptions [40]. When attention is high, even small ESG-related signals can trigger stronger market reactions, putting firms under psychological and reputational pressure to conform to ESG expectations [41]. These psychological mechanisms do not operate in isolation. Rather, as Institutional Responsibility Theory suggests, increased investor scrutiny often acts as a catalyst for regulatory attention and institutional responses [42]. Policymakers and regulators may respond to heightened public and investor focus by tightening ESG disclosure requirements or introducing new ESG-related regulations [43]. Collectively, these theories interact in a reinforcing cycle: investor attention increases both corporate visibility and accountability, while also activating behavioral and institutional channels that jointly drive improvements in ESG performance.

Based on the above theoretical analysis, we can hypothesize that investor attention can enhance corporate ESG performance. An increase in investor attention may induce stricter scrutiny of a company's ESG practices, which, in turn, can stimulate the company to enhance its ESG performance.

Hypothesis 1 Investor attention can enhance corporate ESG performance.

2.2 Mediators of the effect of investor attention on ESG

Existing research has not directly identified mediators for the effect of investor attention on a company's ESG performance. However, some study findings do offer insights. For instance, Bae et al. [44] discussed how a firm's consideration of employee interests in financial decisions impacts its financial constraints. Chava [45] explored how environmental concerns influence a firm's financial constraints. The study by Cheng et al. [46] confirmed that companies with a high sense of social responsibility have an easier time accessing financing, which may influence their decisions on research and development (R&D) investments. Sen et al. [47] researched how CSR activities enhance relationships with various stakeholders, including customers. Luo and Bhattacharya [48] also provided evidence for a relationship between CSR and customer satisfaction. These pieces of literature have enlightened us: financial constraints, R&D expenditure, and customer relations might act as mediating variables in the influence of investor attention on a company's ESG performance. The specific theoretical analysis is as follows:

Firstly, financial constraints can act as a potential mediating factor. ESG initiatives often require long-term and sizable capital commitments—such as upgrading green technologies, improving supply chain transparency, or enhancing employee welfare—which can be especially burdensome for financially constrained firms [49]. When investor attention increases, firms may experience improved investor confidence and credibility, which in turn facilitates access to external capital at lower cost or on more favorable terms. This alleviation of financial pressure enables firms to redirect resources toward ESG activities that might otherwise be deprioritized under tight budgets. In addition, reduced financial constraints may lower internal risk aversion and increase managerial willingness to invest in non-immediate-return initiatives like ESG improvements. Therefore, the easing of financial constraints not only expands funding availability but also empowers firms to make strategic, forward-looking investments in ESG, thereby ultimately improving ESG ratings. This reflects a “financial cost” transmission mechanism through which investor attention promotes ESG performance.

Secondly, R&D expenditure can also serve as a mediator. For many companies, ESG activities often rely on innovation and new technologies, which usually stem from R&D expenditure [46]. For instance, environmental initiatives may require new clean energy technologies, while social responsibility activities might need innovative community service models. Therefore, investor attention can indirectly stimulate a company's ESG activities and ratings by encouraging increased R&D expenditure. Pinheiro et al. (2023) also verified the effect of R&D investment on ESG performance of enterprises [50]. This mechanism can be considered as the “innovation capability” transmission mechanism through which investor attention affects ESG ratings.

Finally, customer relations may be another potential mediator. Healthy customer relationships not only help maintain a company's reputation and brand value but may also prompt the company to pay more attention to implementing ESG activities [51]. Therefore, as investor attention increases, they may pay more attention to a company's relationship with its customers, which is vital for the company's reputation and brand value, thereby indirectly influencing the company's ESG ratings. This mechanism can be seen as the “customer relations” transmission mechanism through which investor attention influences ESG ratings. After the above analysis we further propose a series of hypotheses:

Hypothesis 2(a) Financial constraints mediates the relationship between investor attention and a company's ESG performance.

Hypothesis 2(b) R&D expenditure mediates the relationship between investor attention and a company's ESG performance.

Hypothesis 2(c) Customer relationships mediate the relationship between investor attention and a company's ESG performance.

2.3 Moderators of the effect of investor attention on ESG

Similarly, current research does not directly provide moderating variables for the effect of investor attention on a company's ESG performance. However, we can still glean insights from several studies. Li and Zhang [52] discussed how China's ownership structure, especially state ownership, influences a company's social responsibility performance. Ding et al. [53] argued that there are differences in earnings management between state-owned enterprises and private firms. This conclusion may indirectly suggest that differences in ownership could also affect ESG performance. Moreover, Dalton et al. [54] conducted a meta-analysis on the relationship between the roles of chairman and CEO being combined and company performance, which could also be related to ESG performance. Additionally, while Berman et al. [55] did not directly discuss digitization, they explored the relationship between stakeholder management and firm performance. In the current digital context, interactions with stakeholders might be influenced by the degree of digitization, thereby affecting ESG performance. Finally, Kim et al. [56] examined the relationship between financial reporting quality (which can be viewed as a proxy for audit quality) and corporate social responsibility. In summary, we've gathered insights that state ownership, whether the chairman also holds the CEO position, the extent of digitization, and audit quality may play moderating roles in the influence of investor attention on a company's ESG performance. The specific theoretical analysis process is as follows:

First, the degree of state ownership may play an important moderating role in the process of investor attention influencing a company's ESG ratings. This view can be theoretically explained based on the differences in ownership structure and governance goals between state-owned enterprises and private enterprises. Specifically, Frynas et al. [57] suggests that state-owned enterprises, due to their specific political resources and public expectations they face, might emphasize social responsibility more. Additionally, an analysis of the environmental responsibility performance of Chinese state-owned enterprises reveals that these companies may pay more attention to environmental protection than their private counterparts, possibly due to public pressure and government expectations for environmental protection [58]. Tang et al. [59] also indicate that ownership structure, including whether a company is state-owned, could impact a company's corporate social responsibility behavior. Therefore, these studies suggest that the degree of state ownership may moderate the relationship between investor attention and company ESG ratings. Specifically, for state-owned enterprises, investor attention may more effectively promote the improvement of ESG ratings.

Second, whether the chairman also serves as the CEO should also be considered as an important moderating variable. The theoretical basis of this viewpoint mainly lies in the

impact of the corporate governance structure. Particularly, the centralization of corporate power, such as the chairman also serving as the CEO, could affect the efficiency and direction of corporate decision-making. When the chairman is also the CEO, decision-making may be more efficient due to centralized power [60]. However, such power centralization could lead to the company overemphasizing short-term gains and neglecting long-term ESG activities. Therefore, in companies where the chairman also serves as the CEO, investor attention may not effectively promote the improvement of ESG ratings. On the other hand, when the roles of chairman and CEO are separated, the company might have a stronger checks and balances mechanism [4], enabling them to better balance short-term gains and long-term ESG activities. In such cases, investor attention may more effectively promote a company's ESG ratings. Thus, whether the chairman also serves as the CEO could moderate the relationship between investor attention and a company's ESG ratings. Specifically, the merging of the chairman and CEO roles could weaken the impact of investor attention on the company's ESG ratings, whereas in companies where the chairman and CEO roles are separated, investor attention may more effectively improve ESG ratings [60, 61].

Third, the degree of a company's digitization could also be an important moderating variable. Digitization not only changes a company's operating mode but also profoundly affects its ESG activities. For instance, digitization can help companies manage their resources more efficiently, thus reducing waste and environmental degradation [62]. Moreover, digitization can increase a company's transparency and accountability [63], potentially enhancing its governance ratings. Lastly, digitization can help companies better serve the community and meet social needs [64], thereby increasing their social ratings. Therefore, investor attention might have a greater impact on digitized companies, further propelling these companies to improve their ESG ratings. Specifically, for highly digitized companies, investor attention could have a greater impact because these companies might possess a stronger ability and motivation to respond to investors' expectations and pressures.

Finally, we need to consider the company's audit quality. High-quality auditing can enhance the transparency and credibility of a company's information [65], enabling investors to better understand the company's ESG activities and thus increasing investor attention [66]. On the other hand, high-quality auditing can also encourage companies [67] to fulfill their ESG responsibilities more effectively, thereby improving their ESG ratings. Therefore, audit quality may play a moderating role in the process of investor attention influencing a company's ESG ratings. Specifically, for companies with high audit quality, investor attention might have a larger impact because these companies' information is more transparent, enabling investors' expectations and pressures to be more easily conveyed to the company. Therefore, we propose the following hypotheses:

Hypothesis 3(a) The degree of state ownership moderates the relationship between investor attention and a company's ESG ratings, with higher state ownership enhancing the effect of investor attention on improving ESG ratings.

Hypothesis 3(b) The dual role of the chairman also serving as the CEO moderates the relationship between investor attention and a company's ESG rating. Specifically, the

impact of investor attention on ESG ratings is weakened when the chairman and CEO roles are merged, while it is enhanced when the roles are separated.

Hypothesis 3(c) The degree of a company's digitization moderates the relationship between investor attention and a company's ESG ratings, with high levels of digitization enhancing the effect of investor attention on improving ESG ratings.

Hypothesis 3(d) Audit quality moderates the relationship between investor attention and a company's ESG ratings, with high audit quality enhancing the effect of investor attention on improving ESG ratings.

To clarify the hypothesized relationships among the key variables and mechanisms discussed, we present a conceptual frame in Fig. 1.

3 Methodology

3.1 Research sample

This study selects the data of companies listed on the main board of Shanghai and Shenzhen stock exchanges in Chinese A-share securities market as our research sample. The time window of the study is from 2011 to 2021. To ensure a balanced sample and to avoid the impact of outliers or special cases in the data on the study results, we exclude companies labeled as ST and *ST³, companies in the financial industry⁴, and companies with missing data from the sample. In addition, we winsorize the data at the 1% and 99% quantiles. Data were obtained from the China Securities Market and Accounting Research (CSMAR) database and the China Wind database.

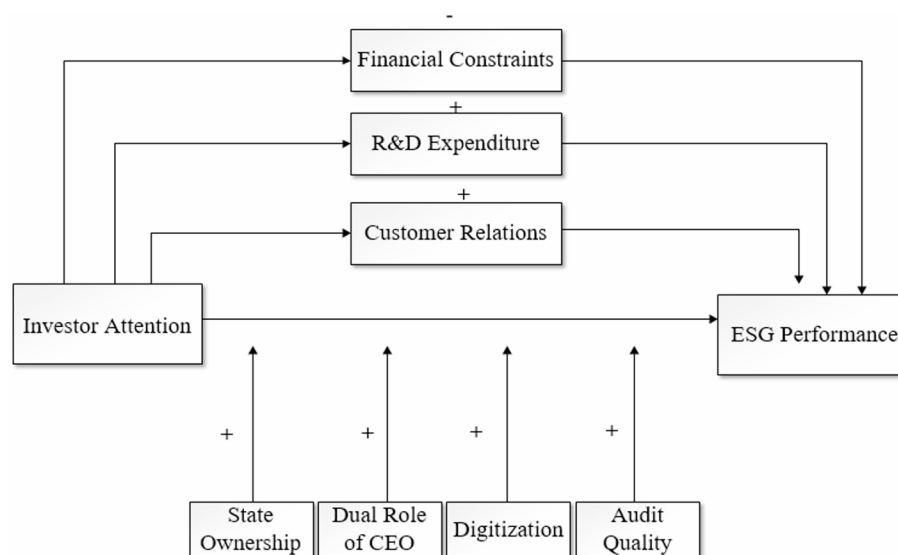


Fig. 1 Conceptual Frame

³ Companies marked as ST (Special Treatment) and ST in the Chinese stock market are usually in financial distress or have lost money for two consecutive years. These companies may have abnormal financial data and may be at risk of delisting themselves.

⁴ The operating models, financial structures, and risk exposures of companies in the financial industry, such as banks and insurance companies, are significantly different from those of non-financial companies. Therefore, directly analyzing financial companies together with non-financial companies may lead to biased results.

3.2 Variables measurement

3.2.1 Dependent variable

The primary dependent variable “ESG” of this study is the ESG ratings of listed companies in the A-share market of China, which is obtained from Sino-securities Index Information Services Company’s ESG rating system (the Hua Zheng ESG rating system). Compared with other ESG rating systems in mainland China, such as Syn Tao Green Finance ESG and China Alliance of Social Value Investment ESG, the Hua Zheng ESG rating system stands out due to its comprehensive rating dimensions, extensive sample coverage, and unique adaptability to Chinese circumstances. It has become the preferred metric for scholars conducting ESG-related studies on Chinese listed companies [68].

The Hua Zheng ESG scoring system divides companies into nine levels according to their ESG performance (from high to low), namely: AAA, AA, A, BBB, BB, B, CCC, CC, C. Following the practice of a majority of existing research [33, 69], this study assigns these grades from highest to lowest as “9~1”. In order to mitigate the impact of heteroscedasticity and extreme values, a natural logarithmic transformation has been applied to this variable.

3.2.2 Independent variable

In this study, the key independent variable is the investor attention index (*Attention*). Initial scholarly research utilized stock trading data such as trading volume and liquidity [39, 70], along with the number of shares and shareholders [71] as measures of investor attention. Nowadays the focus has shifted towards using metrics like social media attention and search engine query volume to gauge investor interest. For instance [72], employed the number of mentions in The Wall Street Journal as a measure of investor attention, while [73] utilized the volume of relevant tweets on Twitter.

Inspired by the methodology of Meng et al. [68], who adopted Google’s search volume as a proxy for investor attention, this study has opted for a similar measure using Baidu, the largest search engine in China. Specifically, we use the summation of the search volume for a company’s stock code, its short name, and its full name on Baidu. To address heteroscedasticity and manage the effect of outliers, we add one to the sum and then apply a natural logarithmic transformation.

3.2.3 Control variables

In accordance with the approach of Meng et al. [68], this study incorporates a range of company-level indicators that could potentially affect a firm’s ESG performance as control variables. These encompass executive compensation (*Compen*), the proportion of shares held by executives (*Share*), the size of the board of directors (*D size*), the number of independent directors (*ID size*), company performance (*Perform*), capital structure (*Capital*), debt structure (*Debt*) and company age (*Age*). Table 1 below provides detailed descriptions of the variables mentioned above, including the dependent, independent, and control variables, with their symbols, names, and definitions.

3.2.4 Mediating variables

To elucidate the mechanism by which increased investor attention enhances a company’s ESG ratings, this study introduces several mediating variables.

Table 1 Variables definition

Symbols	Name	Definition
Dependent Variable		
<i>ESG</i>	ESG Performance	ESG ratings of listed companies in the A-share market of China, which is obtained from the Hua Zheng ESG rating system
Independent Variable		
<i>Attention</i>	Investor attention	The summation of the search volume for a company's stock code, its short name, and its full name on Baidu
Control Variables		
<i>Compen</i>	Executive Compensation	The natural logarithm of the sum of the compensation for the top three executives in the company
<i>Share</i>	Executive Shareholding Ratio	Number of shares held by executives/total share capital
<i>D size</i>	Size of the board of directors	Board size in natural logarithm
<i>ID size</i>	Size of Independent Directors	Number of independent directors / Total number of board members
<i>Perform</i>	Company Performance	Net profit/ Operating revenue
<i>Capital</i>	Capital Structure	Fixed Assets/ Total Assets
<i>Debt</i>	Asset Liability Ratio	Total liabilities/ Total assets
<i>Age</i>	Age of Company	Natural logarithm of the number of years the company has been listed + 1

First, to verify the “Financing cost” transmission mechanism, we incorporate the mediating variable of corporate financial constraint level, employing the “*KZ Index*⁵” as its proxy [74, 75]

Furthermore, to validate the “*customer relationship*” as a transmission mechanism, this study introduces “operating revenue” as a mediating variable [76]. In line with the statistical practices previously discussed, this variable also undergoes a natural logarithmic transformation.

Finally, to investigate the “*innovation capability*” transmission mechanism, this paper introduces the mediating variable of “the company’s current year RD Expenditure” as a proxy variable [77, 78], which is then processed by taking the natural logarithm.

3.2.5 Moderating variables

The chosen moderating variables and their respective processing methods for this research are as follows:

State Ownership (*SOE*): Firms with a higher level of social responsibility are able to obtain more favorable financing conditions [46]. This finding corroborates that state-owned enterprises (SOEs) may face different financing conditions, thereby influencing their handling of ESG issues. This variable is a dummy variable, taking a value of 1 if the enterprise is state-owned, and 0 otherwise.

Digital Transformation (*Dt*): The digital transformation can assist companies in achieving a higher level of social responsibility [79], thereby improving ESG performance. This variable is a dummy variable, determined by examining the textual content of the company’s annual periodic and interim reports. If the enterprise undertook digital transformation in the given year, the value is 1; otherwise, it’s 0.

⁵The KZ Index was first introduced in a 1997 article by economists Steven Kaplan and Luigi Zingales as a measure of a firm’s financial constraints. The larger the KZ index, the greater the company’s financing constraints. The calculation formula is:

$$KZ\ Index = -1.002 * (Cash\ Flow / Total\ Assets) - 39.368 * (Dividends / Total\ Assets) + 3.139 * Leverage - 1.315 * (Net\ Assets / Total\ Assets).$$

Dual Leadership (*Dual*): The concentration of power in CEOs in Chinese companies (such as simultaneously holding the positions of Chairman and General Manager) correlates with corporate risk-taking, subsequently affecting the ESG performance of the enterprise. This variable is a dummy variable, taking a value of 1 if the Chairman and General Manager positions were held by the same individual in the given year, and 0 otherwise.

Audit Quality (*Opinion*): Higher audit quality can reduce the short-term nature of accounting earnings, possibly reflecting a higher quality of financial information [80]. This variable is a dummy variable, taking a value of 1 if the company's audit opinion for the given year is standard and unqualified, and 0 otherwise.

3.3 Research models

In order to investigate the influence of investor attention on corporate ESG ratings in Chinese A-share market, this study uses the fixed-effects model as the benchmark regression, as exemplified in Model (1). This approach is in line with the method adopted by Zhang and Zhang [33].

$$ESG_{i,t} = \beta_0 + \beta_1 Attention_{i,t} + \beta_2 Controls_{i,t} + \sum Year_t + \sum Industry_i + \sum Province_i + \varepsilon_{i,t} \quad (\text{Model 1})$$

The dependent variable ESG, which was discussed in Sect. 3.2.1, is accompanied by the independent variable Attention, as explicated in Sect. 3.2.2. Controls, representing a set of control variables, were outlined in Sect. 3.2.3. Concurrently, Model (1) takes into account the fixed effects attributed to the Year, Industry, and Province.

To examine the transmission mechanism of the impact of investor attention on corporate ESG ratings, this study will scrutinize whether a mediating variable exhibits a mediation effect within this relationship. In line with the “Stepwise Regression” [81] for mediation effect testing, we have established Models (2) to (4).

Regress the Dependent Variable on the Independent Variable (main effect regression):

$$ESG_{i,t} = \alpha_0 + \alpha_1 Attention_{i,t} + \alpha_2 Controls_{i,t} + \sum Year_t + \sum Industry_i + \sum Province_i + \varepsilon_{i,t} \quad (\text{Model 2})$$

Regress the Mediator on the Independent Variable:

$$Mediator_{i,t} = \beta_0 + \beta_1 Attention_{i,t} + \beta_2 Controls_{i,t} + \sum Year_t + \sum Industry_i + \sum Province_i + \varepsilon_{i,t} \quad (\text{Model 3})$$

Regress the Dependent Variable on both the Independent Variable and on the Mediator:

$$ESG_{i,t} = \gamma_0 + \gamma_1 Attention_{i,t} + \gamma_2 Mediator_{i,t} + \gamma_3 Controls_{i,t} + \sum Year_t + \sum Industry_i + \sum Province_i + \varepsilon_{i,t} \quad (\text{Model 4})$$

In keeping with the baseline regression model, Models (2) to (4) also control for fixed effects attributable to the year, industry, and province. The definitions of variables Attention and ESG in this model are consistent with those in Model (1). The term “Mediator” in Models (2) to (4) refers to the variables KZ Index, Operating Revenue, and RD Expenditure, as outlined in Sect. 3.2.4. The mediation effect is computed as the product

of coefficients β_1 and γ_2 . Full mediation is supported if the direct effect γ_1 becomes non-significant after the mediator is included. If the direct effect γ_1 is still significant while the indirect effect $\beta_1 * \gamma_2$ is also significant, it indicates a case of partial mediation.

Finally, this study investigates whether a series of variables exhibit moderation effects within the relationship between investor attention and corporate ESG ratings. The majority of current academic methods for testing moderation effects stem from the research of Aiken and West⁶, which involves incorporating an interaction term—constructed from the independent and moderation variables—into the regression model. The existence of moderation effects is then inferred through testing the significance of the coefficients of the interaction term. Accordingly, Model (5) has been established in this paper to scrutinize the moderation effects of a series of variables.

$$\begin{aligned} ESG_{i,t} = & \beta_0 + \beta_1 Attention_{i,t} + \beta_2 Moderator_{i,t} * Attention_{i,t} \\ & + \beta_3 Controls_{i,t} + \sum Year_t + \sum Industry_i \\ & + \sum Province_i + \varepsilon_{i,t} \end{aligned} \quad (\text{Model 5})$$

In alignment with the baseline regression Model (1), Model (5) also controls for fixed effects at the year, industry, and province levels. The independent variable Attention, dependent variable ESG, as well as the control variables Control, are all consistent with those in Model (1). In models (1) to (5), the subscript i, t represents the value of the variable for company i in year t .

4 Empirical results and discussion

4.1 Descriptive analysis

Table 2 presents the descriptive statistics of all variables after they were winsorized at the 1% and 99% levels, demonstrating a relatively stable overall fluctuation. Specifically, following the approach of Meng et al. (2023) [68], after applying the natural logarithm to the data, the average ESG ratings (ESG) for listed companies in the Chinese A-share market is 1.374, with a standard deviation of 0.300. The average attention from investors is 6.709, with a standard deviation of 0.690. The standard deviations of the proportion of shares held by executives (*Share*) and financing constraints (*KZ*) are 19.213 and 2.384 respectively, suggesting significant individual differences between companies. Moreover, when examining the descriptive results of the moderating variables, we find that in the sample, 35.9% of companies are state-owned, 65.5% have successfully undergone digital transformation, and only 27.8% have a chairman who concurrently holds the position of general manager. Impressively, over 90% of these listed companies exhibit high audit quality.

4.2 Correlation analysis of variables

Tables 3 and 4 present the results of Pearson correlation analysis for the dependent variables, independent variables, control variables, and other variables (including mediating and moderating variables), with all correlation coefficients between the variables less than 0.5. In the baseline regression, the dependent variable “ESG” and the independent variable “Attention” exhibit a significantly positive correlation, with a correlation

⁶The process for testing moderation effects was laid out by Aiken, West, and Reno in their book “Multiple Regression: Testing and Interpreting Interactions” published in 1991.

Table 2 Descriptive statistics

Variable	Mean	p50	Max	Min	SD
Depend variable					
<i>ESG</i>	1.374	1.386	2.079	0.000	0.300
Independ Variable					
<i>Attention</i>	6.709	6.649	8.760	5.263	0.690
Control Variables					
<i>Compen</i>	14.446	14.423	16.432	12.752	0.702
<i>Share</i>	13.064	0.550	67.410	0.000	19.213
<i>D size</i>	2.206	2.197	2.833	1.609	0.239
<i>ID size</i>	0.379	0.364	0.600	0.250	0.065
<i>Perform</i>	0.066	0.068	0.494	-0.965	0.176
<i>Capital</i>	0.211	0.178	0.694	0.002	0.159
<i>Debt</i>	0.427	0.420	0.894	0.055	0.205
<i>Age</i>	1.485	1.000	2.000	1.000	0.500
Mediating Variables					
<i>KZ index</i>	1.034	1.259	6.481	-5.787	2.384
<i>Operating Reven</i>	1.057	1.058	1.126	0.958	0.030
<i>RD Expenditure</i>	2.878	2.882	3.083	2.606	0.085
Moderating Variables					
<i>SOE</i>	0.359	0	1	0	0.480
<i>Dt</i>	0.655	1	1	0	0.475
<i>Dual</i>	0.278	0	1	0	0.448
<i>Opinion</i>	0.970	1	1	0	0.170

Notes: This table reports the descriptive statistical characteristics of all variables, which are defined in Table 1

Table 3 Correlation analysis of dependent, independent, control variables

Variables	ESG	Attention	Compen	Share	D size	ID size	Perform	Capital	Debt	Age
<i>ESG</i>	1.000									
<i>Attention</i>	0.095***	1.000								
<i>Compen</i>	0.168***	0.172***	1.000							
<i>Share</i>	0.084***	-0.244***	-0.072***	1.000						
<i>D size</i>	0.005	0.146***	0.073***	-0.199***	1.000					
<i>ID size</i>	0.053***	-0.002	-0.007	0.117***	-0.276***	1.000				
<i>Perform</i>	0.215***	0.020***	0.102***	0.108***	-0.013**	0.009	1.000			
<i>Capital</i>	0.036***	0.067***	-0.129***	-0.155***	0.122***	-0.051***	-0.067***	1.000		
<i>Debt</i>	0.08***	0.194***	0.102***	-0.315***	0.139***	-0.040***	-0.304***	0.077***	1.000	
<i>Age</i>	0.020***	0.134***	0.031***	-0.288***	0.143***	-0.066***	0.019***	0.136***	0.208***	1.000

Notes: ***, **and* represent significance at 1%,5% and 10% levels, respectively

Table 4 Correlation analysis of mediator and moderate variables

	KZ	Operating revenue	RD expenditure	SOE	Dt	Dual	Opinion
<i>KZ</i>	1						
<i>Operating revenue</i>	-0.065***	1					
<i>RD expenditure</i>	-0.062***	0.032***	1				
<i>SOE</i>	0.195***	0.056***	0.062***	1			
<i>Dt</i>	-0.112***	0.164***	0.165***	-0.097***	1		
<i>Dual</i>	-0.092***	-0.022***	-0.024***	-0.299***	0.067***	1	
<i>Opinion</i>	-0.158***	0.069***	0.068***	0.035***	0.013**	0.001	1

Notes: ***, **and* represent significance at 1%,5% and 10% levels, respectively

coefficient of 0.095. This preliminary evidence suggests a relationship wherein an increase in investor attention contributes to higher corporate ESG ratings. Building upon this, the study also performs a Variance Inflation Factor (VIF) test. Due to space limitations in the paper, only the results are reported, with VIF values ranging from 1.07 to 1.27, indicating no significant multicollinearity issues among the variables.

4.3 Baseline regression analysis

The primary focus of this baseline regression analysis is to examine the relationship between investors' attention and a company's ESG ratings. Preliminary Hausman test results for the regression analysis revealed a P-value of 0.000, leading to the rejection of the null hypothesis that a random effects model should be utilized. Consequently, a fixed effects model was selected as the model for the baseline regression. Table 5 presents the results of the baseline regression using various models.

In Table 5, we employ the modeling methodology utilized by Zhao et al. [69]. Model (1) represents an elementary regression equation without the inclusion of control variables and fixed effects. The analysis demonstrates a coefficient of 0.0416 for investor attention (Attention), substantiating its significance at the 1% level.

Model (2) extends the analysis by introducing a range of control variables, though it does not incorporate fixed effects. Notably, the coefficient associated with Attention persistently exhibits a positive value, and its statistical significance is high.

Table 5 Baseline regression results

	(1)	(2)	(3)	(4)
	ESG	ESG	ESG	ESG
<i>Attention</i>	0.0416*** (0.0110)	0.0393*** (0.0070)	0.0542*** (0.0090)	0.0520*** (0.0080)
<i>Compen</i>		0.0619*** (0.0050)	0.0686*** (0.0040)	0.0702*** (0.0060)
<i>Share</i>		0.0013*** (0.0000)	0.00144*** (0.0000)	0.00140*** (0.0000)
<i>D size</i>		0.0243* (0.0140)	0.0191 (0.0110)	0.0194* (0.0110)
<i>ID size</i>		0.2200*** (0.0670)	0.2490*** (0.0480)	0.2590*** (0.0440)
<i>Perform</i>		0.3060*** (0.0200)	0.2780*** (0.0200)	0.2700*** (0.0180)
<i>Capital</i>		0.0111 (0.0280)	0.0966*** (0.0250)	0.0943*** (0.0250)
<i>Debt</i>		-0.0475** (0.0230)	-0.1380*** (0.0250)	-0.1380*** (0.0250)
<i>Age</i>		-0.0029 (0.0090)	-0.2300*** (0.0550)	-0.2100*** (0.0550)
Constant	1.0920*** (0.0750)	0.0622 (0.1370)	0.2240** (0.1070)	0.1920* (0.1060)
Year FE	NO	NO	YES	YES
Industry FE	NO	NO	YES	YES
Province FE	NO	NO	NO	YES
N	25,832	25,832	25,832	25,832
Adjusted R ²	0.0090	0.0820	0.1540	0.1680

Notes: The standard errors for clustering at the provincial level are in parentheses. The Year, Industry and Province indicators are included in the corresponding models, but their coefficients are not in this table. ***, ** and * represent significance at 1%, 5% and 10% levels, respectively

Building upon Model (2), Model (3) integrates fixed effects related to both annual and industry-specific influences. The results continue to highlight a positive and significant coefficient for the key independent variable. Noteworthy, with the integration of fixed effects, the quantity of control variables presenting significant coefficients markedly increases in comparison to Model (2).

Lastly, Model (4) enriches Model (3) by incorporating fixed effects at the provincial level. The regression results from this model indicate that the coefficients for all variables hold statistical significance, underscoring the robustness of our findings.

The outcomes of models (1) to (4) denote a positive correlation between investor attention in Chinese A-share market and company ESG ratings [33, 69, 82], which validates Hypothesis 1 posited in this study. This indicates that an uptick in investor attention catalyzes an enhancement in company ESG ratings, thereby affirming the preceding theoretical discussions. In actuality, an amelioration in company ESG ratings further escalates investor attention, initiating a “virtuous cycle.” Being a comprehensive metric for evaluating companies across multiple dimensions, ESG ratings encapsulate their performance in domains such as environmental protection, social responsibility, and governance structure facets that are drawing escalating interest from investors [4, 83]. In addition, companies with superior ESG ratings tend to exhibit improved performance amidst economic oscillations or market pressures, which heightens investor attention [5]. Contemporary research further corroborates these findings. Amir & Serafeim (2018) [29] discerned that investors harbor a greater inclination towards companies with elevated ESG ratings, as this signals superior risk management and long-term operational capabilities. Furthermore, higher ESG ratings can enhance a company’s reputation, thereby amplifying investor attention [84].

This observation also concurs with the escalating significance of ESG ratings in investment decision-making within Chinese stock market. The prevalence of responsible investment strategies is on an upward trend among investors in Chinese A-share market. Responsible investment strategies entail the consideration of a company’s environmental, social, and governance (ESG) performance in tandem with its financial performance when delineating investment targets. This investment approach has garnered extensive global recognition and is experiencing swift expansion in China.

Moreover, the regression outcomes illustrated in Table 5 suggest a significant positive correlation between the size of independent directors (*D size*) of Chinese A-share listed companies, company performance (*Perform*), and the company’s ESG ratings. The ESG ratings, a quantitative indicator, is employed to assess a company across three pivotal realms: environmental protection, social responsibility, and corporate governance. Prior research has drawn a connection between ESG ratings and a company’s long-term prosperity and profitability [5]. These results are not surprising. Firstly, a larger team of independent directors may harbor a more expansive perspective and diversified thinking, thereby aiding in crafting more comprehensive ESG strategies [4]. Secondly, a larger team of independent directors might command more resources and capabilities to execute and supervise the company’s ESG strategies, assisting the company in achieving higher standards in environmental protection, social responsibility, and effective corporate governance.

Regarding the positive correlation between company performance (*Perform*) and the company’s ESG ratings, several plausible explanations exist. Firstly, high-performing

companies are likely to have more substantial resources and capabilities to invest in ESG initiatives. This could result in increased investments in environmental protection, enhancements in employee benefits and working conditions, and the establishment of stricter corporate governance structures and processes. Such investments and enhancements could in turn boost the company's ESG ratings [71]. Secondly, high-performing companies may place a higher emphasis on their brand image and corporate reputation. A strong ESG ratings can enhance a company's brand image and elevate its standing among stakeholders. As a result, high-performing companies may endeavor to improve their ESG ratings in order to maintain their brand and reputation [85]. Lastly, high-performing companies might be subject to increased pressure to meet stakeholder expectations, including those of customers, employees, investors, and the community. These stakeholders may demand that the company excels in environmental, social, and governance aspects. In order to fulfill these expectations, high-performing companies might take steps to augment their ESG ratings.

4.4 Robustness and endogeneity

To enhance the reliability of the empirical findings in Table 5, which suggest that investor attention can improve ESG performance, this paper conducts several tests to address potential endogeneity issues. The baseline regression model (Model 1) incorporates multidimensional fixed effects, including year, industry, and province fixed effects, aimed at mitigating bias from unobserved factors and reducing endogeneity due to omitted variables. The coefficient of the core explanatory variable, attention, remains significantly positive. Additionally, to address endogeneity arising from potential reverse causality, we regress ESG performance on lagged attention variables, specifically using one-, two-, and four-period lags (L. Attention, L2. Attention, L4. Attention) [86]. Columns 1–3 of Table 6 report the corresponding regression results, showing that the coefficients of lagged attention remain significantly positive, indicating a long-term and sustained positive impact of investor attention on ESG performance.

Furthermore, following the method of Zhang W. [87], we select the number of administrative duties held by the company's board secretary (IV1) and the lagged investor attention index of other listed companies in the same industry (IV2) as instrumental variables, employing a two-stage least squares (2SLS) approach for estimation. The rationale behind these instrument choices is that a board secretary, as the primary liaison with investors, is likely to reduce investors' need for extensive online searches due to a deeper understanding of the company's situation, though this is not directly related to ESG performance. Similarly, the investor attention pattern toward other companies in the same industry may influence the focus on a specific company without directly affecting its ESG performance. This approach provides a robust mechanism for controlling potential endogeneity in the study.

To assess the validity of the instrumental variables, we conduct under-identification, weak instrument, and over-identification tests. Specifically, the Kleibergen-Paap rk LM statistic is used for testing under-identification, the Kleibergen-Paap rk Wald F statistic for weak instruments, and the Hansen J statistic for over-identification. The overall results confirm the validity of using IV1 and IV2 as instruments. Columns 4–5 of Table 6 present the first-stage and second-stage results of the 2SLS regression, showing that

Table 6 Endogeneity test results

	(1)	(2)	(3)	(4)	(5)
	Lagged Explanatory Variable			Instrumental Variable Regression (2SLS)	
	1 period Lagged	2 period Lagged	4 period Lagged	First stage	Second stage
	ESG	ESG	ESG	ESG	ESG
Attention					0.5039** (0.027)
L. Attention	0.3182*** (0.002)				
L2. Attention		0.4150*** (0.003)			
L4. Attention			0.4103*** (0.003)		
IV1				0.1065* (0.059)	
IV2				0.1101*** (0.041)	
Control Variables	YES	YES	YES	YES	YES
Fixed effect	YES	YES	YES	YES	YES
Kleibergen-Paap rk LM					10.43 [0.005]
Kleibergen-Paap Wald rk					15.667 {12.93}
Hansen J					0.463 [0.796]

Notes: The standard errors for clustering at the provincial level are in parentheses. The fixed effect indicators and control variables are included in the corresponding models, but their coefficients are not in this table. *** represents significance at 1% level. values within square brackets [] represent the p-values of the respective statistics, while values within curly braces {} denote the critical values for weak instrument tests at the 10% significance level

attention remains significantly positive. Thus, after accounting for endogeneity, the baseline conclusion remains robust: investor attention can enhance ESG performance.

For further validation, we conducted robustness tests on our baseline regression by substituting key variables and adjusting the sample. Firstly, we altered the dependent variable, employing the Syn Tao ESG index [3] as a substitute for the Hua Zheng ESG index used in our baseline regression. Compared to the Hua Zheng ESG index, the Syn Tao ESG index provides varied weightages to its indicators based on the evaluation of companies across different sectors, and it is a crucial index for Chinese scholars conducting ESG-related research. Table 7 presents the regression results for Model A and Model B. Model A replaces the dependent variable of the baseline regression model—the Hua Zheng ESG index—with the Syn Tao ESG index. Given that the Syn Tao ESG index encompasses fewer China A-share listed companies than the Hua Zheng ESG evaluation system, the sample size for Model A is 17,990, smaller than the 25,382 of the baseline regression. In contrast, Model B modifies the baseline regression model's primary explanatory variable, substituting the median value of investor attention for the original data. Both Model A and Model B retain the control measures of the baseline regression model, which account for fixed effects at the year, industry, and province levels. The final results reveal that the coefficients of the independent variables in both Model A and Model B remain significantly positive, strengthening the positive correlation between

Table 7 Regression results with replacement of variable and sample

	A	B
	Syn Tao ESG	ESG
<i>Attention</i>	0.225*** (0.041)	
<i>Attention Median</i>		0.217*** (0.038)
<i>Compen</i>	0.244*** (0.020)	0.250*** (0.029)
<i>Share</i>	0.00465*** (0.001)	0.00447*** (0.001)
<i>D size</i>	0.0587 (0.037)	0.0597 (0.039)
<i>ID size</i>	0.904*** (0.208)	0.961*** (0.198)
<i>Perform</i>	0.959*** (0.069)	0.926*** (0.065)
<i>Capital</i>	0.411*** (0.104)	0.417*** (0.102)
<i>Debt</i>	-0.502*** (0.094)	-0.498*** (0.094)
<i>Age</i>	-1.131*** (0.197)	-1.031*** (0.203)
Constant	-0.0447 (0.448)	-0.186 (0.492)
Fixed Effect	YES	YES
N	17,990	25,832
Adjusted R ²	0.172	0.189

Notes: The standard errors for clustering at the provincial level are in parentheses. The Year, Industry and Province indicators are included in the corresponding models, but their coefficients are not in this table. ***, **and* represent significance at 1%,5% and 10% levels, respectively

investor attention and corporate ESG ratings. This reaffirms the conclusion that elevated levels of investor attention are associated with enhanced ESG ratings.

4.5 Mediating effect analysis

To investigate the transmission mechanism of investor attention to a listed company's ESG ratings, we conducted a mediation effect test on three significant mediating variables: financing constraints, RD expenditure, and operating revenue. We performed a fixed-effects regression on panel data by establishing Models (2) to (4). The regression results are presented in Table 5. According to the study by Baron and Kenny (1986), for a variable to exhibit a mediation effect, the significance of the coefficient $\beta_1\gamma_2$ in Models (2) to (4) must be confirmed. If $\beta_1\gamma_2$ is significantly valid, it indicates the presence of a mediation effect. As the main effect regressions of the three mediating variables are consistent, they are singly listed in Table 5. Additionally, Table 5 displays the coefficients and errors corresponding to each mediating variable in Models (3) and (4).

Based on the results presented in Table 8, we draw the following observations:

First, the coefficients of $\beta_1\gamma_2$ (representing the mediating effect) for each mediator are significant, and γ_1 (representing the direct effect) is simultaneously significant, indicating that the three mediators - financing constraints, RD expenditure, and operating revenue - partially mediate the relationship between investor attention and ESG ratings of listed companies. This suggests that the influence of investor attention on a company's

Table 8 Results of the mediating effect test

Dependent Variable	Main Effect ESG	Mediator: KZ		Mediator: RD Expenditure		Mediator: Operating Revenue	
		KZ	ESG	RD Expenditure	ESG	Operating Revenue	ESG
Attention	0.0520*** (6.59)		0.0506*** (6.60)		0.0209** (2.37)		0.0219** (2.48)
ESG		-0.655*** (-14.47)		0.0427*** (13.66)		0.0148*** (13.83)	
KZ			-0.0194*** (-13.91)				
RD Expenditure					0.768*** (14.41)		
Operating Revenue							2.160*** (14.27)
Constant	0.192* (1.81)	6.325*** (12.40)	0.314*** (2.91)	2.065*** (92.45)	-1.212*** (-8.04)	0.775*** (101.15)	-1.302*** (-8.37)
Fixed Effect	YES	YES	YES	YES	YES	YES	YES
N	25,832	26,675	25,832	22,206	21,370	22,206	21,370
Adjusted R ²	0.168	0.563	0.179	0.443	0.180	0.439	0.180
Mediation Effect		-0.013		0.033		0.032	

Notes: The standard errors for clustering at the provincial level are in parentheses. The Year, Industry and Province indicators are included in the corresponding models, but their coefficients are not in this table. Due to space constraints, this table does not display the regression coefficients and errors of the control variables. ***, **and* represent significance at 1%, 5% and 10% levels, respectively

ESG ratings can be transmitted through the respective pathways represented by these mediators.

Second, the mediating effect of financing constraints is negative. This suggests that an increase in investor attention can reduce the financing constraints faced by listed companies, thereby promoting an improvement in their ESG ratings. Conversely, the mediating effects of RD expenditure and operating revenue are both positive, suggesting that the variation in investor attention, company ESG ratings, and either company's RD investments or operating revenue are in the same direction. In other words, an increase in investor attention can lead to an increase in a company's RD investments or operating revenue, thereby driving up the company's ESG ratings.

We found that among the mediators, financing constraints, RD expenditure, and operating revenue, the mediating effect of RD expenditure on investor attention and ESG ratings is the most pronounced. This suggests that RD expenditure might be the most influential mediator in this context. One possible interpretation is that RD expenditure directly signifies a company's investment in its future growth and success. Investments in RD highlight a company's commitment to innovation, which is considered a critical factor for long-term success and sustainability [88]. Thus, as investor attention increases, companies may focus more on RD, demonstrating their dedication to future growth and sustainability. This increased investment in RD, in turn, could potentially raise a company's ESG rating, as these ratings typically consider a firm's long-term sustainability strategies [89].

Finally, we observed that compared to the main effect model, the inclusion of mediators increases the model's adjusted R² value. This suggests that the integration of mediators enhances the model's fit, implying that the mediators contribute to a more accurate explanation of the variation in the dependent variable. In simpler terms, this

demonstrates that the mediators play a pivotal role in the model, boosting its explanatory power over the data. This strengthens the case for mediation effects, as it suggests that the mediators act as conduits in the relationship between the independent and dependent variables, elucidating this relationship more accurately.

To further consolidate our findings, particularly the mediation effect, we will employ both the Sobel-Goodman test and Bootstrap methods. These methods can be utilized under broader circumstances and can estimate the sampling distribution of the mediation effect more accurately [90]. By doing so, our results will gain more robust and convincing support.

Table 9 presents the key indicators of the Sobel-Goodman mediation test for three potential mediating variables: financing constraints, RD expenditure, and operating revenue. In line with expectations, the Sobel and Goodman values for all three potential mediating variables are statistically significant, validating the mediating effects of these variables. Notably, RD expenditure demonstrates the most substantial proportion of mediation effects among the three variables, consistent with our earlier findings. These results offer solid empirical evidence in support of the mediating roles of financing constraints, RD expenditure, and operating revenue.

Table 10 provides the bootstrap test results for the same potential mediating variables: financing constraints, RD expenditure, and operating revenue. In appraising and interpreting the outcomes of the bootstrap mediation effect test, our primary concern is the confidence interval of the effect coefficient yielded by the bootstrap method [91]. A significant mediation effect is implied if this confidence interval excludes zero. Additionally, bias-corrected and accelerated confidence intervals (BCa) were employed to rectify the bias and skewness in the bootstrap estimates [91]. Based on our findings, both the direct and indirect effects of the three potential mediating variables exhibited significant mediation effects, given that the confidence intervals of their effect coefficients, generated via the bootstrap method, do not contain zero.

By adhering to rigorous mediation effect testing methodologies, we have confirmed the mediating roles of financing constraints, RD expenditure, and operating revenue in the relationship where increased investor attention enhances a company’s ESG ratings, thereby substantiating hypothesis 2(a)–2(c). Specifically, financing constraints were identified as a negative mediating effect. Essentially, companies that command high investor attention are more likely to secure external financing, thereby reducing their financing costs and constraints [92]. As a result, these companies can allocate more

Table 9 Sobel-Goodman test results

Variable	Coef.	Std. Err.	Z score	P>Z
Mediator: KZ				
Sobel	0.002	0.000	7.454	0.000
Goodman	0.002	0.000	7.467	0.000
Proportion of total effect that is mediated 0.055				
Mediator: RD Expenditure				
Sobel	0.013	0.001	16.076	0.000
Goodman	0.013	0.001	16.081	0.000
Proportion of total effect that is mediated 0.323				
Mediator: Operating Revenue				
Sobel	0.012	0.001	15.861	0.000
Goodman	0.012	0.001	15.867	0.000
Proportion of total effect that is mediated 0.312				

Table 10 Bootstrap test results

Variable	Coef.	Std. Err.	99% Conf. Interval	
Mediator: <i>KZ</i>				
Indirect effect	0.012829	0.000878	0.010544 0.010547	0.015029(P) 0.015093(BC)
Direct effect	0.026947	0.003123	0.018998 0.019207	0.0350651(P) 0.035185(BC)
Mediator: <i>RD Expenditure</i>				
Indirect effect	0.012829	0.000878	0.010703 0.010616	0.015229(P) 0.015175(BC)
Direct effect	0.026947	0.003073	0.018382 0.018176	0.034565(P) 0.034553(BC)
Mediator: <i>Operating Revenue</i>				
Indirect effect	0.012397	0.000886	0.010283 0.010273	0.014735(P) 0.014651(BC)
Direct effect	0.027379	0.003147	0.018957 0.019417	0.036134(P) 0.036739(BC)

NOTE: (P) indicate percentile confidence interval, and (BC) indicate bias-corrected confidence interval; bootstrap = 1000

resources to improving their ESG performance, such as investing in eco-friendly technologies or community development projects. Therefore, while financial constraints may negatively influence the ESG ratings, heightened investor attention can counteract these constraints, thereby indirectly uplifting the ESG ratings.

Furthermore, RD expenditure was identified as a positive mediating effect. Investment in RD could yield a higher level of innovation and improved production processes, both of which may bolster a company's ESG performance [93]. For instance, an increase in RD expenditure may give rise to more environmentally friendly production processes or products, in turn boosting the ESG ratings. Lastly, operating revenue emerged as a positive mediating effect. High operating revenue generally signals a company's robust financial status, potentially enabling more resource allocation towards ESG-related activities, and thereby, raising the ESG ratings [51].

4.6 Moderating effect analysis

To assess the moderating effects of state ownership, digital transformation, dual leadership, and audit quality on the relationship between investor attention and the improvement of a company's ESG ratings, we employed a hierarchical regression analysis method. Specifically, we introduced interaction terms between the independent variable (investor attention) and the moderating variables into the baseline regression model. The presence of moderating effects is denoted by the significance of the interaction coefficients. A positive coefficient signifies a positive moderating effect, and conversely, a negative one indicates a negative moderating effect.

Table 11 illustrates the outcomes of testing the moderating effects of the four potential moderating variables. The results highlight that the coefficients of the interaction terms between the independent variable and the four potential moderators are significant, thus confirming the existence of moderating effects. Interestingly, the coefficient of the independent variable, investor attention, retains its significance even after the incorporation of moderating variables and interaction terms into the baseline regression model. This outcome bolsters the foundational relationship previously validated in the baseline regression model, suggesting that this relationship is not eliminated by the addition of

Table 11 Results of the moderating effect test

	(1)	(2)	(3)	(4)
	Moderator: SOE	Moderator: Dual	Moderator: Opinion	Moderator: Dt
Attention	0.0409*** (6.05)	0.0530*** (6.64)	0.0200** (2.45)	0.0466*** (6.01)
Attention*SOE	0.0156*** (9.03)			
Attention*Dual		-0.00541*** (-4.83)		
Attention*Opinion			0.0336*** (12.14)	
Attention*Dt				0.00501*** (3.97)
Constant	0.291*** (2.78)	0.225** (2.17)	0.211** (2.05)	0.228** (2.24)
Fixed Effect	YES	YES	YES	YES
N	25,832	25,832	25,832	25,832
Adjusted R ²	0.186	0.171	0.183	0.170

Notes: The standard errors for clustering at the provincial level are in parentheses. The Year, Industry and Province indicators are included in the corresponding models, but their coefficients are not in this table. Due to space constraints, this table does not display the regression coefficients and errors of the control variables. ***, **and* represent significance at 1%, 5% and 10% levels, respectively

moderating variables. Additionally, the adjusted R² of the model exhibits a significant improvement after the inclusion of the moderating variables compared to the baseline regression model (0.1680, as shown in Table 5), indicating an enhanced fit of the model. Thus, our analysis discerns the moderating effects of four potential variables - dual leadership, state ownership, digital transformation, and audit quality - on the relationship between investor attention and a company's ESG ratings.

Our findings depict a negative moderating effect when the company's Chairman simultaneously holds the position of General Manager. In such situations, the positive influence of investor attention on a company's ESG ratings is diminished. This effect could potentially be ascribed to the structural traits of dual leadership, which might restrict the efficacy and transparency of corporate governance [71]. Hence, these limitations on robust corporate governance practices may curtail the sway of investor attention on a company's ESG performance. Conversely, the remaining three variables - state ownership, digital transformation, and audit quality - exhibit a positive moderating effect. This indicates that within state-owned enterprises, highly digitized companies, and firms with high audit quality, the positive influence of investor attention on a company's ESG ratings is intensified. For state-owned enterprises, the attention they garner from the public and government might compel them to prioritize improving their ESG performance [83]. This societal and political pressure may augment the positive impact of investor attention on ESG ratings. In highly digitized firms, they likely possess superior capabilities in information disclosure and data management. Consequently, these firms may offer investors increased transparency and accessibility, thereby fortifying the influence of investor attention on ESG performance. Finally, high audit quality, suggestive of the reliability and accuracy of information, is another context that may amplify the positive impact of investor attention on ESG ratings [65]. Dependable audit information can enhance investor trust, thereby boosting their engagement and influencing a company's ESG practices. This corroborates the analysis we presented in Sect. 2, thereby validating hypothesis 3(a) – 3(d).

5 Conclusion

The primary objective of this study is to elucidate the influence of investor attention on the ESG ratings of companies listed on China's A-share market and its mechanism of influence. Through constructing a two-way fixed-effect model and a series of testing methods for mediation and moderation effects, this research found a significant positive correlation between external investor attention and a company's ESG rating [30, 32, 94, 95]. This indicates that increased investor attention encourages companies to enhance their ESG performance. Furthermore, investor attention can positively influence a company's ESG performance by reducing financing constraints, increasing R&D expenditure, and fostering customer relations [46]. Moreover, factors like the ownership structure of the company (whether it's state-owned), the state of the company's digital transformation, whether the chairman also serves as the CEO [96], and the quality of company audits can all modify the effect of investor attention on ESG ratings [97]. This research examines the impact of investor attention on corporate ESG ratings from a behavioral finance perspective, offering a fresh perspective and theoretical framework for the ESG research domain. Additionally, the conclusions provide new evidence for the relationship between investor attention and corporate ESG ratings, deepening the understanding of how companies respond to external pressures to enhance their ESG performance. By examining mediation variables like financing constraints, R&D expenditure, and customer relationships, as well as moderation variables like company ownership structure and digital transformation status, this research depicts a more intricate and comprehensive framework for understanding how investor attention impacts corporate ESG ratings.

Simultaneously, our findings offer crucial insights and practical implications for stakeholders like investors, companies, and policymakers. For investors, they should focus on firms with high ESG scores and significant investor attention. Understanding a company's financial constraints, research expenditure, customer relations, and corporate governance can help investors evaluate investment targets more comprehensively. Or they might prioritize features proven to be positively correlated with high ESG scores in this research, such as being state-owned, high audit quality, advanced digitization, and where the chairman also acts as the CEO. Given the strong positive correlation between investor attention and ESG scores, listed companies should actively boost investor awareness and attention [98]. This can be achieved through transparent information disclosure, proactive shareholder communication, and robust brand building and maintenance. For policymakers, the findings can assist them in understanding and optimizing market regulations related to ESG and guiding better corporate ESG practices. Notably, these findings align with the recently proposed sustainability disclosure guidelines jointly released in February 2024 by the Shanghai Stock Exchange, Shenzhen Stock Exchange, and Beijing Stock Exchange. These guidelines encourage A-share listed companies to publish sustainability or ESG reports and provide a detailed framework for disclosure. By promoting standardization and improving the quality of ESG information disclosure, the guidelines are expected to play a pivotal role in advancing ESG practices among Chinese companies. As financial constraints play a negative mediating role between investor attention and ESG scores, companies should actively optimize their capital operation's financing structure to reduce financing costs and risks [83]. R&D expenditure has a positive mediating role in the relationship, so companies should increase R&D investments

to enhance product and service quality and foster technological innovation. Moreover, state-owned firms, those with high audit quality, high digital maturity, and where the chairman also functions as the CEO, show more pronounced relations between investor attention and ESG scores. Therefore, listed firms should continually optimize corporate governance, such as enhancing audit quality, promoting digital transformation, and judiciously arranging the dual roles of chairman and CEO.

Moreover, the Chinese government can facilitate better implementation of ESG practices by improving the policy framework. Specifically, the government should strengthen mandatory ESG disclosure requirements and provide clear regulatory guidelines to ensure the authenticity and completeness of corporate disclosures [99, 100]. Additionally, the government can incentivize companies to enhance their ESG performance through tax incentives and financial subsidies, particularly in areas such as carbon reduction and technological innovation [101]. Furthermore, establishing national or industry-level ESG rating and evaluation systems would enable more comprehensive monitoring and assessment of corporate ESG performance [102]. By enhancing education and awareness campaigns, the government can also raise public understanding of the importance of ESG, further encouraging companies to proactively improve their ESG standards in competitive environments and fostering a sustainable economic landscape.

Policymakers and corporate managers can draw on this study's findings to enhance ESG performance in more structured ways. First, regulatory bodies such as the CSRC (China Securities Regulatory Commission) or local exchanges could consider mandating standardized ESG disclosure frameworks aligned with international practices (e.g., GRI Standards or SASB guidelines), particularly for high-impact sectors. These disclosures should be subject to third-party verification to ensure transparency and credibility. In addition, authorities should strengthen enforcement mechanisms—such as periodic ESG audits, random inspections, and penalties for misreporting—to reinforce compliance. Second, companies should integrate ESG factors into corporate governance systems by embedding them into executive performance evaluations, risk management protocols, and internal audit processes. Special attention should be given to mitigating financial constraints and strengthening capabilities in R&D, customer engagement, and board oversight [65]. Third, auditors should enhance the audit scope to include ESG data, not only validating its authenticity but also offering feedback to firms on improving ESG performance. Regular ESG briefings between auditors and corporate boards could institutionalize this process. These targeted measures will collectively help foster a more robust ESG reporting environment and promote long-term corporate sustainability.

This study has several limitations that open avenues for future research. First, although we explore key mechanisms through which investor attention affects corporate ESG performance, the relationship is likely to involve more complex mediating and moderating variables than those captured in our current framework. Future studies could investigate additional factors—such as managerial incentives, stakeholder engagement, or industry-specific ESG dynamics—to offer a more nuanced understanding of how investor attention shapes ESG outcomes. Second, our sample is limited to A-share main-board listed firms in Shanghai and Shenzhen. While this focus ensures consistency and data availability, it may restrict the generalizability of the findings. Future research could expand the scope to include firms listed on other boards (e.g., ChiNext, STAR Market), cross-listed companies, or even international samples. Subgroup analyses based

on ownership structure, industry classification, or regional development level could also reveal important heterogeneity effects. Third, the measurement of investor attention presents inherent methodological challenges. This study uses Baidu search volume as a proxy, which—though commonly adopted in the literature—reflects only one dimension of investor behavior. It may not fully capture the multifaceted and dynamic nature of attention, especially in the context of digital and social media environments. To enhance measurement precision, future studies could incorporate more diverse data sources, such as social media sentiment analysis (e.g., Weibo or Twitter), analyst recommendations, and financial news coverage, to construct more comprehensive and robust attention indicators. Enhancing both the measurement of key variables and the scope of empirical analysis will strengthen the explanatory power, robustness, and external validity of subsequent research.

Supplementary Information

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Supplementary Material 1.

Author contributions

Tiantian Meng wrote the manuscript text and the rest of three authors reviewed the manuscript.

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Data is provided within the manuscript or supplementary information files.

Declarations

Ethics approval and consent to participate

This study did not involve any human participants or animals. Therefore, ethical approval was not required. Not applicable. This study did not involve human subjects requiring consent.

Consent for publication

Not applicable. This manuscript does not contain any individual person's data in any form (including individual details, images, or videos).

Competing interests

The authors declare no competing interests.

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