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Research article

The impact of stock liquidity on corporate environmental information disclosure: Does climate risk matter?

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Abstract: From the perspective of the Chinese market microstructure, we took Chinese A-share listed companies as samples to explore the impact and mechanism of stock liquidity on the quality of corporate environmental information disclosure (EID). Our results indicated that stock liquidity has a positive impact on the quality of corporate EID. Using the stock market interconnection events of the 2014 Shanghai-Hong Kong Stock Connect and the 2016 Shenzhen-Hong Kong Stock Connect as a quasi-natural experiment and applying the IV approach, the research results remained robust after controlling for endogeneity issues. Moreover, both climate physical risk and climate transition risk positively regulated the relationship between stock liquidity and the quality of corporate EID. Further analysis revealed that the positive impact of stock liquidity on the quality of corporate EID is determined by the information effect path and governance effect path of stock liquidity, and the role of the information effect path is more important. In summary, stock liquidity has had an important feedback effect on Chinese companies' active EID behavior through two pathways: Information effect and governance effect.

Keywords: stock liquidity; corporate environmental information disclosure; climate risk; information effect; governance effect

JEL Codes: F36, G32, Q56

1. Introduction

With the increasing instability of the climate system caused by global warming, the boost in environmental awareness worldwide requires firms to take on more environmental responsibilities (Jiang et al., 2023). Corporate environmental information disclosure (EID) is an important way for firms to fulfill their environmental responsibilities, and it is also an important channel for the external stakeholders to understand and supervise the performance of corporate environmental responsibilities (Liu and Guo, 2023). Improving the quality of corporate EID can help to bridge the information gap between managers and stakeholders, so as to obtain more green investment and enhance corporate reputation, obtaining long-term benefits for stockholders (Li et al., 2023). Therefore, in the context of intensified climate risks, the factors affecting the quality of corporate EID have become an important issue of concern in academic and practical circles.

Some scholars have examined the determinants of the quality of corporate EID from the perspectives of government environmental regulation, corporate management characteristics, state ownership, and customer concentration (Pan and Yao, 2021; Liu and Guo, 2023). However, the quality of EID will receive attention from stakeholders such as regulators, investors, and analysts in the capital market, making capital market mechanisms one of the prerequisites for the quality of corporate EID that firms must consider (Li et al., 2023). There is insufficient research in previous literature on how capital market mechanisms affect the quality of corporate EID. Stock liquidity is an important indicator to test capital market mechanisms' effectiveness from the perspective of market microstructure (Khosroshahi et al., 2021). Thus, focusing on the Chinese stock market and Chinese A-share listed companies, we attempt to fill this gap by exploring the impact of stock liquidity on the quality of corporate EID from the perspective of Chinese market microstructure and explore its boundary conditions and mechanisms.

Researchers have found that corporate environmental responsibility disclosure can have an impact on stock liquidity (Egginton and McBrayer, 2019; Chen et al., 2023; He et al., 2023; Zhang and Yang, 2023; Li et al., 2024). However, the latest authoritative literature explores the inverse relationship between voluntary disclosure and stock liquidity, suggesting that, in the United States, a decrease in stock liquidity reduces the frequency of voluntary disclosure of management earnings forecasts (Hope and Liu, 2023). Compared to the research investigating whether EID affect liquidity, this study explores the reverse relationship between EID and liquidity, and introduces exogenous liquidity changes (China Stock Exchange Interconnection Event) to support the research conclusions. Our research findings supplement previous research, indicating that EID and stock liquidity are interdependent. In contrast to focusing on the behavior of disclosing environmental information, we pay more attention to the quality of EID. Based on Hope and Liu (2023), we further consider the impact of stock liquidity on non-financial indicator disclosure in the context of China's microstructure, as market investors gradually pay more attention to the corporate environmental orientation. In this case, we provide causal inferences on whether and how stock liquidity shapes corporate environmental disclosure incentives, bringing management insights to more developing countries.

Stock liquidity has a price discovery function, which is a true reflection of the investment behavior of capital market investors and an important way for the financial economy to provide feedback to the real economy. The stock market can have a significant impact on a company's behavior or strategy through stock liquidity (Ee et al., 2022). Based on the theory of market microstructure, on the one hand, higher stock liquidity can reduce market transaction costs, improve price discovery efficiency, and

improve information asymmetry between internal and external companies through information effects; on the other hand, higher stock liquidity will increase the number of major shareholders and optimize the market's selection of major shareholders and management efficiency, then suppress the tunnel excavation of major shareholders and the opportunistic behavior tendencies of management through governance effects (Hope and Liu, 2023). Researchers have found that stock liquidity can affect stock returns, company value, cash holdings, financial information disclosure, and capital allocation efficiency in Chinese capital markets (Nyborg and Wang, 2021; Ee et al., 2022). However, there is less discussion on the profound impact and major mechanism paths of stock liquidity on corporate EID quality.

In the context of global sustainable development, the climate risk of enterprises is increasingly receiving attention from regulatory agencies, institutional investors, and other stakeholders. As an important source of financing for enterprises in the capital market, institutional investors will pay more attention to the long-term sustainable development and incorporate climate risk factors into the investment process (Khosroshahi et al., 2021). An increasing number of studies indicate that institutional investors generally believe that climate environment or climate policy changes will have a potentially significant impact on whether they hold the company's stocks (Wang et al., 2022). Some studies have also pointed out that climate change and related climate policies can have a significant impact on the micro behavior of companies (Li et al., 2023). The higher the stock liquidity, the higher the attention of the capital market to the climate risk and corporate EID, and the more likely it is to suppress the disclosure of false environmental information. Stroebel and Wurgler (2021) identified physical and transition risks as the main climate risks that will affect business and investor decisions over the next 5 and 30 years. Therefore, climate risk, stock liquidity, and corporate EID are closely related factors that cannot be ignored in this study.

Although researchers conducting theoretical and empirical studies focused on the economic and financial consequences of stock liquidity, the relationship between stock liquidity and corporate EID quality has not been given sufficient attention. Thus, by examining a sample of Chinese listed firms from 2010 to 2023, we explore the relationship and mechanism paths between stock liquidity and corporate EID quality, and simultaneously discuss the role of climate risk on this causal relationship. Empirical analysis suggests that stock liquidity has a positive effect on corporate EID quality. The result remains robust after considering endogeneity, by the IV approach, a difference-in-difference (DID) model based on the 2014 *Shanghai-Hong Kong Stock Connect* or 2016 *Shenzhen-Hong Kong Stock Connect* events as a quasi-natural experiment. Moreover, when the climate physical and transition risks of the enterprise are higher, this positive causal relationship is more significant. Last, the mechanism paths of the information effect and governance effect are proved, and the joint test of the two mechanisms implies that the information effect outweighs the governance effect, playing a prominent role in strengthening the relationship between stock liquidity and EID quality.

This paper contributes to the literature in three aspects. First, we explore the inverse relationship between EID and liquidity and reveal the determining factors of corporate EID quality from the perspective of the Chinese market microstructure. Several researchers have found that corporate social responsibility (CSR) and environmental behavior can affect stock liquidity (Egginton and McBrayer, 2019; Chen et al., 2023; Zhang and Yang, 2023). Based on Hope and Liu (2023), who conducted their study in the context of the United States, we present evidence of the relationship between liquidity and EID quality against the backdrop of the Chinese stock market. Moreover, we present a novel perspective for further research of EID determinants from a stock liquidity viewpoint and expand literature on the impact of stock liquidity on non-financial information disclosure. Researchers have mainly investigated

the impact of government regulation (Li and Ramanathan, 2018), media supervision (Rulley et al., 2012), and management characteristics (Giannarakis et al., 2020; Li et al., 2023; Zhang, 2017) on EID. Unlike other researchers, we use the content analysis method to measure corporate EID quality to more accurately evaluate the relationship between the two and provide empirical experience for leveraging corporate environmental responsibility through capital market mechanisms.

Second, we incorporate climate risk factors into the research framework against the backdrop of low-carbon transformation. Researchers have mainly provided evidence of a link between climate risk and stock prices (Krueger et al., 2020; Alok et al., 2020; Huynh and Xia, 2021, 2023). This study makes a contribution to the existing literature on the effects of climate risk by examining its regulatory effect on stock liquidity and EID quality. It further enriches the existing research literature on stock liquidity and corporate EID quality. By incorporating climate physical risks and climate transition risks into the micro-enterprise risk research framework (Wang et al., 2022), this study supports that climate environmental change is an important factor affecting the corporate EID quality, and provides a practical basis for supporting the national strategic goals of "carbon peaking and carbon neutrality" through financial markets.

Third, this study supplements and extends the literature on the impacts of stock liquidity on corporate-level strategy and decision-making. Previous studies have validated the channel effect of stock liquidity based on its information attributes (Chen et al., 2015; Brogaard et al., 2017; Chang et al., 2019; Nian and Gu, 2022). Finding the evidence that it influences social responsibility related dependent variables (Ben-Nasr and Alshwer, 2016; Nian and Gu, 2022). This study opens the "black box" of how stock liquidity affects EID quality from information and governance effects, further testing that the information effect plays a leading role. It elucidates the pathways that stock liquidity affects EID. This helps deepen the understanding of the relationship between stock liquidity and corporate EID quality and promotes the construction of an efficient transmission mechanism for the financial market and firm's decision-making.

The rest of this research is structured in the following manner: In Section 2, we discuss the background of EID and develop our hypotheses; in Section 3, we present the research design, describe the sample, variable measurements, and model specification; and in Section 4, we provide the baseline regression results, discuss the endogeneity issues, then the role of climate risk, and the mechanism analysis. Finally, we conclude the study in Section 5.

2. Hypothesis development

2.1. The influencing factors of EID quality

Researchers have investigated the influencing factors of EID, including government environmental regulations, media attention, and the characteristics of corporate executives (Dawkins and Fraas, 2010; Moroney et al., 2012). First, it is found that mandatory environmental regulation positively affects the disclosure of monetary and non-monetary environmental information (Liu and Guo, 2023; Zhang et al., 2023), and the government's mandatory requirements for EID quality need to be achieved through both punishment and incentive measures (Li et al., 2019). For example, environmental administrative penalties and taxes will encourage firms to disclose environmental information (Bárcena-Ruiz and Sagasta, 2022; Li et al., 2018). Punishment measures enhance EID from the perspective of avoiding losses and risks, while incentive measures such as government subsidies strengthen firms' motivation to

disclose environmental information from a positive perspective. The government's environmental pressure will complement and influence environmental protection awareness from the media and within firms. Second, media attention positively affects EID quality and has a positive effect on green economy development and the awareness and behavior of environmental protection (Fan et al., 2020), as well as a decrease in green-washing activities (Lyon and Montgomery, 2013). Finally, the internal motivation for enhancing EID quality is primarily influenced by top executives, and numerous studies have also validated the diverse impacts of executive characteristics and experiences on EID quality (Lewis et al., 2014; Meng et al., 2015; Shahab et al., 2020).

Overall, research on capital market mechanisms driving corporate EID quality is relatively lacking. From the external capital market perspective, stock liquidity has a vital information filtering function, which means that the capital market will allocate more attention to firm information disclosure (Amihud and Levi, 2023). Potential investors in the capital market have higher requirements for the quality of environmental information firms disclose based on their long-term interests (Baginski et al., 2000). From the internal governance perspective of firms, executives will improve the quality of EID and prevent negative EID behavior from being perceived and abandoned by the capital market to maintain the firm's reputation and achieve good performance in the capital market (Meng and Zhang, 2022). Based on extant research, this study further explores the effect and mechanism of stock liquidity on EID quality from the perspective of micro-market structure.

2.2. The effect of stock liquidity on EID quality

Against the backdrop of the increasingly prominent climate issues, the Chinese government places significant emphasis on enhancing firms' awareness of embracing environmental duties. This encourages firms to disclose environmental information in the capital market publicly. Stock liquidity reflects the external market's judgment of listed firms after integrating all kinds of information (Chang et al., 2017), making predictions about the listed firms' future development. Moreover, stock liquidity will affect executives' judgment about the firm's developing path and decision-making (Seroka-Stolka and Fijorek, 2020). In the context of receiving more attention from external markets and internal executives, stock liquidity may impact corporate EID quality. We adapt the theories of information effect and governance effect according to Nian and Gu (2022), which can elucidate how stock liquidity can positively affect EID.

From the perspective of external capital markets: First, based on the information content of stock prices, on the one hand, high stock liquidity enhances the efficiency of information transmission and the private information content of stock prices, which has a substantial incentive effect on investors' information collection and stock trading behavior (Zhang and Xu, 2023). High liquidity can stimulate the interest of both individual and institutional investors (Jiang et al., 2017), thereby enhancing their motivation to pay attention to stock information (Platikanova, 2008; Zhu et al., 2017). Conversely, stocks with high liquidity are more likely to garner attention. As an information intermediary in the capital market, analysts utilize their professional knowledge and expertise, along with their team, to regularly track corporate Financial Reports and Social Responsibility Reports, thereby assisting investors in interpreting the company's financial and environmental information. The greater the quantity of company information that investors are able to obtain, the higher the information content of the company's stock. These factors have a significant impact on the decision-making processes of companies (Brogaard et al., 2017). Second, from the perspective of enhancing stock liquidity and improving stock

pricing efficiency. The feedback effect of stock liquidity enables the stock price of highly liquid companies to more accurately reflect their intrinsic value, thereby enhancing capital pricing efficiency (Harford, 2005). Consequently, the management engages in the manipulation of disclosure information, and the firm tends to adopt a more sustainable development approach, which results in an improvement in EID quality. Ultimately, high stock liquidity enhances the transparency of information within and beyond the enterprise, mitigating the impediments posed by information asymmetry. This has resulted in raising environmental awareness and triggering high EID quality.

From the perspective of internal governance, the governance effect of stock liquidity has a positive impact on EID quality. This is due to the influence that stock liquidity has on investors' entry, exercise of supervisory power, and exit. Specifically, higher stock liquidity facilitates the entry of institutional investors, who can engage in "voice intervention" (Firth et al., 2016) to supervise the firm and its agents. Second, investors exercise their supervisory power through the act of voting. Furthermore, elevated stock liquidity facilitates the incorporation of the added value generated by supervision into the market, thereby facilitating the acquisition of corresponding benefits by investors. Ultimately, high liquidity serves to reinforce the deterrent effect of stock sales based on the "exit threat." These factors indicate that stock liquidity enables investors to influence companies to adopt long-term strategies and assume greater environmental responsibilities through their buying, holding, and selling behaviors (Edmans, 2009). Conversely, high stock liquidity can diminish agency costs and enhance governance structures. Furthermore, it can enhance the deterrence of opportunism within the company, facilitate efficient management and stable financial conditions, encourage managers to adopt a more visionary approach, and prompt a more serious and cautious attitude toward EID (Norri et al., 2015; Edmans et al., 2013; Maug, 1998). Consequently, we propose Hypothesis 1.

Hypothesis 1: Stock liquidity has a positive effect on corporate EID quality.

2.3. The regulatory effect of climate risk

Researchers have proved the linkage between climate risk, financial stability and institutional investors' behavior (Bolton et al., 2020; Jagannathan et al., 2018). Based on Stroebel and Wurgler (2021), we divide climate risk into physical and transition risks. Physical risks, such as floods, droughts, etc. (Krueger et al., 2020), are mainly caused by climate change. Transition risk is primarily related to the uncertainties that firms face during the rapid transition to a low-carbon economy or the impact of external environmental regulations on a firm's production and operations (Painter, 2020). Climate risk can affect EID quality by influencing firms' risk perceptions and investment decisions, regulating the relationship between stock liquidity and corporate EID quality.

First, due to increasing environmental consciousness in society, firms with high pollution levels are blamed for the deterioration of the environment. According to the risk management hypothesis, firms with higher CSR standards perform better in crises (Mbanyele and Muchenje, 2022). Therefore, climate risks may incentivize firms to increase their investment in CSR and enhance their focus on environmental protection. Then, by disclosing high-quality environmental information, firms can improve their environmental performance and establish a positive reputation, ultimately reducing the negative impact of climate risks on themselves.

Second, climate risks can create uncertainty in production and investment. As for strategic management suggests that when uncertainty increases, firms should adopt more cautious and conservative decisions until they acquire more information or wait until the external environment improves (Mbanyele

and Muchenje, 2022). Nevertheless, investments in environmental protection and CSR are omitted. When environmental concerns become more prevalent, external investors favor eco-friendly stocks and select firms with superior environmental performance (Mbanyele and Muchenje, 2022).

Third, climate risks put the firm's management system to the test. Stakeholder theory suggests that climate risks may lead to stricter regulations and public concerns over heavily polluted firms. Climate risks may also cause changes in preferences for sustainable development products and increase the costs of managing risks (Mbanyele and Muchenje, 2022). Hence, climate risk can lead to a strategy shift from performance-improving purposes toward eco-friendly activities such as EID. Climate risks can strengthen the positive linkage between stock liquidity and corporate EID quality, and further affect the degree and efficiency of financial market mechanisms that regulate EID quality. Therefore, we propose Hypothesis 2.

Hypothesis 2: Climate risks can enhance the promotion of stock liquidity on corporate EID quality.

3. Research design

3.1. Sample selection and data sources

Due to considerations for data availability and ensuring sufficient sample size, Chinese A-share listed firms from 2010 to 2023 were selected to empirically study how stock liquidity affects corporate EID quality. We merged the database with financial data from the China Stock Market & Accounting Research Database (CSMAR), and then the samples were analyzed in accordance with the subsequent principles: (1) We exclude the sample with ST and *ST; (2) financial firms are excluded; and (3) we eliminate observations with missing or abnormal key indicators and each continuous variable is adjusted by winsorizing the 1% and 99% tails. After applying these screens, we obtain an unbalanced panel of 28,055 observations representing 2,904 unique firms.

3.2. Variable definition

3.2.1. Dependent variable

According to Clarkson et al. (2008), we conduct the content analysis method based on a firm's sustainable development reports, CSR reports, or firm's annual reports to obtain information relevant to EID. Then we subdivide EID into five components based on the classification of EID data in CSMAR database (Khosroshahi et al., 2021). The concrete content and scoring standard for each element are shown in Table 1.

Each component includes several dimensions, further divided into 30 parts, we merged some parts with similar properties and retained 21 parts in Table 1. As illustrated in Table 1, the EID score is calculated using the following method. As different components contain different types of information, if the score range is 0–1, it indicates that the component is scored based on whether relevant information is disclosed. If pertinent information is specifically or separately reported, the score is 1; otherwise, it is 0 (Li et al., 2023). Suppose the score range is 0–2; in this case, the component can be qualitatively or quantitatively described, and the quantitative information was given a value of 2. In contrast, descriptive information was given a value of 1, and 0 if no information was disclosed. More specifically, dimensions in C1 and C2 are scored 0–1, C3 is scored 0–2, C4 is scored 0-1, and C5 is

scored 0–2. The EID score is the aggregate of all 30 parts from five components; the maximum score could be 42. We then use the logarithm form of EID score plus one to measure EID quality in the empirical analysis.

Table 1. Content analysis index measurements for EID quality.

Components	Secondary Indicator
Environmental management C1	Environmental protection concept, environmental management, environmental goals C11
	Environmental education and training, special action on environmental protection C12
	The occurrence of major environmental problems, environmental protection rewards C13
	Implementation of the "three simultaneous" regulation C14
Government supervision and environmental certification C2	ISO14001 certification, ISO9001 certification C21
	Paying for discharging wastes, key pollution issues, environmental violations C22
	Environmental conditions C23
	Environmental petitions C24
Environmental liabilities C3	Waste water emissions C31
	COD emissions C32
	SO_2 emissions C33
	CO_2 emissions C34
	Soot and dust emissions C35
	Industrial solid waste production C36
Environmental disclosure carrier C4	Annual reports C41
	Corporate social responsibility reports C42
	Environmental reports C43
Environmental performance and environmental governance C5	Exhaust gas emission reduction, wastewater emission reduction, soot and dust emission reduction C51
	Industrial solid waste emission reduction C52
	Noise and light pollution governance C53
	Clean production implementation C54

3.2.2. Independent variable

In the empirical analysis, we use Amihud's illiquidity ratio (*Liquidity*) to represent liquidity level. *Liquidity* measures the extent to which the average price change per stock trades in terms of price shock (Ee et al., 2022; Nyborg and Wang, 2021). We define the *Liquidity* in Equation 1 by Amihud's illiquidity indicator (Amihud, 2002). As Amihud illiquidity increases when stock liquidity drops, we use the opposite of Amihud in all empirical analyses.

$$Liquidity = \frac{1}{N_{i,t}} \sum_{d=1}^{N_{i,t}} \frac{\left|r_{i,t,d}\right|}{DVol_{i,t,d}} \tag{1}$$

In Equation 1, $r_{i,t,d}$ means stock i's return rate on day d in year t, and $DVol_{i,t,d}$ is the price corresponding to the stock in US dollars. The number of days that stock i has been traded in year t is denoted by $N_{i,t}$. All the data required for constructing *Liquidity* are collected from CSMAR database.

3.2.3. Regulatory variable

The regulatory variables are climate risk, including physical risk and transition risk. The frequency of natural disasters and the enforcement of environmental policies are commonly utilized in developing climate risk indicators in numerous types of research. However, they failed to encompass climate risks' intricate and ever-changing essence (Zhang, 2022). By examining the text, we can gain a more comprehensive understanding of the potential dangers of climate change. We used the annual reports of Chinese A-share listed companies from 2010 to 2023 to document various climate risks, extracting words such as "snow," "storm," and "drought" to measure physical risks and extracting words such as "low-carbon" "emission reduction," and "environmental protection" to measure transition risks, creatively quantified climate risk at the firm level. The level of climate risk is defined as the ratio of the sum of keyword occurrences to the total word count in the annual report (Wang et al., 2022).

3.2.4. Mechanism variable

(1) Information effect. Analyst tracking and information transparency are used to test the information effect of stock liquidity. First, we use the number of analysts as the measurement for analyst tracking (*Analyst*). Based on the data provided by CSMAR, the number of analysts that track the specific listed firm can be counted (Wu et al., 2022). Second, information transparency (*Trans*) can represent the quality and efficiency of information transmission, the higher the analyst tracking and information transparency, the stronger the information effect (Wang et al., 2016). The transparency utilized is a comprehensive indicator based on five factors: Earnings quality, accounting information disclosure level, number of analysts, earnings forecast accuracy, and Big4 (Lang et al., 2012).

(2) Governance effect. We use the first and second types of agency costs to represent the governance effect of stock liquidity. This set of variables is the management expense ratio (management expense/sales revenue) (*Cost1*) and other accounts receivable ratio (other receivable balance/total assets) (*Cost2*), respectively (Lei et al., 2013). Decreased agency costs indicate that the governance effect plays a more significant role in alleviating agency conflicts.

3.2.5. Control variables

According to Li et al. (2022) and Li et al. (2023), we manage the variables that could influence EID quality, including firm size (*Size*), profitability (*Roe*), return on asset (*Roa*), ownership concentration (*Top1*), asset turnover (*Ato*), cashflow (*Cash*) and duality (*Dual*). Additionally, we incorporated a collection of individual and year dummies to manage individual and temporal fixed effects, correspondingly. Table 2 provides a comprehensive breakdown of variable definitions.

Table 2. Variable definition.

Variable type	Variable	Symbol	Definition
Dependent variable	Corporate EID quality	*EID*	Logarithm form of EID score
Independent variable	Stock liquidity	*Liquidity*	Amihud illiquidity indicator
regulatory variables	Climate physical risk	*Physical risk*	Physical risk keyword / total words in an annual report
	Climate transition risk	*Transition risk*	Transition risk keyword / total words in an annual report
Mechanism variables	Analyst tracking	*Analyst*	Logarithm form of research report attention
	Information transparency	*Trans*	Information transparency indicator
	The first type of agency cost	*Cost1*	Management expense / operating income
	The second type of agency cost	*Cost2*	Other receivables / total asset
Control variables	Firm size	*Size*	Natural logarithm of total assets
	Return on equity	*ROA*	Net profit / average equity
	Return on asset	*ROE*	Net profit / total assets
	Top 1 shareholder	*Top1*	Shareholding ratio of the top 1 shareholder
	Asset turnover	*Ato*	Net sales revenue/average balance of total assets
	Cashflow rate	*Cash*	Cashflow rate statement data
	Dual job integration	*Dual*	Value at 1 if it is concurrent, and 0 otherwise

Note: The calculation method for EID score is shown in Table 1. In the mechanism variables, analyst tracking and information transparency are used to test information effect path, and the first and second type of agency cost are used to test governance effect path.

3.3. Model specification

In order to verify the hypothesis proposed in this study, referring to Ee et al. (2022), we test the correlation between stock liquidity and EID quality by constructing the multiple regression model as follows:

$$EID_{it} = \beta_0 + \beta_1 Liquidity_{it} + \sum_i^J \omega_j \, Controls + +\mu_i + \gamma_t + \varepsilon_{it} \quad (2)$$

In Equation 2, the firm is indicated by the subscript *i*, while the subscript *t* denotes the year. EID_{it} is the *EID* quality of firm *i* in period *t*. *Liquidity* is the stock liquidity variable. *Controls* are the control variables. μ_i stands for individual fixed effect, regulating all elements that remain constant over time at the firm level. γ_t represents time fixed effect, which controls factors that remain constant regardless of an individual, but evolve over time. ε_{it} is a random disturbance term. In Equation 2, we mainly focused on the coefficient β_1 of $Liquidity_{it}$. If it is significantly positive, it means that increased stock liquidity can positively affect the corporate EID quality, and support hypothesis 1.

Next, we further test the mediating role of information effect and governance effect. First, to verify the mechanism of information effect, we conducted the study from the perspective of internal and external information effects. On the one hand, we examine the information effect of external stakeholders through analyst tracking and investigate whether stock liquidity can affect the information efficiency of external investors, thereby improving EID quality. On the other hand, the information effect from within the firm is tested through the transparency of the disclosed information, thereby verifying the mediation mechanism of stock liquidity, which positively impacts EID quality (Nian and Gu, 2022). Regressions are run on the basis of the following model:

$$information = b_0 + b_1 Liquidity_{it} + \sum_i^J b_j \, Controls + + \mu_i + \gamma_t + \varepsilon_{it} \tag{3}$$

Then, to investigate the governance effect of stock liquidity on EID quality, we use the management expense ratio (*Cost1*) and other accounts receivable ratio (*Cost2*) to measure the first and second types of agency costs, respectively. The model is constructed as follows:

$$governance = d_0 + d_1 Liquidity_{it} + \sum_i^J d_j \, Controls + + \mu_i + \gamma_t + \varepsilon_{it} \tag{4}$$

After clarifying the mechanisms between stock liquidity and corporate EID, we further explore which mechanism is dominant in determining EID quality. The joint test will be conducted on the information and governance effects of stock liquidity. By introducing dummy variables of both information and governance effects in the regression and comparing their coefficient significance, we can determine which effect plays a major role. The model can be constructed as follows:

$$\begin{gathered} EID_{it} = \alpha_0 + \alpha_1 Liquidity_{it} + \alpha_2 information_{it} + \alpha_3 governance_{it} + \\ \sum_i^J d_j \, Controls + + \mu_i + \gamma_t + \varepsilon_{it} \end{gathered} \tag{5}$$

4. Empirical analysis and discussions

4.1. Descriptive statistics

As shown in Table 3, we conduct descriptive statistics for the full sample over time. The EID quality, stock liquidity, and control variables of sample firms are all presented. The mean value of EID quality is 1.964; the standard deviation is 0.792; the minimum value is 0, and the maximum value is 3.638. The mean value of EID quality is slightly higher than the median, with a right-skewed distribution. The mean value of the liquidity indicators is −0.380, respectively. In addition, the descriptive statistical results of other control variables are consistent with other literature (Li et al., 2023). Overall, the selected variables vary significantly among the firms in the sample.

Table 3. Descriptive statistics.

Variables	Observations	Mean	Standard deviation	Min	Max	Median
EID	28,055	1.964	0.792	0	3.638	1.946
Liquidity	28,055	−0.380	7.022	−492.5	−0.0002	−0.328
Size	28,055	22.428	1.363	15.58	28.644	22.238
ROA	28,055	0.042	0.070	−1.324	1.285	0.039
ROE	28,055	0.061	0.564	−85.65	2.379	0.075
ATO	28,055	0.703	0.571	0.00084	11.453	0.589
Cashflow	28,055	0.050	0.075	−0.744	0.876	0.049
Dual	28,055	0.242	0.428	0	1	0
Top1	28,055	0.358	0.154	0.00286	0.900	0.338

4.2. Baseline results

The regression results are presented in Table 4, and the coefficients of *Liquidity* on EID quality are all positive and significant, showing that the increase in stock liquidity can lead to an improvement in EID quality. In columns (1) and (2), when only controlling the individual and year-fixed effects, the coefficient of *Liquidity* is positive and significant at a 1% level. Then, all the control variables were taken into account, and the coefficient is positively substantial, indicating a positive relationship between stock liquidity and EID quality. As indicated in columns (3) and (4), we replace individual fixed effects with province and industry fixed effects, and our primary estimates remain unaltered (Zeng et al., 2024). The results provide evidence for Hypothesis 1, indicating that stock liquidity can positively affect corporate EID quality. Our findings are generally consistent with that of Li et al. (2023). Moreover, the control variables indicate that an increased firm size is conducive to an increase in EID quality, whereas a CEO duality is associated with a reduction in EID quality. This is thought to be because large-scale firms are more capable of bearing the costs of environmentally friendly activities than small firms. Dual employment integration (*Dual*) is not conducive to an effective internal supervision system, thus having a negative impact on environmental protection strategies.

Table 4. Baseline regression results.

	(1)	(2)	(3)	(4)
Variables	*EID*			
Liquidity	0.001***	0.001**	0.001***	0.001***
	(2.88)	(2.55)	(2.93)	(3.29)
Size		0.124***	0.191***	0.204***
		(10.46)	(25.38)	(32.17)
Top1		−0.067	0.098	0.114**
		(−0.87)	(1.49)	(2.10)
ROE		−0.001	−0.013	−0.004
		(−0.60)	(−1.47)	(−1.41)
ROA		0.048	0.259**	0.081
		(0.73)	(2.47)	(0.87)
ATO		−0.005	0.003	−0.006
		(−0.29)	(0.13)	(−0.34)
Cashflow		0.037	0.823***	0.445***
		(0.76)	(9.87)	(6.34)
Dual		−0.024*	−0.024	−0.048***
		(−1.69)	(−1.27)	(−2.88)
Constant	1.409***	−1.251***	−2.395***	−2.661***
	(95.77)	(−4.81)	(−14.41)	(−18.87)
Year FE	YES	YES	YES	YES
Company FE	YES	YES	NO	NO
Province FE	NO	NO	YES	NO
Industry FE	NO	NO	NO	YES
Observations	28,055	28,055	28,055	28,055
R−squared	0.331	0.341	0.284	0.413

Note: Robust standard errors at the firm level and reported parentheses. Year and firm fixed effects are included.

*Significant at 10% lower levels.

**Significant at 5% lower levels.

***Significant at 1% lower levels.

4.3. Endogeneity concerns

While we have documented a positive relationship between stock liquidity and firms' EID quality, the results could be subject to endogeneity. The extant literature has demonstrated that corporate social responsibility and environmental disclosure behavior can affect stock liquidity (Egginton and McBrayer, 2019; Chen et al., 2023; Zhang and Yang, 2023). As corporate environmental strategies can affect investors' judgments, which are finally reflected in the market supply and demand of stocks and, in turn, affect stock liquidity. Combined with our empirical evidence, this indicates that the impact between EID and stock liquidity is bidirectional (the reverse causality bias) (Chang et al., 2019; Hope and Liu, 2023). To address these concerns, we employ multiple approaches.

4.3.1. DID and PSM-DID

The exogenous event that affects stock liquidity can distinguish the impact that stock liquidity and other unobservable variables have on EID quality, which can identify the causal relationship more precisely (Fang et al., 2014). It can also eliminate the influence of the reverse causality problem as it contributes to controlling the possible reverse relationship between EID quality and stock liquidity.

In order to alleviate endogeneity concerns, we apply a DID model of interconnection of China's stock market and a PSM-DID to investigate the impact of stock liquidity on EID quality. The *Shanghai-Hong Kong Stock Connec*t (SHHKSC) began in 2014 and the *Shenzhen-Hong Kong Stock Connect* (SZHKSC) began in 2016 have resulted in greater transparency and openness in China's capital market, thereby enhancing the propensity of domestic and foreign investors to engage in the Chinese market, which has led to a notable increase in stock liquidity (Sha et al., 2022). The SHHKSC and SZHKSC system determines the list of targeted companies in batches. This provides scenarios of exogenous events and precisely determines the treatment and control groups. We construct a multi-period DID model based on whether the target company's stocks are listed in SZHKSC or SHHKSC, and the specific year in which the company was listed. The DID model is constructed as follows:

$$EID_{it} = \alpha_0 + \alpha_1 Treat_i \times Post_t + \sum_i^J \alpha_j \, Controls + + \mu_i + \gamma_t + \varepsilon_{it} \tag{6}$$

In Equation 6, $Treat_i$ is the stock dummy variable. If the firm's stock is a SHHKSC or SZHKSC stock, the value is 1; otherwise, it is 0. $Post_t$ is the time stock *i* joined SHHKSC or SZHKSC. The value is 1 after the year that stock *i* joined. Otherwise, it is 0. The definitions of other variables are the same as Equation 2. In the PSM-DID analysis, using the caliper nearest neighbor matching method in a ratio of 1:2 and the control variables as matching variables, we have assigned a new control group for the treatment group.

Columns (1) and (2) of Table 5 display the regression results, and the coefficient of $Treat_i \times Post_t$ in both DID and PSM-DID and positively significant at the 5% level. These findings indicate that the observed positive relationship between stock liquidity and EID quality is not attributable to reverse causality. We then further conduct a parallel trend test to ensure the effectiveness of DID, as presented in Figure 1, the sample regression has passed the parallel trend test. We include policy variables that are more than four years prior to the start of the policy in the fourth year before the policy, and take the first year before the policy as the base period (Sha et al., 2022).

Table 5. Endogeneity concerns.

Variables	(1) DID *EID*	(2) PSM-DID	(3) 2SLS	(4)	(5) Lagged liquidity
Liquidity				0.001*** (9.88)	
Max			0.991*** (517.22)		
DID	0.056** (2.54)	0.057** (2.56)			
					0.108*** (2.08)
					0.068** (2.34)
					−0.0008** (−2.39)
Constant	−1.177*** (−4.50)	−1.186*** (−4.54)	-4.717*** （-3.03）	-1.251*** -4.81	−0.733* (−1.65)
Controls	YES	YES	YES	YES	YES
Company FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Observations	28,055	28,042	27,991	27,991	13,236
R-squared	0.341	0.341	−	0.341	0.280

Note: Robust standard errors at the firm level and reported parentheses. Year and firm fixed effects are included.

*Significant at 10% lower levels.

**Significant at 5% lower levels.

***Significant at 1% lower levels.

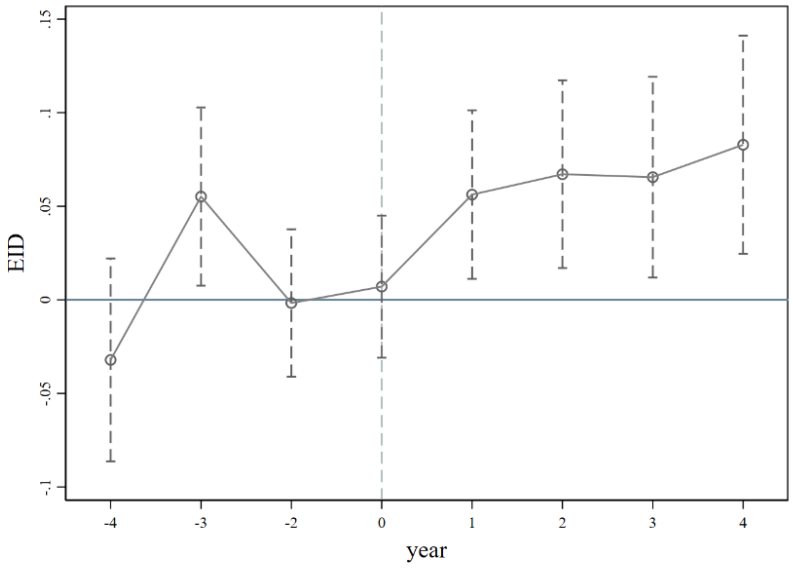

Figure 1. Parallel trend test.

4.3.2. 2SLS

The instrumental variable method is employed to further address the issue of reverse causality. We use the highest corporate stock liquidity in a certain industry that year as the instrumental variable (Shang, 2020). Generally speaking, companies within the same industry tend to exhibit similar characteristics, and will see the industry-leading company as a role model for learning and imitation. Consequently, there is no direct correlation between the industry-leading company's stock liquidity and the *i*-th company's EID quality in the industry. The industry-leading company's stock liquidity can only indirectly affect the *i*-th company's EID quality by affecting the *i*-th company's stock liquidity. In such cases, the instrumental variable meets the criteria for correlation and exogeneity and satisfies the requirements of IV approach (Edmans et al., 2012).

As presented in Table 5, in the first stage of 2SLS analysis, we use Max Liquidity as the independent variable and stock liquidity as the dependent variable. In column (3), *Max* has a significantly positive impact on stock liquidity. In the second stage of 2SLS, the coefficient of column (4) is statistically positive and significant at 1% level.

4.3.3. Lagged independent variable

To address the issue of reverse causality, we employ a long-lagged measure of stock liquidity (at t−3, t−4, and t−5) as the independent variable, and present the findings in the column (5) of Table 5. The results demonstrate that the positive association between liquidity and EID quality remains consistent when using long-lagged liquidity measures. In conclusion, the findings of this study indicate that reverse causality does not cause an influence on the observed relationship.

4.4. Robustness test

4.4.1. Alternative measure of EID quality

To test the robustness of the benchmark results, we employed an alternate measure of EID quality for regression. The benchmark analysis constructs the weighted EID quality by summing the score of each component with equal weights. In contrast, the importance and information content of different components may vary, which means assigning weights to different components on the basis of their importance, and that recalculating the EID quality should be considered (Khosroshahi et al., 2021).

We measure the importance of each component by the degree of its dispersion. By calculating each component's coefficient of variation (*CV*), we can possess the dispersion level of each indicator. As *CV* increases, so does the data's information dispersion and content level, thus elevating its significance. Therefore, the *CV* of each component is used as the multiplier, and by summing the new scores, we obtain the weighted EID quality. The regression result in column (1) of Table 6 is in agreement with our baseline results, indicating the robustness of the benchmark results.

Table 6. Robustness test.

Variables	(1) Weighted EID *EID*	(2) Turnover	(3) Time window	(4)	(5)
Liquidity	0.001**		0.001**	0.001***	0.001***
	(2.33)		(2.57)	(2.80)	(2.88)
Turnover		0.015**			
		(2.53)			
Constant	−1.979***	−1.394***	−1.127***	−0.589**	−0.031
	(−6.17)	(−5.20)	(−4.17)	(−1.98)	(−0.09)
Controls	YES	YES	YES	YES	YES
Company FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Observations	28,055	28,055	26,197	21,727	17,257
R-squared	0.323	0.341	0.316	0.234	0.181

Note: Robust standard errors at the firm level and reported parentheses. Year and firm fixed effects are included.

*Significant at 10% lower levels.

**Significant at 5% lower levels.

***Significant at 1% lower levels.

4.4.2. Alternative measure of the liquidity indicator

After replacing the dependent variable for robustness test, we further change the independent variable form. the stock's turnover rate is another widely used liquidity indicator (Datar et al., 1998; Banerjee et al., 2007). Its value increases when stock liquidity rises. We process daily data into annual data and use its logarithmic form in the following empirical analysis.

$$Turnover_{i,t} = \frac{1}{N_{i,t}} \sum_{d=1}^{N_{i,t}} Turnover_{i,t,d} \tag{7}$$

In Equation 7, $Turnover_{i,t}$ is the stock *i*'s turnover rate on the day *d i*n year *t*, and other variables have symbolic meanings identical to Equation 2. The results are presented in column (2) of Table 6, and the coefficient continues to exhibit a positive and statistically significant relationship.

4.4.3. Change the time period

The time interval of the original sample is from 2010 to 2023, and we further employ the method of adjusting the sample's time interval to test the sensitivity of stock liquidity on corporate EID quality. We select the sub-samples from 2011 to 2022, 2012 to 2021 and 2013 to 2020 for regression to study whether the promoting effect was altered by changing the sampling window. The results are shown in columns (3) to (5) of Table 6, and our results are robust in different time windows.

4.5. The regulatory effect of climate risk

Climate risk is a threat to human social systems and natural ecosystems. The proliferation of climate risks can have an impact on economic development and financial stability (Li and Pan, 2022), and thus pose challenges to business operations and management. Climate risk can be divided into physical and transitional risks; physical risks are brought about by rising temperatures, while transformation risks are caused by low-carbon transformation (Gambhir et al., 2022). Based on previous research's method, we divided the whole sample into two sub-samples for regression to demonstrate the regulatory role of climate risk in the impact of stock liquidity on EID quality (Akerman et al., 2022; Li and Mao, 2023), testing Hypothesis 2. When the climate risk faced by the firm is lower than the annual median, it is divided into the low climate risk group.

4.5.1. Physical risk

Physical risk may increase production costs in some industries and reduce their demand for raw materials. The increase in physical risks indicates that firms face more severe environmental issues. Whether responding to external doubts about environmental performance or taking social responsibility to protect the environment, firms are more sensitive to EID quality. Table 7 shows the regression results of the regulatory effect of physical risk. The estimated coefficient of stock liquidity in Columns (2) is 0.001, which is significantly positive at the 1% level. This indicates that stock liquidity has a more pronounced beneficial effect on enhancing EID quality when firms face higher levels of physical risks. Hypothesis 2 is proved.

There may be two possible reasons for this result, that is, the promoting effect of EID on building a good reputation, and the uncertainty caused by physical risks to corporate decision-making. First, corporate EID can help firms build good fame, helping them during a crisis. Therefore, firms facing severe climate risks can invest more in CSR activities such as EID to protect themselves from the damage of future severe climate risks. Second, physical risks may generate uncertainty and hurt the firm's financial performance and investment returns (Matsumura et al., 2014). When the level of uncertainty is high, firms usually become more cautious and conservative. However, varying from other decisions, firms have the motivation to invest in EID to reduce systemic risks and increase firm value in the long term. Therefore, firms affected by climate change can improve their EID quality as a risk management strategy to hedge physical climate risks.

Table 7. The regulatory effect of climate risk.

Variables	(1) Low physical risk *EID*	(2) High physical risk	(3) Low transition risk	(4) High transition risk
Liquidity	−0.001	0.001***	0.012	0.002***
	(−0.09)	(3.44)	(1.17)	(2.99)
Constant	−1.531***	−0.703*	−1.437***	−0.474
	(−3.89)	(−1.93)	(−4.40)	(−1.24)
Controls	YES	YES	YES	YES
Company FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Observations	12,918	15,137	12,917	15,138
R-squared	0.350	0.246	0.390	0.286

Note: Robust standard errors at the firm level and reported parentheses. Year and firm fixed effects are included.

*Significant at 10% lower levels.

**Significant at 5% lower levels.

***Significant at 1% lower levels.

4.5.2. Transition risk

Transition risk will challenge the firms' ability to adjust their business and managerial skills. High transition risk means firms must be more cautious about environmental issues to smooth the low-carbon transition period. Therefore, when stock liquidity increases, its regression coefficient to EID is larger and more significant (Li et al., 2020). Columns (3) and (4) of Table 7 show the regression results of the regulatory effect of transition risk. The estimated coefficient of stock liquidity is 0.002, which is significantly positive at the 1% level. Compared to the coefficient in column (3), the significance level is higher. This indicates that stock liquidity has a more pronounced beneficial effect on enhancing EID quality when firms face higher transition risks. Hypothesis 2 is proved.

Unlike physical risks, transition risks enhance liquidity and EID through the firm's internal behaviors. Transition risks may also play a role in promoting corporate environmental performance, as it adversely affects a firm's financial policies. Transition risks may trigger stricter regulations for firms that are considered contributors to climate risk (Painter, 2020), forcing firms to invest more resources in EID.

4.6. Further analysis

The analysis above indicates that stock liquidity has a significant and positive impact on EID quality, which means that the information and governance effects of stock liquidity may be a major factor in determining corporate EID quality. In this section, further analysis is conducted on the governance and information effects of stock liquidity. Then, we perform a joint test between the two effect mechanisms to clarify which path plays a dominant role in determining EID quality.

4.6.1. Mechanism analysis of information effect

The regression results of the information effect are shown in columns (1) and (2) of Table 8. The coefficients of *Liquidity* are positively significant at 5% level. When analyst tracking and information transparency are used as the mechanism variables, the results of mechanism analysis are positive. These findings collectively demonstrate that stock liquidity positively influences EID quality through the information effect.

Based on the theoretical assumptions, the information effect of stock liquidity can promote EID quality. High stock liquidity will attract more informed investors to inject their internal information, such as industrial outlook and economic situation, into the stock of listed firms through trading, leading to an increase in the stock's information content and efficiency (Bennett et al., 2020). The information effect promotes information transmission at the firm level and makes the informational environment more transparent (Nian and Gu, 2022). This mechanism can help focus management's attention on sustainable developing strategies, such as emphasizing environmental disclosure.

Table 8. The mechanism analysis of information effect.

	(1)	(2)	(3)	(4)
Variables	Analyst	Trans	Cost1	Cost2
Liquidity	0.003**	0.036**	−0.0001*	0.000
	(2.47)	(2.53)	(−1.90)	(1.22)
Constant	−8.719***	−117.414***	1.066***	0.020
	(−18.28)	(−15.04)	(3.06)	(1.26)
Controls	YES	YES	YES	YES
Company FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Observations	28,055	27,540	28,055	28,036
R-squared	0.222	0.125	0.017	0.013

Note: Robust standard errors at the firm level and reported parentheses. Year and firm fixed effects are included.

*Significant at 10% lower levels.

**Significant at 5% lower levels.

***Significant at 1% lower levels.

4.6.2. Mechanism analysis of governance effect

Columns (3) and (4) of Table 8 reported the results of the mechanism analysis of governance effect. For the first type of agency cost, the coefficient is negatively significant at the 10% level. For the second type of agency cost, the coefficient of *Cost2* and *Liquidity* did not pass the significance test, suggesting that the mediating effect of the second type of agency cost is insignificant. In summary, the governance effect of stock liquidity is mainly achieved by reducing the first type of agency costs, thereby improving EID quality.

As for the governance effect, the increasing stock liquidity facilitates institutional investors to purchase shares, and they are entitled to monitor firms and their agents through "voice intervention." Moreover, the possibility of "exit threat" is enhanced by the increasing stock liquidity, which also facilitates the exit of institutional investors (Nian and Gu, 2022). Consequently, higher stock liquidity

mitigates the first type of agency conflicts through the "voice mechanism" and "exit threat" (Dou et al., 2018).

4.6.3. Joint test of information effect and governance effect

To further explore which mechanism of stock liquidity plays a leading role in promoting EID quality, we conduct a joint test of information and governance effects by introducing them in the regression (Nian and Gu, 2022). The regression results of the joint test of information effect and governance effect on stock liquidity are presented in Table 9. The regression results indicate that the coefficients of the information effects are both positively significant in the joint test at the 5% level, respectively. However, the governance effect is insignificant in the regression. This means that when both the information effect and governance effect variables are included in the regression, the role of the information effect will mask the role of the governance effect, and the information effect of stock liquidity is more crucial than the governance effect in increasing EID quality.

Table 9. The joint test of information effect and governance effect.

	(1)	(2)
Variables	*EID*	
Liquidity	0.001**	0.001**
	(2.46)	(2.49)
Analyst	0.014**	
	(2.46)	
Trans		0.001**
		(2.49)
Cost1	−0.001	−0.001
	(−0.14)	(−0.11)
Constant	−1.127***	−1.139***
	(−4.31)	(−4.31)
Controls	YES	YES
Company FE	YES	YES
Year FE	YES	YES
Observations	28,055	27,540
R−squared	0.341	0.335

Note: Robust standard errors at the firm level and reported parentheses. Year and firm fixed effects are included.

*Significant at 10% lower levels.

**Significant at 5% lower levels.

***Significant at 1% lower levels.

5. Conclusion and implications

Stock liquidity in the financial market can affect a firm's environmental decisions. This research investigated how stock liquidity affects corporate EID quality based on a sample of 2,904 listed firms in China from 2010 to 2023. Our findings indicate that: (1) Stock liquidity has a positive impact on the EID quality. Stock liquidity enables firms to adopt more proactive environmental strategies, thereby promoting

sustainable development. Furthermore, the existence of climate risk can reinforce the correlation between stock liquidity and EID quality. Climate risk plays a regulatory role by influencing a company's risk perception and investment decisions. It amplifies the relationship between stock liquidity and the company's EID quality, thereby achieving an increase in EID quality. (2) We further discover that stock liquidity mainly promotes EID quality through two channels: information effect and governance effect. Specifically, the causal relationship between stock liquidity and EID quality is strengthened through high analyst tracking levels and information transparency in information effect. Higher stock liquidity may also be conducive to EID quality by reducing the first type of agency costs in governance effect. (3) The joint test on the information effect and governance effect shows that it is the information effect playing a leading role in determining the impact of stock liquidity on EID quality. Our findings are robust and not affected by endogeneity after a series of tests.

We provide suggestions from the perspective of stakeholders. For policymakers, first, the facilitating effect of stock liquidity on EID quality is more pronounced in an efficient market context. Regulators should ensure an efficient and orderly stock market, promote effective information transmission within and outside firms, and help stock liquidity play an environmentally friendly role (Lin and Li, 2023). Second, the information effect mechanism reflects the role of the capital market, while the governance effect mechanism emphasizes the role of firms. As the information effect plays a major role in the relationship between liquidity and EID quality, the government should fully stimulate the regulatory potential of the capital market and maximize the feedback effect of the information effect. Third, the existence of climate risk will attract stricter public attention and government regulations, therefore it can enhance the positive relationship between financial markets and EID quality. Relevant departments should speed up the improvement of regulatory mechanisms and create market conditions for climate risk to play its regulatory role.

Based on the fact that high liquidity can lead to an improvement in EID quality, we propose recommendations based on research conclusions. For investors, the capital market's sensitivity to corporate environmental strategies has increased due to prominent environmental problems and increasing external environmental concerns. It is incumbent upon investors to pay close attention to the compensation system, reinforce their supervisory role, and seek to mitigate the agency problem (Bebchuk and Fried, 2003; Bebchuk et al., 2017). Such an approach can prevent opportunism and short-sightedness on the part of managers, improve EID quality, and promote the sustainable development path. Second, for firms planning to adopt environmental strategies, external environmental pressures caused by climate risks can be positively utilized to improve their EID quality.

It is important to note that the relative effective spread is typically regarded as the most reliable indicator for gauging stock liquidity. This metric is frequently utilized as a benchmark for calculating low-frequency liquidity. However, there are difficulties in processing high-frequency data and matching our dependent variables, which led to the decision to abandon the use of the relative effective spread as a measure of stock liquidity. This represents an important avenue for further exploration in the future. Additionally, the increasingly sophisticated environmental information disclosure system may facilitate the use of more accurate EID data for more comprehensive and detailed research in the future.

Author contributions

Jinyu Chen: reviewing, editing, conceptualization and supervision. Junqi Liu: writing—original draft preparation. Meng He: methodology, data collection, reviewing.

Use of AI tools declaration

The authors declare they have not used Artificial Intelligence (AI) tools in the creation of this article.

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Conflict of interest

All authors declare no conflicts of interest in this paper.

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