



The impact of corporate environmental information disclosure on stock price crash risk——based on the perspectives of institutional investors and financing constraints

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Abstract

Exploring the influence of corporate environmental information disclosure on stock price crash risk from the perspective of institutional investors and financing constraints is essential for reducing information asymmetry and mitigating stock price crash risk. This paper empirically examines a sample of non-financial A-share listed companies in China from 2012 to 2022 to determine the influence of environmental information disclosure on stock price crash risk and to determine the moderating roles of institutional investors and financing constraints via panel regression. Additionally, this study analyses heterogeneity across various industry types and ownership structures. The results show that (1) environmental information disclosure exhibits a significant negative correlation with stock price crash risk. For instance, after controlling for other covariates, the estimated effects of environmental information disclosure on the negative return skewness coefficient (*NCSKEW*) and the ratio of upwards and downwards fluctuations in returns (*DUVOL*) are -0.027 and -0.021 , respectively. Environmental information disclosure can reduce stock price crash risk through the information path and the reputation path. (2) Both an increase in institutional investor ownership and an improvement in the level of financing constraints weaken the negative relationship between environmental information disclosure and stock price crash risk. For example, for institutional investor ownership, the estimated coefficients of the interaction term $L_INST * L_EID$ on *NCSKEW* and *DUVOL* are 0.082 and 0.052 , respectively. (3) The negative influence of environmental information disclosure on stock price crash risk is more pronounced for non-heavy polluter firms and non-state-owned enterprises. On the basis of these results, relevant policy recommendations are proposed to mitigate stock price crash risk.

Keywords Environmental information disclosure · Stock price crash risk · Institutional investors · Financing constraints

1 Introduction

During recent decades, China's economy has achieved rapid growth, and urbanisation has progressed steadily. However, this growth has led to significant environmental issues, such as resource depletion, air pollution, and ecological damage, all of which pose serious challenges to sustainable economic development. With the rising awareness of environmental issues, environmental information disclosure (*EID*) has developed into a critical tool for enhancing environmental governance and advancing sustainable development (Nguyen et al., 2021; Tzouvanas et al., 2020). The Chinese government has implemented a range of environmental protection policies and regulations, mandating that companies disclose environmental information. For example, laws and regulations such as the *Environmental Protection Law* and the *Measures for environmental information disclosure* clearly specify the scope, procedures, and requirements for the disclosure of environmental information (Bu et al., 2022; Liu et al., 2021). The Chinese Securities Regulatory Commission requires listed companies to disclose environmental information in their annual reports to enhance investors' awareness of environmental risk and to improve the companies' environmental management practices (Yu et al., 2021). Against the backdrop of green and low-carbon development being a central focus and the imperative to achieve the "dual carbon" targets in the foreseeable future, enterprises are urged to proactively participate in emission reduction and ecological protection initiatives. Therefore, many companies actively disclose environmental information to demonstrate their corporate social responsibility and sustainable development capability (Morales-Raya et al., 2019). The *EID* has also attracted many investors concerned about environmental protection, thus driving up stock prices. Moreover, a growing number of investors who are concerned with environmental protection are finding that the disclosure of environmental information may affect the stock price of a company (Lobo et al., 2020; Lennox et al., 2018). For example, some enterprises drive up their share prices by strongly prioritising *EID* (Zhang et al., 2022). There are also enterprises whose share prices have remained relatively stable, even though they have been actively promoting green development and *EID* (Utomo et al., 2020). Therefore, clarifying the relationship between *EID* and the stock market plays an important role in reducing corporate management risk.

As one of the largest stock markets in the world, the Chinese stock market has consistently been a focal point of concern regarding the risk of stock price crashes (Xu et al., 2014). The Chinese stock market, with its relatively short history and high level of speculation, often experiences significant price fluctuations. The frequent occurrence of extreme tail events, such as stock price crashes, not only results in severe losses for investors but also has the potential to destabilise the entire financial system. The primary cause of stock price crash risk (*SPCR*) is internal information asymmetry within companies. Driven by self-interest, management often deliberately conceals negative information about the company. When this negative information accumulates and is eventually released to the external market, it can lead to a sharp decline in the company's stock price in a short period, ultimately resulting in a crash (Habib et al., 2018). Research has indicated that information asymmetry and the hiding of adverse news by executives are factors that contribute to *SPCR* (Jin & Myers, 2006; Hutton et al., 2009).

In recent years, the Chinese stock market has experienced multiple stock price crash events. For instance, in May 2017, Huishan Dairy's stock price plummeted from a peak

of over \$0.384 to less than \$0.0512, a decline exceeding 85%. This sharp decline caused Huishan Dairy's market value to plummet, eventually leading to its delisting from the Hong Kong Stock Exchange and its path towards bankruptcy and liquidation. On 19 July 2021, the stock of Jiudian Pharmaceuticals opened with a decrease of 6.98% and rapidly declined, ultimately dropping by 23.51%, experiencing a 30% crash within two days. Of particular interest is the fact that the share prices of several companies' who experienced collapses have been closely linked to environmental information. For example, in October 2018, Luoyang Molybdenum was penalised by regulators for environmental issues, triggering a sharp fall in its share price, with a cumulative fall of more than 20% in half a month. Similarly, in November 2019, Fengle Seed Industry Co. was exposed by the media for environmental violations, sparking concerns among investors about its environmental compliance. This resulted in a significant drop in its stock price, with a cumulative decline exceeding 15%. In September 2020, Aluminium China was penalised by the Ministry of Ecology and Environment for failing to implement some of its environmental impact assessment requirements and highlighting environmental risks, causing its stock price to decline for eight consecutive days. The active disclosure of environmental information is highly important for alleviating information asymmetry and reducing corporate reputation loss. Research on the relationship between *EID* and *SPCR* is still relatively scarce. Zhang et al. (2022) reported that *EID* can affect *SPCR* through operational transparency, investor response and information authenticity. However, there is a lack of research on the moderating effects of institutional investors (*INST*) and financing constraints (*FC*). Therefore, it is valuable to explore the impact of *EID* on *SPCR* from the perspectives of *INST* and *FC*.

The contributions of this paper can be summarised in the following three points. First, exploring the impact of *EID* on *SPCR* from the perspectives of *INST* and *FC* not only complements the research regarding the economic consequences of *EID* but also increases our understanding of the factors influencing *SPCR*. Second, exploring the heterogeneity of *EID* effect on *SPCR* on the basis of different industry types and property rights types can help companies accurately identify the critical factors affecting *SPCR* and reduce corporate *SPCR*. Finally, relevant policy recommendations to facilitate corporate sustainable development and capital market stability are proposed.

The remaining sections of this paper are as follows. The literature review is presented in Sect. 2; Sect. 3 formulates the research hypotheses; Sect. 4 details the research design; The empirical analysis is provided in Sect. 5; and the Sect. 6 presents the conclusions and recommendations.

2 Literature review

This paper provides a literature review from three perspectives: the factors influencing *SPCR*, the relationship between *INST* and *SPCR*, and the relationship between *FC* and *SPCR*.

2.1 Factors influencing *SPCR*

A stock price crash is a phenomenon in which the price of a stock falls drastically in a very short period without warning. In this paper, *SPCR* is defined as the degree of leftward bias

in the returns of a corporation's individual shares, as evidenced by the possibility of large fluctuations in the corporation's stock price (Callen & Fang, 2013). A stock price crash will undoubtedly cause significant losses for investors and even trigger panic in the market, thus affecting the entire financial system. Similarly, a stock price crash will have a considerable effect on the operation and development of a corporation, which will seriously affect its financing ability, capital structure and business development.

Academic research on the factors affecting *SPCR* has focused primarily on two perspectives: internal factors and external factors. With respect to internal factors, studies have focused on aspects such as the quality and transparency of information disclosure, corporate governance structures, and the characteristics and behaviours of executives (Dai et al., 2019; Dang & Nguyen, 2024; Li & Zeng, 2019). Lobo et al. (2020) reported that low-quality internal controls increase the tendency of management to hide negative information for self-serving motives, thereby exacerbating the future *SPCR*. Lennox et al. (2018) reported that improper earnings management practices and financial statement adjustments lead to inadequate internal controls, which negatively impact the mitigation of *SPCR*. Ashbaugh-Skaife et al. (2006) argued that companies with poor internal control quality are more likely to receive negative evaluations from credit rating agencies, which increases their financing costs, thus leading to a greater risk of a stock price crash. From the perspective of external factors, research has focused primarily on aspects such as analysts (He et al., 2019), media coverage (An et al., 2020), and *INST* (Liao et al., 2023). With respect to analyst attention, analysts play a crucial role as information intermediaries, as their reports are essential in enhancing information transparency. For analysts, as key players in information intermediation, analyst reporting plays a crucial role in increasing information transparency and reducing information asymmetry. Kothari et al. (2009) reported that when negative information about a company emerges, the private information acquisition and reporting process reduces information asymmetry to a certain extent, which in turn reduces *SPCR* by increasing analyst coverage. However, analysts' behaviour is not always aligned with this ideal. Considering personal interests, corporate pressure, or market sentiment, the information provided by analysts is often characterized by an optimistic bias. Gleason and Lee (2003) reported that analyst forecast revisions have a greater impact on market prices in high-opacity situations. This can lead to market overreactions to company expectations, thereby exacerbating the *SPCR*. Similarly, Irani and Oesch (2016) reported that increasing analyst coverage might amplify pressure on firm managers to prioritize short-term results, prompting bad news concealment and boosting *SPCR*.

For media coverage, Da et al. (2011) reported that media coverage can attract increased market attention, leading to a higher trading volume and volatility in stocks. Negative and pessimistic media reports can cause overreactions, thereby increasing the *SPCR*. Bushee and Miller (2012) reported that the more media reports there are, the more investors are attracted and the stronger their willingness to purchase. Correspondingly, research has revealed that the lower the efficiency of IPO pricing is, the greater the likelihood of *SPCR* after a company goes public. Fan and Fu (2020) reported that *INST* in corporate governance often act as bystanders or collude with executives due to short-term profit motives. Ni et al. (2020) reported that dispersion of investor attention exacerbates *SPCR*. In terms of audit supervision, Robin and Zhang (2015) reported that high-quality auditing can improve the quality of a corporation's accounting disclosure and reduce the chances of executives covering up issues, thus reducing *SPCR*. Habib et al. (2018) reported that insufficient informa-

tion in audit reports will exacerbate *SPCR* in the future. Li et al. (2017) reported that social auditing improves the transparency of information and mitigates the risk of individual stock crashes caused by information asymmetry through independent review and attestation of company financial statements. Moreover, the external factors affecting *SPCR* include macroeconomic policies, market regulation and international relations. For example, Liu et al. (2023) argued that the implementation of a green credit policy raises the *SPCR* of polluting-intensive firms. Luo and Zhang (2020) argued that the uncertainty of economic policy affects firms' debt levels and solvency, thus increasing *SPCR*. Lowry and Schwert (2002) reported that regulatory intensity affects the flow of information in the market and investor sentiment towards the market, which in turn affects the percentage of equity in new stock issued as well as stock price movements. Li and Wang (2017) reported that the appointment of local government officials as directors and boards with political connections exacerbates the crash risk for listed state-owned enterprises.

2.2 The relationship between *INST* and *SPCR*

In recent years, research on the relationship between *INST* and *SPCR* has attracted extensive academic attention. However, no consensus has been reached. One view is that *INST* can effectively mitigate information asymmetry and act as “stabilisers” of share price volatility by virtue of their professional knowledge, information superiority, supervisory role and participation in governance (Callen & Fang, 2013). Another viewpoint is that *INST* are “enablers” of stock price volatility (An & Zhang, 2013). From this viewpoint, the herd effect, short-sighted behaviour, positive feedback trading, shareholding structure, and agency problems of *INST* are commonly identified as factors that increase *SPCR* (Hsieh, 2013; Xu et al., 2017). Combined with China's current overall market environment, *INST* holdings can also contribute to increasing *SPCR*. Despite the rapid development of *INST* in China, compared with those in developed countries, the development time is relatively short, and *INST* in China are still not familiar enough with various investment strategies and risk management. Coupled with the obvious short-term tendencies of Chinese *INST* (Jiang & Kim, 2015), it is very possible that they may collude with management and use insider trading to reap enormous short-term profits. This pursuit of short-term profits also increases the risk of a share price collapse. Additionally, accounting for factors such as the market environment, information transparency, and institutional investor heterogeneity, the correlation between institutional ownership and *SPCR* may vary. For example, Lu et al. (2024) reported that institutional ownership significantly mitigates crash risk under conditions of high effectiveness and marketisation. Ma et al. (2023) reported that economic policy uncertainty can exacerbate *SPCR* by exacerbating the short-term investment behaviour of *INST*.

2.3 The relationship between *FC* and *SPCR*

FC, as crucial aspects of corporate operations, have been a significant topic of research in corporate finance and economics. Recently, some scholars have shifted their attention to examining the connection between *FC* and *SPCR*. Li et al. (2021) reported that *FC* aggravate the overinvestment and underinvestment dilemmas faced by listed companies. Inefficient corporate investment strengthens management's self-interest, thus exacerbating *SPCR* (Xie et al., 2023). That is, when a corporation faces *FC*, it will give up some valuable invest-

ment projects due to the inability to obtain sufficient funds, and this underinvestment will lead to a decline in future earnings, thus triggering investors' questioning of the company's management and increasing the *SPCR*. Moreover, some scholars have explored the relationship between *FC* and *SPCR* from the perspective of market microstructure. Roberts and Dowling (2002) reported that the presence of *FC* affects firms' disclosure decisions in the presence of information asymmetry, which in turn affects *SPCR*. Similarly, the conclusion that *FC* promote *SPCR* is supported by the empirical results of He and Ren (2023).

Although numerous studies have explored relevant issues regarding *SPCR*, gaps still exist: (1) Although existing studies have provided a rich perspective for understanding *SPCR*, few studies have provided insights from the perspective of *EID*. (2) The moderating roles of *INST* and *FC*, which are important factors in the capital market and in the operations of firms, respectively, have not received sufficient attention in studies of the relationship between *EID* and *SPCR*. (3) Existing studies also have several limitations in terms of sample selection, as they focus only on specific industries, such as highly polluting industries or environmentally sensitive industries, and the overall research scope is often narrow. Thus, this paper selects non-financial A-share listed companies in China as the research sample, and it is of great significance to explore the impact of *EID* on *SPCR* from the dual perspectives of *INST* and *FC*. In theoretical terms, this study not only complements the research on the economic consequences of *EID* but also enriches the understanding of the determinants of *SPCR*, thereby providing new theoretical perspectives and research agendas for the academic field that bridges the two domains. In practical terms, this study helps enterprises better understand the market impact of *EID*, prompting them to prioritize environmental protection, optimize disclosure strategies, mitigate environmental risks, and enhance sustainability. Additionally, the research assists investors in making more informed investment decisions, reducing stock price volatility caused by information asymmetry, and fostering both corporate sustainability and capital market stability.

3 Research hypotheses

To explore the impact of *EID* on *SPCR*, this paper proposes the following research hypotheses from both direct and indirect perspectives.

3.1 The impact of *EID* on *SPCR*

According to stakeholder theory, *EID* is an effective mechanism for coordinating between a company itself and its stakeholders. *EID* creates a platform to demonstrate their capacity for sustainable development. By disclosing information related to environmental management, certification, and other pertinent factors, enterprises exhibit their commitment to environmental responsibility and willingness to implement proactive measures. This shows that the needs of stakeholders are fully accounted for in business operations and production, which is beneficial for earning a good corporate reputation. This positive profile will attract investors who focus on environmental factors, help expand the investor base, improve the competitiveness and attractiveness of the company, enable investors and stakeholders to more accurately assess the overall value and risks of the company, stabilise investor sentiment,

avoid panic selling among investors, and thus effectively mitigate the possibility of a share price crash. On this basis, the following Hypothesis H_1 is proposed:

H_1 : *EID* is significantly negatively related to *SPCR*.

3.2 The impact of *EID* on *SPCR* from the perspective of *INST*

Stricter environmental regulations have elevated the importance of environmental information. As global environmental problems intensify, governments are gradually implementing stricter regulations and standards for environmental protection. The stringency of these regulations requires enterprises to focus on environmental protection in their management activities (Liu et al., 2024). Against this background, the role of *INST* increasingly highlights their key role in shaping sustainable development and efficient market functioning. At present, there has been controversy in the academic community about the influence of *INST* on corporate governance and business decisions. On the one hand, *INST*, as important participants in corporate activities, have the ability to lead corporate management and market operations, and their influence should not be underestimated. On the other hand, although *INST* play a facilitating role in monitoring and constraining corporate management, they are also exposed to potential behavioural risks. Moreover, there may be more complex entanglements of interest between *INST* and listed companies. Certain institutions have deep business relationships with enterprises, which may lead them to remain silent regarding *EID* or acquiesce to management concealment and deception. These scenarios, on the other hand, significantly undermine the role of *INST* as supervisors, exacerbate *SPCR*, and undermine the fairness and transparency of the market. Therefore, Hypothesis H_2 is proposed as follows:

H_2 : An increase in institutional investor ownership weakens the negative relationship between *EID* and *SPCR*.

3.3 The relationship of *FC*, *EID* and *SPCR*

As society vigorously promotes environmental governance, the performance and responsibility of enterprises in terms of the environment are increasingly in the spotlight, and the impact of *FC* is becoming increasingly widespread. On the one hand, active *EID* by enterprises can help reduce the degree of information asymmetry and avoid benign corporate development, while *FC* are closely related to serious information asymmetry. Specifically, corporations with a high degree of *FC* tend to face greater business risk, which makes managers more inclined to conceal or delay disclosing unfavourable environmental information under financing pressures. This further exacerbating the information asymmetry between managers and investors, making it difficult for investors to obtain comprehensive and accurate information and increasing adverse selection and moral hazard issues in the capital market. In this case, once negative environmental information accumulates to a certain level and is exposed in the external market, it can trigger panic selling behaviour among investors and increase the possibility of a stock price crash. On the other hand, corporations with high *FC* intensity typically adopt more short-sighted financial strategies, prioritising the use of their limited available capital in areas that are expected to generate higher returns.

This short-sighted strategy results in a lack of sufficient investment in environmental performance, which inhibits the development of a good corporate reputation, thereby increasing the *SPCR*. Additionally, corporations with severe *FC* are prone to cash flow shortages because of difficulties in obtaining external financing, thereby increasing the risk of a break in the financial chain. This risk may cause investors to become concerned about the financial position and future prospects of the company, thereby decreasing their confidence in the enterprise. This decrease in confidence will lead investors to reduce their investment in the enterprise or sell their stocks. When many investors choose to sell their stocks, the share price of the corporation may crash. Therefore, Hypothesis H_3 is proposed as follows:

H_3 : An increase in the degree of *FC* weakens the negative relationship between *EID* and *SPCR*.

4 Research design

This paper provides a research design from three perspectives: sample selection and data sources, variable definition, modelling design. The specific process is shown in Fig. 1.

4.1 Sample selection and data sources

In this paper, Chinese non-financial A-share listed corporations from 2012 to 2022 are selected as the research sample. The *EID* data are from listed companies' annual reports, social responsibility reports and environmental reports. The remaining data are derived from the China Stock Market Accounting Research (CSMAR) database. To guarantee data reliability, the sample was processed as follows: (1) financial companies are excluded; (2) ST (ST stands for "Special Treatment") and *ST (*ST represents "Delisting Risk Warn-

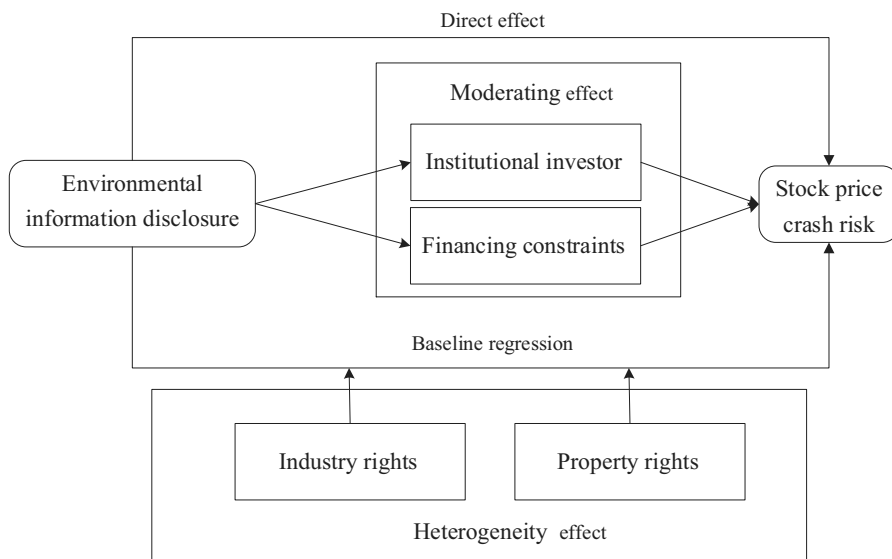


Fig. 1 Research design of this study

ing”) listed companies are excluded; (3) listed companies with fewer than 30 annual trading weeks are excluded; (4) samples with large quantities of missing data are excluded; (5) the corresponding data are treated with a lag of one period; and (6) the continuous variables are reduced-tailed at the 1% and 99% quantiles. Ultimately, the sample included 2,881 listed companies with a total of 15,381 observations.

4.2 Variable definition

This paper presents the measurement of *SPCR*, *EID*, institutional investor, *FC* and control variables.

4.2.1 The measure of *SPCR*

Drawing on the study of Chen et al. (2001), the negative return skewness coefficient (*NCSKEW*) and the ratio of upwards and downwards fluctuations in returns (*DUVOL*) are selected to measure *SPCR*. The detailed calculation procedure is as follows:

First, weekly specific returns on stock i are regressed for each year by using the composite market weekly returns. The estimated model is

$$\gamma_{i,t} = \beta_0 + \beta_1\gamma_{m,t-2} + \beta_2\gamma_{m,t-1} + \beta_3\gamma_{m,t} + \beta_4\gamma_{m,t+1} + \beta_5\gamma_{m,t+2} + \varepsilon_{i,t} \quad (1)$$

where $\gamma_{i,t}$ denotes the return of stock i in week t , $\gamma_{m,t}$ denotes the weighted average return of the market capitalisation of the stock market outstanding in week t , and $\varepsilon_{i,t}$ denotes the residual term.

Second, the *NCSKEW* is calculated.

$$NCSKEW_{i,t} = -\frac{\left[n(n-1)^{\frac{3}{2}} \sum W_{i,t}^3\right]}{(n-1)(n-2)(\sum W_{i,t}^2)^{\frac{3}{2}}} \quad (2)$$

where $W_{i,t} = \ln(1 + \varepsilon_{i,t})$ is the characteristic return of stock i in week t .

Finally, the *DUVOL* is calculated:

$$DUVOL_{i,t} = \ln \left\{ \frac{\left[(n_u - 1) \sum_{DOWN} W_{i,t}^2\right]}{\left[(n_d - 1) \sum_{UP} W_{i,t}^2\right]} \right\} \quad (3)$$

where n_u and n_d denote the number of weeks in which the week-specific return $W_{i,t}$ for stock i is above (below) the average annual weekly return, respectively.

4.2.2 The measure of *EID*

The *EID* is quantified via content based evaluation with reference to Clarkson et al. (2008) and Meng et al. (2013). This method involves analysing various publicly disclosed reports to determine the score for each specific item, and then calculating the overall evaluation.

The specific calculation process is as follows: First, based on the measures for *EID*, the environmental information disclosed by companies is divided into five categories: the *EID* vehicle, environmental management, environmental liabilities, environmental performance and governance, and environmental regulation and certification. These five categories are further divided into 30 secondary indicators (see Table 8 in the Appendix). Second, each company's secondary indicators are scored and summed to obtain the *EID* score. Finally, the *EID* score of a single sample company is logarithmically processed to obtain the *EID* index.

4.2.3 Moderating variables

To explore the impact of *EID* on *SPCR*, we choose *INST* and *FC* as the moderating variables. For *INST*, the approach of Bushe et al. (2014) is applied, and institutional shareholding is selected as a proxy variable for this indicator, which is measured as the total number of shares held by *INST* divided by the outstanding share capital. With respect to *FC*, a *FC* index is used to measure the degree of corporate *FC* on the basis of the approach introduced by Fee et al. (2009). The calculation process is as follows. (1) Standardise the three indicators of enterprise size, listing time and cash dividend payment rate, and determine the financing constraint dummy variable *QUFC* by calculating the mean value of the variables obtained after the standardisation process for three quartiles; the degree of financing constraint for enterprises with a mean value that is higher than the 1/3 quartile is low (*QUFC*=0), and the degree of financing constraint for enterprises with a mean value that is lower than the 1/3 quartile is high (*QUFC*=1). (2) Implement logit regression according to Model (5) to fit the *FC* (value 0~1) for each year; the larger the value of *FC* is, the higher the degree of *FC* of the enterprise. In Model (5), *size* denotes the enterprise size, *lev* denotes the gearing ratio, *cashdiv* denotes the cash dividend declared in the year, *ta* is total assets, *MB* is the market-to-book ratio, *NWC* is the net working capital, and *EBIT* is the profit before interest and tax.

$$P(QUFC = 1|Z_{i,t}) = \frac{e^{Z_{i,t}}}{1 + e^{Z_{i,t}}} \quad (4)$$

$$\begin{aligned} Z_{i,t} = & \alpha_0 + \alpha_1 size_{i,t} + \alpha_2 lev_{i,t} + \alpha_3 \left(\frac{CashDiv}{ta} \right)_{i,t} + \alpha_4 MB_{i,t} \\ & + \alpha_5 \left(\frac{NWC}{ta} \right)_{i,t} + \alpha_6 \left(\frac{EBIT}{ta} \right)_{i,t} \end{aligned} \quad (5)$$

4.2.4 Control variables

In terms of control variables, financial risk, profitability, operating ability and equity structure indicators are selected in this study with reference to the studies of Kim et al. (2011), Ball et al. (2015), and Zhang and Li (2022). Moreover, the negative earnings skewness coefficient (*L_NCSKEW*) and the earnings fluctuation ratio (*L_DUVOL*) in the lagged period are controlled to eliminate their effects on the *SPCR* in the current period. Additionally, controls are implemented for year and industry dummy variables.

4.3 Modelling design

(1) The impact of *EID* on *SPCR*.

To explore the impact of *EID* on *SPCR*, we construct the following model with reference to Zhang et al. (2022):

$$Crash_{i,t+1} = \beta_0 + \beta_1 EID_{i,t} + \sum \beta_2 Control_{i,t} + \sum Ind + \sum Year + \varepsilon_{i,t} \quad (6)$$

where $Crash_{i,t+1}$ is the *SPCR* in year $t + 1$, measured by *NCSKEW* and *DUVOL*, respectively; $EID_{i,t}$ is the *EID* variable in year t ; and $Control_{i,t}$ is the control variables. For the sign of the coefficient β_1 of $EID_{i,t}$ in Eq. (6) and its significance, if $\beta_1 < 0$ and is significant, it means that *EID* exhibits a significant negative correlation with *SPCR*.

(2) Modelling the moderating effects of *INST*.

To test Hypothesis H_2 , the proportion of *INST* shareholding, the interaction term between the proportion of institutional investor shareholding and the explanatory variables ($INST \cdot EID$), is added to Model (6), which is then rewritten as follows:

$$Crash_{i,t+1} = \beta_0 + \beta_1 EID_{i,t} + \sum \beta_2 INST_{i,t} + \sum \beta_3 INST_{i,t} \cdot EID_{i,t} + \sum \beta_i Control_{i,t} + \sum Ind + \sum Year + \varepsilon_{i,t} \quad (7)$$

(3) Modelling the moderating effects of *FC*.

To test Hypothesis H_3 , the degree of *FC* (*FC*) and the interaction term between the degree of *FC* and *EID* ($FC \cdot EID$) is added to Model (6); then, Model (6) is rewritten as follows:

$$Crash_{i,t+1} = \beta_0 + \beta_1 EID_{i,t} + \sum \beta_2 FC_{i,t} + \sum \beta_3 FC_{i,t} \cdot EID_{i,t} + \sum \beta_i Control_{i,t} + \sum Ind + \sum Year + \varepsilon_{i,t} \quad (8)$$

5 Empirical analysis

To conduct a comprehensive empirical analysis, this paper discusses the topic from the following multiple aspects.

5.1 Descriptive statistics

Table 9 in the Appendix shows that the mean values of *NCSKEW* and *DUVOL* are negative, which is consistent with the results of existing studies (Li et al., 2017; Sun et al., 2017). The standard deviations of *NCSKEW* and *DUVOL* are 0.717 and 0.472, respectively, indicating high volatility. The minimum and maximum values of L_EID after logarithmic processing are 0 and 3.367, respectively, and the standard deviation is 0.955, which indicates that

EID level of different listed companies is heterogeneous. The mean value of *EID* score is 1.612, indicating that the overall level of *EID* has remained low over the past decade, with substantial room for improvement to reach the desired disclosure level. The results for the remaining variables are reasonable and consistent with the fundamental characteristics of China's listed companies.

Table 10 in the Appendix shows the descriptive statistics for *EID* in different industries, with details including the *EID* scores and mean values of each industry. The mining industry has the largest *L_EID* mean value (2.200). The average *L_EID* value for the mining sector is 1.746, and the average *L_EID* value for the electricity, heat, gas and water production and supply industry is 1.890. The mean value of *L_EID* for only these three industries is greater than the mean *EID* value for the total sample (1.612). This finding indicates that *EID* is most common in the manufacturing, mining and fabrication industries in China. This finding can be explained by the fact that heavy polluters typically face greater environmental risks and pollution issues (Lin et al., 2021). Therefore, the state has imposed stricter requirements for these companies to disclose environmental information. These requirements have encouraged heavy polluters to be more proactive in their environmental disclosures. Additionally, we observe significant differences in *EID* among various industries, with the overall disclosure level being lower than that of heavily polluting industries.

Table 11 in the Appendix displays the correlation coefficients between the variables. We found the correlation coefficient between *L_EID* and *NCSKEW* is -0.033 , and the correlation coefficient between *L_EID* and *DUVOL* is -0.043 , both of which are significant at the 1% level. These findings suggest that the *EID* in the previous year (*L_EID*) is significantly negatively correlated with the current year's *SPCR*, which is consistent with intuition. This result provides partial support for Hypothesis H_1 . Additionally, the variance inflation factor (*VIF*) of each variable is below 10, suggesting no multicollinearity exists among the variables.

5.2 The effect of *EID* on *SPCR*

Table 1 presents the results of benchmark regression regarding the influence of *EID* on *SPCR*. The results show that the effects of *L_EID* on *NCSKEW* and *DUVOL* are significantly negative with or without the inclusion of the control variables—i.e., *EID* significantly reduces *SPCR*. This finding is consistent with the existing studies and provides support for Hypothesis H_1 (Lee et al., 2024). This finding may be because, from the viewpoint of the information path, active *EID* by listed firms can reduce the degree of information asymmetry of the firms and reduce the possibility of management concealing negative information, thus effectively mitigating *SPCR*. On the other hand, from the perspective of corporate reputation, the public disclosure of environmental information by a company can demonstrate its commitment to environmental responsibility and positive action, enhance corporate reputation and stabilise investor sentiment, thus effectively reducing *SPCR*.

In terms of control variables, *L_NCSKEW* and *L_DUVOL* are significantly positively correlated with the *NCSKEW* of the stock in the next period and the ratio of return volatility, respectively. The rate of total return on assets (*L_Roa*) is significantly positively related to *SPCR*, which is consistent with the findings of Wang et al. (2021). High returns are often accompanied by high risks. *Roa* is an important financial indicator of corporate profitability.

Table 1 The benchmark regression results

	(1) NCSKEW	(2) DUVOL	(3) NCSKEW	(4) DUVOL
<i>L_EID</i>	-0.031*** (-4.64)	-0.025*** (-5.75)	-0.027*** (-4.01)	-0.021*** (-4.75)
<i>L_NCSKEW</i>			0.049*** (3.02)	0.027** (2.46)
<i>L_DUVOL</i>			-0.001 (-0.04)	0.009 (0.56)
<i>L_Lev</i>			-0.118*** (4.36)	-0.124*** (3.16)
<i>L_Roa</i>			0.642*** (5.42)	0.320*** (4.12)
<i>L_Growth</i>			0.024 (1.51)	0.008 (0.75)
<i>L_Top1</i>			-0.099** (-2.50)	-0.062** (-2.39)
_cons	-0.381*** (-7.18)	-0.234*** (-6.74)	-0.310*** (-5.52)	-0.168*** (-4.57)
YEAR	YES	YES	YES	YES
IND	YES	YES	YES	YES
N	15,381	15,381	15,381	15,381
R ²	0.030	0.035	0.037	0.042
F	17.22	20.17	17.68	20.23

A high return on assets means that the company will attract more investor attention, but when investors rely on financial indicators and ignore nonfinancial disclosure, they overestimate the company's share price, thus increasing *SPCR*. The gearing ratio (*L_Lev*) is significantly negatively related to *SPCR*. This finding aligns with the results reported by Kim et al. (2011). Corporations with high debt levels are usually heavily regulated. In such cases, management's self-interested motivation to hide negative news is reduced, disclosure practices are transparent, and the *SPCR* is low. The coefficient between the growth rate of operating income (*L_Growth*) and *SPCR* is positive but not significant. *L_Top1* is significantly negatively correlated with *SPCR*, which is consistent with the findings of Park and Song (2018). That is, as the *L_Top1* increases, large shareholders actively play a monitoring role to safeguard their own interests and reduce the self-interested behaviour of management, thereby reducing *SPCR*.

5.3 Moderating effect of *INST*

Table 2 presents the regression results of the impact of *EID* on *SPCR* after the inclusion of *INST* as a moderator. Columns (1) and (2) report the results for the effect of *L_EID* and the interaction term $L_INST \cdot L_EID$ on *NCSKEW* and *DOUVOL* without the control variables. Columns (3) and (4) report the regression results of *L_EID* and the interaction term $L_INST \cdot L_EID$ on *NCSKEW* and *DOUVOL*, including control variables.

The coefficient of *L_EID* is significantly negative regardless of the inclusion of the control variables, thus providing further support for Hypothesis H₁. The regression coefficients for $L_INST \cdot L_EID$ are positive, and the estimated coefficients for $L_INST \cdot L_EID$ have the opposite sign as the estimated coefficients for *L_EID*. This finding suggests that

Table 2 Moderating effect results for *INST*

	(1)	(2)	(3)	(4)
	<i>NCSKEW</i>	<i>DUVOL</i>	<i>NCSKEW</i>	<i>DUVOL</i>
<i>L_INST L_EID</i>	0.075*** (2.74)	0.049*** (2.78)	0.082*** (3.01)	0.052*** (2.95)
<i>L_EID</i>	-0.050*** (-3.62)	-0.033*** (-3.75)	-0.052*** (-3.81)	-0.033*** (-3.78)
<i>L_INST</i>	-0.000 (-0.01)	0.006 (0.17)	-0.008 (-0.16)	0.003 (0.10)
<i>L_NCSKEW</i>			0.076*** (4.53)	0.041*** (3.78)
<i>L_DUVOL</i>			-0.045* (-1.76)	-0.021 (-1.26)
<i>L_Lev</i>			-0.040 (-1.09)	-0.060** (-2.53)
<i>L_Roa</i>			1.117*** (9.10)	0.703*** (8.89)
<i>L_Growth</i>			0.027* (1.65)	0.009 (0.85)
<i>L_Top1</i>			-0.147*** (-3.34)	-0.079*** (-2.79)
_cons	-0.502*** (-8.64)	-0.361*** (-9.66)	-0.453*** (-7.47)	-0.323*** (-8.27)
YEAR&IND	YES	YES	YES	YES
N	15,381	15,381	15,381	15,381
R ²	0.036	0.043	0.047	0.053
F	19.49	23.36	21.36	24.46

INST attenuate the negative impact of *EID* on *SPCR*, thus supporting Hypothesis H₂. This effect may be due to imperfections in the regulatory system of China's capital market. *INST* tend to focus on short-term investment returns while ignoring the long-term development of enterprises. When *INST* hold many shares, there is a tendency for them to collude with the management of the company. Furthermore, the increase in their shareholding may inhibit "effective monitoring" and fail to curb the incentives for management to hide bad news. To a certain extent, this mechanism limits the effect of improving the quality of *EID* and increases *SPCR*.

5.4 Moderating effects of *FC*

Table 3 presents the regression results of the effect of *EID* on *SPCR* after the inclusion of *FC* as moderators. The results of the effects of *L_EID* and the interaction term *L_FC L_EID* on *NCSKEW* and *DOUVOL* without control variables are reported in Columns (1) and (2). Columns (3) and (4) report the regression results of the effects of *L_EID* and the interaction term *L_FC L_EID* on *NCSKEW* and *DOUVOL* with control variables. The results show that the *L_EID* coefficient is significantly negative at both the 5% and 1% significance levels regardless of the inclusion of the control variables, thus providing further support for Hypothesis H₁. The regression coefficients of *L_FC L_EID* are significantly positive at the 5% and 1% levels, and the estimated coefficients of *L_FC L_EID* have the opposite sign as the estimated coefficients of *L_EID*. This finding indicates that *FC* attenuate the negative

Table 3 The moderating effects of *FC*

	(1) NCSKEW	(2) DUVOL	(3) NCSKEW	(4) DUVOL
<i>L_FC L_EID</i>	0.046** (2.04)	0.041*** (2.78)	0.050** (2.19)	0.042*** (2.79)
<i>L_EID</i>	-0.029** (-2.54)	-0.022*** (-2.93)	-0.034*** (-2.97)	-0.024*** (-3.18)
<i>L_FC</i>	-0.097** (-2.24)	-0.060** (-2.12)	-0.118** (-2.42)	-0.056* (-1.73)
<i>L_NCSKEW</i>			0.033** (2.00)	0.017 (1.58)
<i>L_DUVOL</i>			0.046* (1.84)	0.042** (2.56)
<i>L_Lev</i>			0.029 (0.63)	0.048 (1.59)
<i>L_Roa</i>			0.724*** (6.05)	0.407*** (5.14)
<i>L_Growth</i>			-0.001 (-0.04)	-0.011 (-1.06)
<i>L_Top1</i>			-0.058 (-1.45)	-0.031 (-1.15)
_cons	-0.408*** (-7.01)	-0.280*** (-7.27)	-0.384*** (-5.69)	-0.284*** (-6.37)
YEAR&IND	YES	YES	YES	YES
N	15,381	15,381	15,381	15,381
R ²	0.027	0.031	0.033	0.037
F	14.83	16.87	15.27	16.83

effect of *EID* on *SPCR*, thus supporting Hypothesis H₃. This may be because firms with a high degree of *FC* are riskier to operate, and managers are more inclined to hide or delay the disclosure of negative news on the basis of financing pressure. Moreover, a high degree of *FC* is associated with a high degree of information asymmetry, especially when hidden negative news suddenly comes to light, which undoubtedly increases *SPCR*. Additionally, firms with high levels of *FC* are unable to achieve full disclosure due to a lack of sufficient resources. In particular, the lack of adequate inputs regarding environmental performance limits the market's understanding of the actual state of the enterprise. Hence, *FC* actually act as a barrier between *EID* and *SPCR*, making it difficult for firms to win investors' trust through positive environmental performance, thereby increasing *SPCR*.

5.5 Heterogeneity analysis

To explore the level of heterogeneity with respect to the effect of *EID* on *SPCR*, we analyse heterogeneity across the following two dimensions: industry and property rights.

5.5.1 Heterogeneity results for industry rights

With respect to the analysis of industry heterogeneity, this paper focuses on dividing the sample into two groups, namely, heavy polluters and nonheavy polluters. Heavy polluters are defined on the basis of the definition provided by Zhang et al. (2022). Table 4 presents

Table 4 Group regression results of industry heterogeneity

	(1) Heavy polluters		(2) Non-heavy polluters	
	<i>NCSKEW</i>	<i>DUVOL</i>	<i>NCSKEW</i>	<i>DUVOL</i>
<i>L_EID</i>	-0.017 (-1.25)	-0.013 (-1.43)	-0.029*** (-3.66)	-0.023*** (-4.36)
<i>L_NCSKEW</i>	0.046 (1.36)	0.016 (0.73)	0.052*** (2.75)	0.031** (2.49)
<i>L_DUVOL</i>	0.000 (0.00)	0.013 (0.38)	-0.000 (-0.01)	0.008 (0.45)
<i>L_Lev</i>	-0.105 (-1.46)	-0.090* (-1.87)	-0.120*** (-2.94)	-0.135*** (-5.04)
<i>L_Roa</i>	0.635** (2.44)	0.361** (2.08)	0.676*** (5.03)	0.337*** (3.84)
<i>L_Growth</i>	0.082** (2.44)	0.048** (2.15)	0.005 (0.27)	-0.005 (-0.44)
<i>L_Top1</i>	0.007 (0.09)	-0.018 (-0.34)	-0.136*** (-2.91)	-0.076** (-2.51)
_cons	-0.354*** (-4.94)	-0.219*** (-4.58)	-0.312*** (-5.34)	-0.167*** (-4.39)
YEAR	YES	YES	YES	YES
IND	YES	YES	YES	YES
N	3724	3724	11,657	11,657
R ²	0.038	0.043	0.038	0.043
F	8.34	9.26	14.05	16.13

the regression results for the heavy polluters and nonheavy polluters. The findings demonstrate that the regression coefficients of *L_EID* for the heavy polluters are all negative, a finding that is consistent with those of Zhang et al. (2022). This result suggests that *EID* among heavy polluters has a dampening effect on *SPCR*. However, the results are not significant. The reason for the lack of significance may be the differences in the Chinese government's policy on *EID* between heavy and nonheavy polluters. In general, heavy polluters are usually involved in energy, chemical, iron and steel, and other high-pollution emission fields. Enterprises in these fields usually face more environmental risks and pollution problems than do other enterprises, and the Chinese government has adopted mandatory *EID* requirements for these heavy polluters. Even if high-polluting firms disclose environmental information, their environmental risk may still be limited in terms of investors' perceptions; thus, the dampening effect on *SPCR* is not significant. The regression coefficients of *L_EID* for non-heavy polluter firms are significantly negative, indicating that the *EID* by non-heavy polluters has a significant inhibitory effect on *SPCR*, a result that is consistent with Xu et al. (2021). This phenomenon may be attributed to the greater autonomy in *EID* afforded to non-heavy polluters, coupled with their reduced exposure to regulatory and disclosure requirements. Given that *EID* is not mandatory for these companies, they are more likely to voluntarily disclose such information to project a positive corporate image and bolster investor confidence. This voluntary disclosure, in turn, significantly mitigates *SPCR*.

5.5.2 Heterogeneous results for property rights

To investigate the impact of *EID* on *SPCR* among firms with varying property rights, it is essential to divide the sample into categories. Given the disparities in business objectives, environmental performance, and stock price performance among firms, the classification approach of Ruggiero et al. (2022) is adopted; the sample is divided into state-owned enterprises (SOE=1) and non-state-owned enterprises (SOE=0) on the basis of the nature of their beneficial controller.

Table 5 presents the results of group regression analyses of the effect of *EID* on *SPCR* across different types of property rights. The findings indicate that the coefficient estimates of *L_EID* for state-owned enterprises are all negative and nonsignificant, suggesting that enhanced *EID* by state-owned firms does not mitigate their *SPCR*. Conversely, the coefficient estimate of *L_EID* for non-state-owned enterprises are all negative, indicating that increased *EID* by non-state-owned firms is associated with a reduction in their *SPCR*. This discrepancy may be attributed to the divergent economic motivations underlying the *EID* practices of state-owned enterprises (SOEs) and non-state-owned enterprises (non-SOEs), which can be encapsulated in two primary dimensions. On the one hand, the principal objective of non-SOEs is to maximise economic gains, whereas SOEs are tasked with fulfilling a

Table 5 Heterogeneity analysis results for the property rights groupings

	(1) state-owned business		(2) Non-state-owned enterprise	
	<i>NCSKEW</i>	<i>DUVOL</i>	<i>NCSKEW</i>	<i>DUVOL</i>
<i>L_EID</i>	−0.011 (−1.05)	−0.010 (−1.46)	−0.023*** (−2.58)	−0.019*** (−3.18)
<i>L_NCSKEW</i>	0.045* (1.72)	0.025 (1.47)	0.047** (2.24)	0.024* (1.75)
<i>L_DUVOL</i>	0.005 (0.12)	0.008 (0.29)	−0.000 (−0.01)	0.014 (0.65)
<i>L_Lev</i>	0.048 (0.83)	−0.002 (−0.04)	−0.098** (−2.10)	−0.114*** (−3.74)
<i>L_Roa</i>	0.947*** (4.26)	0.454*** (3.15)	0.539*** (3.84)	0.281*** (3.04)
<i>L_Growth</i>	0.030 (1.14)	0.004 (0.22)	0.010 (0.52)	0.003 (0.25)
<i>L_Top1</i>	−0.072 (−1.14)	−0.023 (−0.55)	−0.058 (−1.08)	−0.052 (−1.47)
_cons	−0.474*** (−5.53)	−0.307*** (−5.52)	−0.282*** (−3.74)	−0.132*** (−2.65)
YEAR	YES	YES	YES	YES
IND	YES	YES	YES	YES
N	6084	6084	9297	9297
R ²	0.042	0.048	0.034	0.044
F	9.12	10.24	10.25	13.36

broader range of administrative responsibilities in addition to pursuing economic benefits. On the basis of economic objectives such as macroeconomic stability, industrial development, and social stability, SOEs primarily disclose environmental information in response to governmental mandates rather than economic incentives. Conversely, non-SOEs place greater emphasis on market response and public image in their operations. Consequently, non-SOEs are more inclined to exhibit a commitment to social responsibility and environmental protection through the *EID*, thereby enhancing their reputation. On the other hand, non-SOEs are also at a disadvantage relative to SOEs in terms of access to resources and financing. Since SOEs have government support and guarantees, it is relatively easy for them to obtain resources and financing. However, non-SOEs need to raise funds through market means, and the *EID* is a way of indicating their dedication to sustainable development to the outside world, thereby attracting more investors and funds. Therefore, non-SOEs have stronger incentives to increase their degree of *EID*, and the effect of mitigating *SPCR* is more obvious.

5.6 Discussion of results

The economic significance of *EID* reducing the *SPCR* is mainly reflected in the following: on the one hand, strengthening *EID* can not only further reduce the asymmetry of corporate information, but also enhance the confidence of investors, thus reducing the financial risk and bankruptcy risk of enterprises. On the other hand, effective *EID* can not only further enhance the market value of enterprises, but also protect the benefits of investors and maintain the stability of the capital market.

Both an increase in the proportion of *INST* and an increase in financing constraint level weaken the finding that environmental disclosure negatively affects *SPCR*. This finding further validates the conclusions that *INST* increase *SPCR* (Hsieh, 2013; Xu et al., 2017), and that *FC* increase *SPCR* (Li et al., 2021; Xie et al., 2023). These results lay the foundation for the government to further support the implementation of green credit policies, the optimization of corporate regulatory policies, the expansion of media monitoring policies, and the maintenance of capital market stability.

5.7 Robustness test

To control for other potential impact factors and reduce endogeneity, robustness tests using instrumental variables and propensity score matching (PSM) are conducted. For the instrumental variable approach, referring to the study of Larcker and Rusticus (2010), we select the mean value of *EID* (*Mean_EID*) as the instrumental variable.

Table 6 presents the regression results from the two-stage least squares (2SLS) instrumental variable test. Column (1) reports the 2SLS first-stage regression results. Columns (2) and (3) report the 2SLS second-stage results. The coefficient estimates of *Mean_EID* are significantly positive, which indicates that there is a significant positive correlation between the mean value of *EID* in the same industry and the mean value of the *EID* of individual

Table 6 Regression results of the 2SLS method

	(1) First	(2) Second_1	(3) Second_2
	<i>L_EID</i>	<i>NCSKEW</i>	<i>DUVOL</i>
<i>Mean_EID</i>	0.942*** (13.04)		
<i>L_EID</i>		-0.241*** (-3.39)	-0.143*** (-3.15)
<i>L_NCSKEW</i>	-0.001 (-0.07)	0.049*** (2.84)	0.026** (2.39)
<i>L_DUVOL</i>	0.001 (0.03)	-0.001 (-0.03)	0.009 (0.56)
<i>L_Lev</i>	0.928*** (22.05)	0.084 (1.11)	-0.009 (-0.18)
<i>L_Roa</i>	1.971*** (14.23)	1.077*** (5.76)	0.568*** (4.70)
<i>L_Growth</i>	-0.193*** (-9.90)	-0.017 (-0.77)	-0.015 (-1.12)
<i>L_Top1</i>	0.470*** (9.92)	-0.003 (-0.06)	-0.007 (-0.22)
_cons	-0.505*** (-5.45)	-0.221*** (-3.51)	-0.118*** (-2.88)
YEAR	YES	YES	YES
IND	YES	YES	YES
N	15,381	15,381	15,381

Table 7 Results of the PSM sample regression

	(1) Basic	(2) Basic	(3) PSM	(4) PSM
	<i>NCSKEW</i>	<i>DUVOL</i>	<i>NCSKEW</i>	<i>DUVOL</i>
<i>L_EID</i>	-0.027*** (-4.01)	-0.021*** (-4.75)	-0.023*** (-3.46)	-0.017*** (-3.91)
<i>L_NCSKEW</i>	0.049*** (3.02)	0.027** (2.46)	0.029* (1.79)	0.009 (0.87)
<i>L_DUVOL</i>	-0.001 (-0.04)	0.009 (0.56)	0.020 (0.80)	0.032** (2.00)
<i>L_Lev</i>	-0.118*** (-3.34)	-0.124*** (-5.36)	-0.134*** (-3.92)	-0.149*** (-6.56)
<i>L_Roa</i>	0.642*** (5.42)	0.320*** (4.12)	0.744*** (6.54)	0.353*** (4.67)
<i>L_Growth</i>	0.024 (1.51)	0.008 (0.75)	-0.042*** (-2.58)	-0.034*** (-3.18)
<i>L_Top1</i>	-0.099** (-2.50)	-0.062** (-2.39)	-0.081** (-2.07)	-0.084*** (-3.24)
_cons	-0.310*** (-5.52)	-0.168*** (-4.57)	-0.215*** (-3.84)	-0.076** (-2.04)
YEAR	YES	YES	YES	YES
IND	YES	YES	YES	YES
N	15,381	15,381	15,371	15,371
R ²	0.037	0.042	0.039	0.042
F	17.68	20.23	19.02	20.49

firms. The coefficients of L_EID are significant, which indicates that after controlling for endogeneity, EID still significantly reduces $SPCR$. Furthermore, the F-value is significantly above 10, suggesting no weak instrument issue exists.

In the PSM approach, samples with L_EID values at or above the annual subindustry median ($PEID$) are assigned a value of 1, while those with L_EID below $PEID$ are assigned 0. Second, matching is performed according to the nearest-neighbour one-to-one matching method, which balances the characteristics of the samples between the treatment group and the control group by selecting the most similar control group of individuals. A logit model is subsequently used to compute the propensity score. The PSM results in Table 7 revealed that the regression coefficients of L_EID in relation to $NCSKEW$ and $DUVOL$ are both negative and significant at the 1% level. This finding aligns with the results of the primary regression analysis, indicating that the findings of this paper remain reliable after accounting for sample self-selection.

This research not only enhances the scholarly comprehension of the intricate association between EID and $SPCR$ but also entails significant practical implications. It provides practical risk management strategies and decision-making guidance for enterprises and investors, while offering strong empirical evidence for regulators to improve information disclosure systems and maintain market stability, thereby promoting the sustainable and high-quality growth of the Chinese economy and the construction of ecological civilization. Promoting the improvement of corporate EID quality is a crucial step toward achieving a win-win situation for economic, environmental, and social benefits.

6 Conclusions and policy recommendations

In this paper, non-financial A-share listed companies from 2012 to 2022 are selected as a sample to explore the effects of EID on $SPCR$. Furthermore, the moderating roles of $INST$ and FC are investigated, and the level of heterogeneity is assessed with respect to the effect of EID on $SPCR$ from the perspectives of different industry and ownership types. The study finds that: (1) EID is significantly and negatively related to $SPCR$, with an average risk reduction of 25% following disclosure. (2) An increase in institutional investor ownership attenuates the negative effect of EID on $SPCR$. (3) An increase in FC attenuates the negative effect of EID on $SPCR$.

This paper not only expands the understanding of risk management but also provides strong evidence in support of proactive corporate strategies in terms of managing and disclosing environmental information by revealing the negative relationship between EID and $SPCR$. Since the overall number of Chinese listed companies disclosing environmental information is low and the level of disclosure varies from company to company, listed companies need more guidance and support to improve their degree of EID . Given the ever-changing market environment and risks, strengthening the regulation and supervision of corporate behaviour to improve market stability and transparency is crucial. Therefore, the following recommendations are proposed from three perspectives.

- (1) Upgrading the level of *EID*. From the perspective of regulatory authorities, the government should formulate detailed guidelines on *EID* with respect to the characteristics of different industries to improve the transparency and authenticity of the information. The government should also crack down on management's manipulation of information to influence share prices. From the perspective of enterprises, enterprises should establish an optimal *EID* system, improve the quality of *EID*, ensure the authenticity and accuracy of data, and avoid misleading investors. From an investor perspective, there is a need to strengthen investor attention to corporate *EID* to assess the investment value of companies from a comprehensive perspective.
- (2) Regulate the investment behaviour of *INST*. From the perspective of the regulator, the regulator needs to strengthen monitoring and combat insider trading and market manipulation by *INST* to ensure fairness in the stock market. Moreover, the regulator may set a cap on the percentage of shareholding and impose restrictions on *INST* exceeding a certain percentage. From the perspective of listed companies, they should establish a communication mechanism with investors, hold regular meetings to explain the operation and environment of the company, respond to investor concerns, and enhance their corporate profile and credibility. From an investor's point of view, *INST* should focus on long-term investment, account for environmental factors, and pursue stable returns rather than just short-term benefits.
- (3) Ease the level of corporate *FC*. From the perspective of the regulator, the government can encourage enterprises to disclose environmental information through tax incentives, financing support and other incentives; provide financing channels to reduce costs; promote the fulfilment of corporate environmental responsibility; improve the quality of information disclosure; and reduce *SPCR*. From the perspective of listed enterprises, listed companies should broaden their financing channels and reduce their reliance on a single financing channel. Moreover, cooperation with financial institutions should be strengthened to obtain favourable financing conditions, thereby reducing financing pressure. From an investor's perspective, market participants should carefully evaluate the authenticity and completeness of environmental information disclosed by enterprises under severe *FC*, and prioritize potential environmental risks to avoid investment losses stemming from information opacity.

This study also has certain limitations. Specifically, this paper only focuses on listed companies and ignores the sample data of non-listed companies. The performance of non-listed companies in environmental information is equally worthy of attention, and they may have different characteristics and laws from listed companies in terms of *EID* and *SPCR*. Therefore, future research can expand the sample to non-listed companies to comprehensively understand the impact of corporate *EID* on *SPCR* and enhance the universality of the conclusions in this paper.

Appendix

Table 8 Evaluation index system for *EID*

Project indicators	Secondary Indicator	Scoring instructions
<i>EID</i> vehicles	Annual reports of listed companies	Yes: 1 score No: 0 score
	Social responsibility report	
	Environmental report	
	Environmental philosophy	
	Environmental protection targets	
Environmental management	Environmental management system	
	Environmental education and training	Disclosure: 1 score Not disclosed: 0 score
	Special environmental action	
	Environmental incident response mechanism	
	Environmental honours and awards	
Environmental liabilities	Three simultaneous system	
	COD emissions	Quantitative description: 2 scores Qualitative description: 1 score No description: 0 score
	SO ₂ emissions	
	CO ₂ emissions	
	Smoke and dust emissions	
Environmental performance and governance	Industrial solid waste generation	
	Total wastewater discharge	
	Emission reduction and treatment of waste gas	Quantitative description: 2 scores Qualitative description: 1 score No description: 0 score
	Wastewater emission reduction management	
	Dust and fume management	
Environmental regulation and certification	Solid waste utilization and disposal	
	Noise, light pollution, radiation, etc.	
	Implementation of cleaner production	
	Major pollution monitoring Organizations	Yes: 1 score No: 0 score
	Pollutant emissions to meet the standard	
	Environmental accidents	
	Environmental offences	
	Environmental petition cases	
	Whether through ISO14001 certification	
	Whether to pass ISO9001 certification	

Table 9 Descriptive statistics of the variables

Variables	<i>N</i>	Mean	P50	SD	Min	Max
<i>NCSKEW</i>	15,381	−0.359	−0.302	0.717	−2.521	1.671
<i>DUVOL</i>	15,381	−0.239	−0.239	0.472	−1.381	1.004
<i>L_EID</i>	15,381	1.612	1.609	0.955	0	3.367
<i>L_INST</i>	15,381	0.414	0.424	0.233	0.001	0.885
<i>L_FC</i>	15,381	0.421	0.413	0.279	0	0.981
<i>L_NCSKEW</i>	15,381	−0.366	−0.321	0.723	−2.522	1.689
<i>L_DUVOL</i>	15,381	−0.249	−0.247	0.476	−1.401	1.012
<i>L_Lev</i>	15,381	0.456	0.457	0.194	0.057	0.887
<i>L_Roa</i>	15,381	0.040	0.036	0.055	−0.220	0.226
<i>L_Growth</i>	15,381	0.160	0.098	0.375	−0.526	2.238
<i>L_Top1</i>	15,381	0.346	0.323	0.149	0.085	0.747

Table 10 Descriptive statistics for *EID* by industry

Name	Code	Listed Company	Score	Average Value
Agriculture, forestry, animal husbandry and fisheries	A	198	256.9	1.300
Mining	B	419	919.9	2.200
Manufacturing	C	9886	17264.3	1.746
Electricity, heat, gas, water production and supply industry	D	639	1206	1.890
Building and Construction	E	458	706.3	1.540
Wholesale and retail trade	F	834	892.8	1.070
Transport, storage and postal services	G	512	807.1	1.580
Accommodation and catering	H	49	70.01	1.430
Information transmission, software and information technology services	I	828	773.2	0.930
Real Estate	K	683	864.4	1.270
Leasing and business services	L	173	182.4	1.050
Scientific research and technology services	M	124	153.0	1.230
Water conservancy, environment and public facilities management industry	N	251	361.2	1.440
Residential services, repair and other services	O	1	0.690	0.690
Education	P	12	8.540	0.710
Health and social work	Q	50	66.72	1.330
Culture, sports and recreation	R	264	253.2	0.960

Table 11 Pearson correlation coefficient of variables

	NCSKEW	DUVOL	L_EID	L_INST	L_FC	L_NCSKEW	L_DUVOL	L_Lev	L_Roa	L_Growth	L_TopI
<i>NCSKEW</i>	1										
<i>DUVOL</i>	0.875***	1									
<i>L_EID</i>	-0.033***	-0.043***	1								
<i>L_INST</i>	-0.018**	-0.027***	0.205***	1							
<i>L_FC</i>	0.055***	0.084***	-0.299***	-0.450***	1						
<i>L_NCSKEW</i>	0.047***	0.044***	0.004	0.024***	0.004	1					
<i>L_DUVOL</i>	0.040***	0.040***	0.005	0.024***	0.003	0.877***	1				
<i>L_Lev</i>	-0.058***	-0.072***	0.128***	0.196***	-0.664***	-0.019**	-0.010	1			
<i>L_Roa</i>	0.068***	0.060***	0.044***	0.105***	0.152***	0.030***	0.011	-0.354***	1		
<i>L_Growth</i>	0.039***	0.030***	-0.051***	-0.027***	-0.006	0.010	-0.001	0.017**	0.246***	1	
<i>L_TopI</i>	-0.029***	-0.032***	0.075***	0.412***	-0.144***	-0.016**	-0.008	0.059***	0.105***	-0.012	1

Note: ***, ** and * indicate significant at the 1%, 5% and 10% levels, respectively

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Declarations

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