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Research article

Research on the relationship between ESG disclosure quality and stock liquidity of Chinese listed companies

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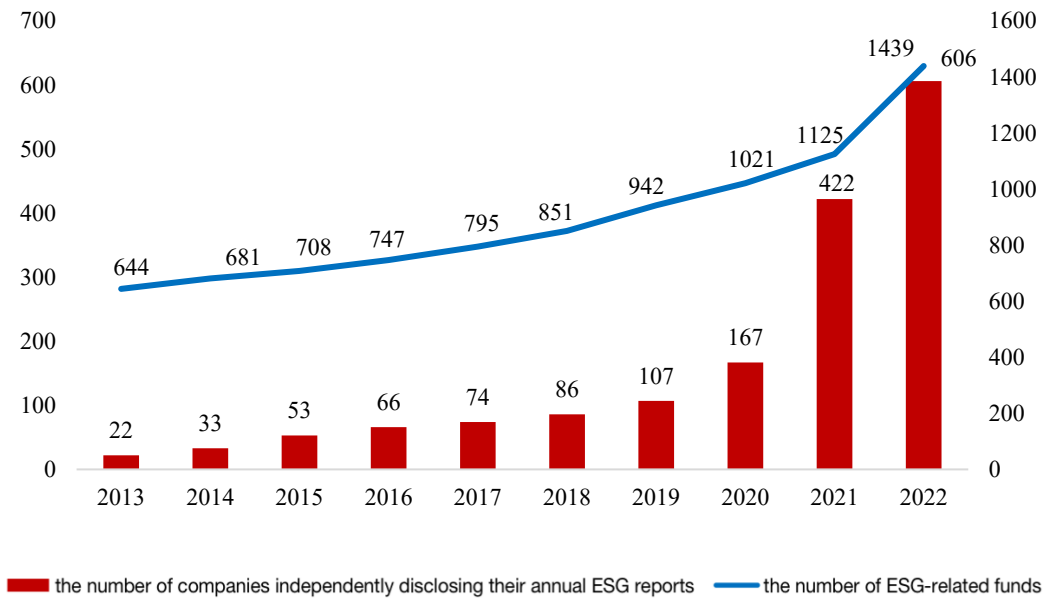
Abstract: In this article, we aim to verify the relationship between ESG disclosure quality and stock liquidity of listed companies and to provide a detailed analysis of its mechanisms. Based on the theories of information asymmetry, signal transmission, reputation, and stakeholder, we summarize and analyze the theoretical and logical framework of how ESG information disclosure can impact stock liquidity. Following the fixed effect (considering individual, year, and industry), panel model was applied to empirically test the relationship between ESG disclosure score and stock liquidity with data ranging from 2012 to 2021. The research findings indicate that improving the quality of ESG disclosure by companies can significantly enhance the level of stock liquidity. Furthermore, we analyze and verify through mechanism tests that ESG disclosure can influence stock liquidity by increasing analyst attention and media coverage (information effect) and enhancing reputation (reputation effect). From a theoretical perspective, the paper enriches the research related to the economic impact of ESG information disclosure and factors affecting stock liquidity. Also, we validate theories connected to information and reputation. From a practical perspective, the research has specific reference value for policymakers, enterprise managers, and investors.

Keywords: ESG disclosure; stock liquidity; listed companies；information effect；reputation effect

JEL Codes: G38

1. Introduction

In recent years, the world has been facing the impact of climate change, COVID-19, geopolitical conflicts, and other events, and the uncertainty of the macro-environment in which businesses operate is growing. In China, with the introduction of the "dual-carbon" target and the shared prosperity strategy, the economic development model is shifting to a new model that considers the environment and social well-being. Against the backdrop of conflict and volatility, the Environment (E), Society (S), and Corporate Governance (G) have become the consensus for the high-quality development of companies and an essential reference for investors' investment decisions in the capital market, which is accompanied by an increase in the willingness of companies to disclose ESG information and the continuous development of the ESG investment market. Figure 1 shows that the number of A-share companies independently disclosing their annual ESG reports has doubled from 644 in 2013 to 1,439 in 2022, and the number of ESG-related funds in China has also risen from 22 in 2013 to 606 in 2022, showing a nearly 30-fold increase in the past ten years.



Source: "China Responsible Investment Annual Report 2022" from SynTao Green Finance.

Figure 1. Number of ESG funds and companies publishing ESG reports.

In this context, it is valuable to understand the economic impact and capital market reaction of corporate ESG disclosure, which is conducive to providing investors with further investment decisions and helps to give some references to the market capitalization management of companies. A large number of scholars research the economic effects of ESG disclosure, such as the impact of ESG disclosure on corporate innovation (Li et al., 2022), corporate financial performance (Tao and Jin, 2012), and financing costs (Qian et al., 2016), which have led to convincing conclusions. More academic research on the impact of ESG disclosure on capital markets is needed. A few studies show a weak positive correlation between ESG disclosure and stock price (Capelle-Blancard and Petit, 2019), which leads to some stock premium and valuation enhancement and helps to reduce stock price

volatility and the risk of stock price collapses (Song et al., 2017b; Sun and Zhou, 2012). However, few scholars have explored the linkage between ESG disclosure and stock liquidity.

As an essential indicator of market interest and trading activity, stock liquidity is also an important dimension of a company's capital market performance. Some studies show that stock liquidity can have a positive effect on firms' performance (Fang et al., 2009), financing costs (Amihud et al., 2015), innovation level (Du et al., 2020), investment efficiency (Sun et al., 2019), and the price of stocks (Kelly and Ljungqvist, 2012). Existing studies show that there are incredibly many factors that affect stock liquidity. At the micro-subject level, stock liquidity may be affected by characteristics such as the firm's equity structure(Brockman et al., 2009), financial performance (Tong and Wei, 2021), and the degree of digital transformation(Wu et al., 2021); at the external level, stock liquidity may be affected by the controlling shareholders(Ke et al., 2020), institutional investor behavior (Wang and Wei, 2021); at the macro level, stock liquidity may be affected by factors such as monetary policy (Fang et al., 2011) and policy uncertainty(Wang et al., 2022). In addition, many studies have shown that alleviating information asymmetry is one of the fundamental reasons for increasing stock liquidity, and corporate disclosure can effectively lessen the level of information asymmetry to impact stock liquidity. Scholars explore the impact of risk disclosure (Yang et al., 2022a), critical audit matter disclosure (Liu et al., 2021), and innovation disclosure (Gao et al., 2022) on stock liquidity, but few scholars explore the marginal impact of ESG-related information.

Based on the above background and the shortcomings of existing studies, this paper studies the relationship between ESG disclosure quality and stock liquidity of listed companies in the A-share market and its impact mechanism. Here, the quality of ESG disclosure refers to the breadth and depth of an enterprise's information disclosure on ESG, such as the richness of information disclosure content and whether it covers multiple dimensions of enterprise ESG performance. The possible contributions of this paper are mainly reflected in the following three aspects. First, we establish a link between ESG disclosure quality and stock liquidity from the research perspective and empirically test the positive correlation between them, which makes up for the lack of existing research. Second, from the theoretical point of view, we analyze and verify the intrinsic mechanism of ESG disclosure affecting stock liquidity, explore the important channel of the reputation effect and the information effect, and further test and enrich the connotation of theories such as reputation theory, signaling, and information asymmetry. We further test and enrich the connotation of reputation theory, signaling, information asymmetry, and other theories. Third, we use the fixed-effects panel regression model that includes individual, time, and industry effects to exclude the interference of the sample's factors on the results as much as possible. Furthermore, we use a variety of robustness tests to ensure the robustness of the model and the persuasiveness of the results.

2. Theoretical foundation and hypotheses

2.1. Theoretical foundation

2.1.1. Information asymmetry theory

In economic activities, different participating subjects have different abilities to acquire information and the degree of utilization of information. Market participants with richer information

are in an advantageous position relative to those with relatively limited information, thus creating information asymmetry. Akerlof founded the information asymmetry theory and first introduced the concept of the "lemon market" (Akerlof, 1970). Existing studies show that information asymmetry and stock liquidity are closely related, and stocks are less liquid when information asymmetry is high in financial markets (Utami et al., 2020).

As important non-financial information of enterprises, improving ESG disclosure quality can reduce the information asymmetry between internal and market investors and let investors better understand enterprises' ESG practices. Cui et al. (2018) verify the inverse relationship between social responsibility disclosure and information asymmetry, further confirming the above view.

2.1.2. Signaling theory

Signaling theory evolved from information asymmetry theory and is considered a meaningful way to reduce the problem of information asymmetry. Spence (1973) first introduced the concept of market signaling, stating that in incomplete information markets such as the job market, information about one's good performance can be communicated to the outside through specific media to attract the attention of the target object (Spence, 1973). Allen et al. (1989) further refined the signaling theory. They argued that given the asymmetry of information between investors and companies, high-quality companies need to send unique signals to the market to demonstrate their intrinsic value, thus obtaining the positive feedback generated by the capital market and being favored by investors and suppliers of finance.

ESG information contains information on social responsibility, fulfilment of environmental obligations, and internal governance, which is beneficial to investors in the market to enhance their overall understanding of the company, thus increasing the attention and liquidity of the stock. Xiao et al. (2015) point out that a high level of social responsibility disclosure can release "quality" signals and increase market effectiveness by reducing principal-agent conflicts and adverse selection (Xiao et al., 2015).

2.1.3. Reputation theory

In the development process of a company, reputation is a valuable asset that can significantly impact long-term operations. In the secondary trading market, investors learn about a company's financial and non-financial condition through public or non-public information. They also form value judgments about a company based on its reputation.

Existing research suggests that the reputations of multiple parties in a capital market impact trading and liquidity. Zhang et al. (2013) argue that highly reputable institutional traders have fewer information asymmetry problems caused by conducting block trades and trade at more favorable prices. Scholars also argued that corporate reputation is essential in market liquidity provision (Battalio, 2007a). Not only that, Li et al. (2020a), based on the data of New Third Board companies, also conclude that the reputation of market makers also affects the liquidity of the stock, which shows the wide range of influence of the reputation mechanism. Companies practicing and disclosing ESG

behaviors will help them build a good reputation, which will enhance the trust of investors and other stakeholders in the company and affect the level of stock liquidity by increasing stock attention.

2.1.4. Stakeholder theory

The stakeholder theory suggests that companies should balance the interests of all parties, not just maximize shareholder wealth; they should not focus only on financial performance but also social benefits. Corporate managers need to respect the needs of all individuals concerned with organizational behavior and outcomes to meet their interests as much as possible (Freeman, 1984). Stakeholder theory requires companies to include the protection of the natural environment, the maintenance of community relations, and the realization of social value as their development and management objectives in addition to shareholder value, thus constituting the theoretical basis for ESG disclosure.

2.1.5. Summarization and central hypothesis

Based on the analysis of theories such as information asymmetry, signaling, reputation mechanism, and stakeholders, we argue that ESG information as a response to the interaction between the company and stakeholders can release a large amount of non-financial information about the company to the outside, thus alleviating the degree of information asymmetry between investors and the company's internal; ESG information can affect the company's reputation and investor's perceptions in the market, thus exerting a strong influence on the investor's investment decisions. Therefore, ESG information can have an impact on stock liquidity. Based on this, we propose the following research hypothesis:

H1: The improvement of the quality of ESG disclosure can help improve stock liquidity.

2.2. Mechanism analysis

Based on the analysis of the above theoretical foundation, we argue that ESG disclosure mainly acts on the liquidity level of stocks through the reputation effect and information effect, and the related analysis is as follows.

2.2.1. Analysis of information effects

From the perspective of information effects, signal transmission and the alleviation of information asymmetry are key factors leading to improved stock liquidity, with the involvement of analysts and media playing essential roles as information intermediaries.

1. Analyst Attention

As interpreters and disseminators of information, analysts play a vital role as intermediaries in the capital market. The presence of analysts can enhance market efficiency and company value (Lang et al., 2003). The improvement in ESG disclosure quality by listed companies attracts greater attention from analysts. On the one hand, existing research indicates that non-financial information enhances the quality of analysts' forecasts, helping analysts gain market recognition and achieve excess returns

(Wang et al., 2013). Thus, analysts not only focus on financial information but also pay attention to companies' non-financial information. On the other hand, improved information disclosure quality reduces analysts' information collection and analysis costs, making them more willing to track such companies and provide more services to investors (Lang and Lundholm, 1996). Empirical analysis by Bai (2009) confirms a positive relationship between the number of analysts following a company's forecasts and the transparency of its information disclosure policy.

When a target company receives more attention and tracking from analysts, it also conveys more signals to the market. Analysts' information collection and processing can further alleviate information asymmetry between external investors and the company, thereby improving the corresponding company's stock liquidity. First, as professional researchers, analysts collect publicly available market information and access specific information that ordinary investors find difficult to obtain through their private channels (Cen et al., 2021a). Additionally, analysts possess professional research skills and industry insights beyond those of individual investors, enabling them to interpret company dynamics and market information comprehensively (Dang et al., 2021), thus reducing information asymmetry between external investors and internal company insiders (Pan et al., 2011). Therefore, when more market analysts track companies with higher ESG disclosure quality, disseminating their interpretations and opinions enriches market information, further reducing the information gap between investors and companies, enhancing attention, and improving the stock liquidity of the corresponding company.

From the above, analyst attention becomes an important mechanism through which ESG disclosure influences stock liquidity.

2. Media Reporting

Media reporting is an important transmission channel for the impact of corporate ESG disclosure on stock liquidity. Information gathering is a prerequisite for stock investment, and investors often need help accessing information disclosed by listed companies due to information channels and cognitive constraints. Media outlets can effectively disseminate company information to a broader audience and potential investors, thus significantly reducing information asymmetry between internal and external stakeholders(Fang and Peress, 2009).Solomon (2012) finds that investors compare the importance of information based on media coverage.[40] Moreover, media interpretations of companies' disclosed information often carry objectivity and independence, leading the public to trust the information conveyed by independent third-party media outlets (Groza et al., 2011). Therefore, the media plays a vital role in influencing public investment decisions and reducing information asymmetry in the capital market, thereby shaping stock market liquidity. In addition, the media also fulfils a supervisory role, effectively reducing agency costs for companies (Kuang et al., 2019). Based on this, Luo et al. (2014) verify the positive effects of media as an information intermediary and public supervision, reducing the risk of stock price collapse. Wang et al. (2015) suggest that companies can improve their capital market pricing efficiency and reduce underpricing through media management behavior. The mitigation of stock price collapse risk and improving pricing efficiency are also beneficial for stabilizing investors, reducing bid-ask spreads, and increasing stock liquidity. ESG information, as a valuable supplement to non-financial company information, attracts increased media attention as its breadth and quality of disclosure improve. The studies by Huang et al. (2022) and Dong (2018) demonstrate a positive correlation between a company's social responsibility index and the

number of media reports. Therefore, media attention is an essential mechanism through which ESG disclosure influences stock liquidity.

Based on the analyses of analyst attention and media reporting, we propose the following hypothesis based on the information effects of ESG disclosure:

H2: ESG disclosure can enhance stock liquidity by increasing analyst attention and media reporting.

2.2.2. Analysis of reputation effects

Based on a series of studies grounded in reputation theory, reputation plays a crucial role in the stock market by facilitating trading by alleviating adverse selection and moral hazard issues (Battalio et al., 2007b). The formation of reputation capital further enhances investor confidence and expedites the establishment of financial contracts (Boot et al., 1993).

ESG disclosure by companies is beneficial in establishing a positive corporate image as a good corporate citizen in the eyes of the public and stakeholders. It conveys critical information about the company's environmental, social, and corporate governance practices, gradually building reputation capital. Research by Shen et al. (2011) finds that improved corporate social responsibility performance enhances corporate reputation, and the disclosure of social responsibility reports significantly strengthens the relationship between the two. Establishing reputation and trust effectively increases investor attention in the market, thereby improving stock liquidity (Blau, 2017a).

Additionally, the reputation capital generated through ESG disclosure can serve as reputation insurance, solidifying investor confidence and reducing the likelihood of hasty sell-offs of held stocks. This effectively mitigates the impact of negative information on the company and the risk of stock price collapse. Based on experimental research, Crifo et al. (2015) find that companies with strong ESG performance are more attractive to private equity investments, and investors have a stronger reaction to disclosures of adverse ESG practices compared to positive ESG disclosures. Therefore, robust ESG disclosure by companies enhances investor confidence, reduces market speculation and sell-off behaviors, mitigates the impact of unit trades on returns, decreases bid-ask spreads, and enhances stock liquidity.

Based on the above analysis, this study proposes the following hypothesis:

H3: ESG disclosure can improve stock liquidity by enhancing corporate reputation.

In conclusion, the theoretical foundation and transmission mechanism of this study are illustrated in Figure 2:

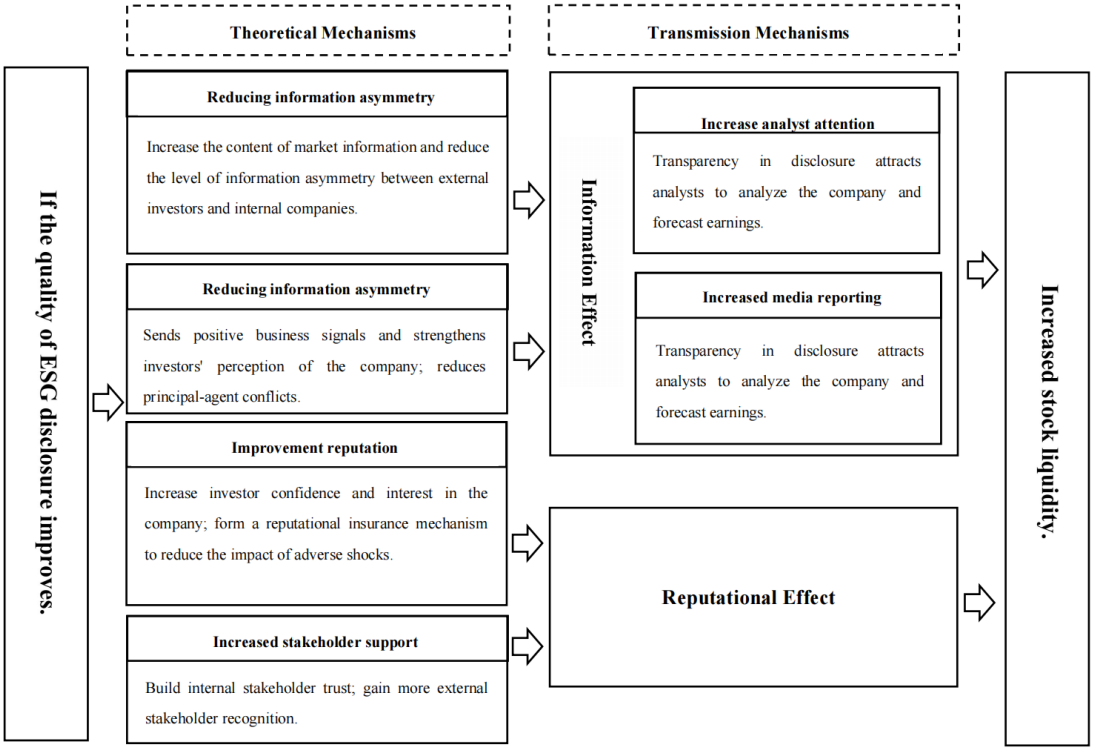


Figure 2. Theoretical foundation and mechanism of action in this study.

3. Empirical analysis

3.1. Sample selection and data processing

In this study, we use annual data from A-share listed companies as the research sample for the period 2012-2021. The original data are sourced from financial databases such as Wind and Guotai An. To ensure data validity, the following data processing steps were taken:

1. Exclusion of companies marked with PT, ST, and *ST (In the Chinese stock market, PT is the abbreviation of Particular Transfer. According to the relevant regulations, if a listed company suffers losses for three consecutive years, etc., its shares will be suspended. ST stocks are stocks of domestic listed companies that have been subject to special treatment for two consecutive years of losses. *ST stocks are stocks of domestically listed companies that have suffered losses for three consecutive years.). These companies have different stock trading rules compared to normal listed companies and are subject to higher risks and more significant impact from market sell-offs.

2. Exclusion of financial and insurance companies. Financial sector companies have distinct industry characteristics.

3. Exclusion of companies listed in 2019 and onwards. These companies lack historical data, and their shorter time series length would affect the regression analysis. Moreover, newly listed stocks tend to have higher volatility and liquidity.

4. Winsorizing the main explanatory and dependent variables at the 1% level. This procedure aims to mitigate the influence of outliers on the regression results by removing extraordinarily high or low values.

5. Exclusion of stocks with partially missing data.

After that, 8,514 observations were selected in the sample, covering 1,243 stocks and 10-year time spans.

3.2. Definition of variables

3.2.1. Explanatory variables

The mainstream ESG rating systems in the market include Wind ESG Rating, Sino-securities ESG Rating, Harvest Fund ESG Rating, SynTao Green Finance ESG Rating, and Bloomberg ESG Disclosure Rating. Among them, Bloomberg's ESG rating is widely adopted in academic research to measure the quality of ESG disclosure (Huang et al., 2023). For example, Li et al. (2020) used this variable as a proxy variable when studying the economic effect of ESG information disclosure. We also adopted the Bloomberg ESG rating as the explanatory variable in the later analysis. This rating is derived from the study of ESG reports, annual reports, and corporate website information, and it assigns a comprehensive score to the level of ESG disclosure based on 120 indicators. Other ESG indicators emphasize measuring a company's ESG performance from multiple perspectives.

3.2.2. Dependent variable

Zhang et al. (2014) conducted a comparative study on different liquidity measures in the A-share market. They found that the Amihud illiquidity measure is the best choice for capturing low-frequency liquidity. Furthermore, foreign scholars' widely used turnover ratio is unsuitable for the Chinese market. Also, Amihud illiquidity considers both the price and volume of stock trade compared to other indexes like turnover ratio which is singly based on trading volume. Many authors have adopted this index in previous research on the stock market. Ng et al. (2016) verified the influence of foreign investors on stock liquidity based on the improved illiquidity index.

Therefore, we adopt the Amihud illiquidity measure to represent stock liquidity. This measure reflects the impact of investors' trades on stock prices (returns). The more significant the impact of trades on prices (returns), the higher the trading costs and the lower the stock liquidity. The construction method for Amihud liquidity is as follows:

$$\mathrm{Amihud}_{i,t} = \frac{1}{D_{i,t}} \sum_{d=1}^{D_{i,t}} \frac{|R_{i,t,d}|}{VOL_{i,t,d}} \tag{1}$$

Among them, $D_{i,t}$ represents the actual trading days of stock i in year t, $R_{i,t,d}$ represents the daily return of stock i considering cash dividends reinvested on the dth day of the tth year, and $VOL_{i,t,d}$ represents the transaction amount (in millions of RMB) on that day. The Amihud measure captures the impact of transaction amount on stock returns. A higher value of this measure indicates a more significant impact of unit transaction amount on stock returns, reflecting lower stock liquidity. To

facilitate the interpretation of empirical regression results and address the issue of the small scale of this measure, this study takes the natural logarithm of the measurement and negates it. Thus, the Liquidity measure is higher when stock liquidity is stronger.

$$\text{Liquidity}_{i,t} = -\ln(\text{Amihud}_{i,t}) = -\ln\left(\frac{1}{D_{i,t}} \sum_{d=1}^{D_{i,t}} \frac{|R_{i,t,d}|}{VOL_{i,t,d}}\right) \quad (2)$$

3.2.3. Control variables

Various macroeconomic, industry-specific, and firm-specific factors can influence stock liquidity. In studies examining the determinants of stock liquidity in listed companies, researchers often pay additional attention to factors such as ownership structure, profitability, and market performance. Referring to the studies of previous scholars, we select the company size, the debt ratio, company duration, ownership concentration, return on net assets, degree of stock volatility, and type of audit opinion as control variables. In addition, we control for individual-level, year-level, and industry-level fixed effects.

Taking into account the core explanatory variable, ESG disclosure quality, the dependent variable, stock liquidity, and the control variables introduced in this study, the symbols representing each variable and their specific descriptions are presented in Table1 below:

Table 1. Relevant variables and characterization methods in the model.

Variable type	Variable	Variable symbol	Variable Characterization Methods
Dependent Variable	Stock Liquidity	Liquidity	negative of the natural logarithm of the Amihud illiquidity measure
Test variable	ESG disclosure level	ESG	Bloomberg ESG disclosure quality score (0-100)
		IsReport	Whether the company has disclosed an independent ESG report for the current year (0、1)
controlled variable	company scale	Size	Natural logarithm of the operating revenue scale (in billions) plus 1
	Debt-to-Asset Ratio	Lev	Total Liabilities/ Total Assets Ratio (%)
	Duration	Lifetime	Natural logarithm of the duration of existence (in years) plus 1
	Degree of Equity Concentration	Top10	Sum of the ownership percentage of the top ten shareholders (%)
	Stock Volatility	Yvol	Annual standard deviation of the daily stock returns (%)
	Return on Equity	Roe	Net Assets /Net Profit Ratio (%)
	Types of Audit Opinions	Audit	If the audit opinion issued for the previous year's annual report in the current year is an unqualified opinion (standard opinion without reservations), assign a value of 1. For all other types of audit opinions, assign a value of 0.
	Individual	Individual	Individual Dummy Variables
	Year	Year	Time Dummy Variables
	Industry	Industry	Industry Dummy Variables

3.2. Model specification

In this study, we employ a fixed effects multiple regression model to examine how ESG disclosure affects stock liquidity. The main regression model is specified as follows:

$$\text{Liquidity}_{i,t} = \alpha_0 + \alpha_1 \text{ESG}_{i,t-1} + \sum_j \beta_{j,i,t} \text{Controls}_{j,i,t} + \varepsilon_{i,t} \quad (3)$$

The dependent variable in the regression is the level of stock liquidity, the core explanatory variable is the ESG disclosure quality score, and Controls refer to the control above variables. In examining the relationship between ESG report disclosure (binary variable) and ESG sub-dimensions with stock liquidity, the model follows the primary regression model by replacing the core explanatory variable accordingly.

To enhance the reliability of the regression results, this study implemented the following procedures:

First, considering that the ESG and ESG sub-dimensions ratings from the Bloomberg database, as well as the indicator of whether ESG reports were disclosed for year t, are sourced from reports disclosed in year t+1, a lag of one period was applied to accurately reflect the impact of ESG data disclosed by companies in the current year on their stock liquidity, ensuring accuracy.

Second, all regression equations incorporated fixed effects for individual companies, years, and industries to minimize the interference of heterogeneity between variables. Additionally, to account for heteroscedasticity and mitigate its impact on experimental results, t-statistics were adjusted using robust standard errors.

These adjustments were made to improve the regression results' reliability and validity and address potential biases and issues associated with data availability and heterogeneity.

4. Empirical results and analysis

4.1. Descriptive statistics

Table 2. Descriptive statistics of variables.

Variable	Observation value	Mean	Standard Deviation	Minimum Value	1/4 quantile	Median	3/4 quantile	Maximum Value
Liquidity_t	8514	8.590	0.967	2.874	7.959	8.627	9.275	10.761
ESG_{t-1}	8514	26.291	7.178	11.236	0.000	26.340	30.077	53.103
Size_t	8514	4.031	1.262	0.047	3.141	3.988	4.898	7.028
Lev_t	8514	47.477	19.372	5.627	32.301	48.570	62.352	92.988
Lifetime_t	8514	3.003	0.268	1.609	2.833	3.045	3.178	3.584
Top10_t	8514	59.294	15.098	22.990	48.290	59.515	70.140	93.330
Roe_t	8514	8.727	10.945	−59.982	3.616	8.387	14.052	51.628
Yvol_t	8514	44.326	17.534	17.567	32.077	40.517	51.824	146.646
Audit_t	8514	0.982	0.132	0.000	1.000	1.000	1.000	1.000

After data cleaning and organization, our main analysis of this study yielded 8,514 observations, covering 1,243 stock tickers and ten years. The sample covers stocks of different A-share sectors

(including The Main Board Market, The Science and Technology Innovation Board Market, second market), and all kinds of industries, which can ensure the integrity and comprehensiveness of the sample. Among the 1,243 stocks, 635 are private enterprises, and 608 are state-owned enterprises; 770 are manufacturing companies, and the left is quite diversified, like IT, Real estate, transportation, etc. As shown in Table 2, the dependent variable, stock liquidity (Liquidity), ranges from 2.87 to 10.76. The mean and median values are around 8.60, indicating that most companies maintain relatively good liquidity. The core explanatory variable ESG disclosure quality (ESG) is evenly distributed, with scores ranging from 11.24–53.10. The distribution patterns of the core and control variables are consistent with prior research, demonstrating their reasonable distribution characteristics.

4.2. Correlation analysis

Table 3. Matrix of variable correlation coefficients.

	Liquidity_t	ESG_{t-1}	Size_t	Lev_t	Lifetime_t	Top10_t	Roe_t	Yvol_t	Audit_t
Liquidity_t	1								
ESG_{t-1}	0.256***	1							
Size_t	0.383***	0.308***	1						
Lev_t	−0.052***	0.041***	0.490***	1					
Lifetime_t	0.094***	0.320***	0.078***	0.099***	1				
Top10_t	−0.155***	0.108***	0.225***	0.038***	−0.189***	1			
Roe_t	0.205***	0.033***	0.099***	−0.167***	−0.032***	0.182***	1		
Yvol_t	0.071***	−0.093***	−0.067***	−0.050***	−0.015	−0.013	−0.021*	1	
Audit_t	0.082***	0.017	0.057***	−0.044***	−0.036***	0.022**	0.076***	−0.003	1

Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

The tables 3 and 4 presents the correlation coefficient matrix of the main variables in our primary analysis. The lower triangle of the matrix displays the Pearson correlation coefficients. Based on the correlation coefficients, there is a significant correlation between the dependent variable Liquidity_t and the core explanatory variable ESG disclosure quality (ESG_{t-1}). At a significance level of 1%, they exhibit a positive correlation, providing preliminary support for the central hypothesis. Furthermore, liquidity positively correlates with company size, tenure, profitability, stock return volatility, and audit opinion type. It demonstrates significant negative correlations with the company's asset-liability ratio and ownership concentration, which aligns with our initial expectations. The correlation analysis reveals the relationships among the variables and provides initial evidence of their associations. The significant correlations observed between the dependent variable and both the core explanatory variable and various control variables support the alignment with our hypothesis. From the perspective

of coefficients, the correlation coefficients between variables are all below 0.7, indicating no significant collinearity among the variables (Judge et al.,1988). We also conducted Variance Inflation Factor (VIF) tests to examine multicollinearity further. The VIF values for each variable are below 2, satisfying the requirement of less than 5. Therefore, it can be concluded that there is no multicollinearity among the variables, ensuring the robustness of the analysis.

Table 4. VIF test results.

Indicator	VIF	1/VIF
ESG_{t-1}	1.28	0.78
$Size_t$	1.61	0.62
Lev_t	1.46	0.69
$Lifetime_t$	1.20	0.84
$Top10_t$	1.15	0.87
Roe_t	1.11	0.90
$Yvol_t$	1.01	0.99
$Audit_t$	1.01	0.99
Mean VIF	1.23	0.84

4.3. Regression results

Table 5 presents the regression results of the main test of the paper. Column (1) includes only the major explanatory variables, while columns (2) include additional control variables. According to the regression results, we can find that the coefficient of the former is positive at 1% significance level regardless of whether the control variables are added or not, proving that the quality of corporate ESG disclosure can significantly improve the liquidity of stocks. The regression results also show that after including control variables, the coefficient of ESG_{t-1} is 0.009; that is, for every point increase in the ESG disclosure score of listed companies, their Amihud illiquidity indicator decreases by 0.9% (constructing the liquidity indicator by taking the logarithm of the Amihud indicator and then taking the negative, through the reduction of the indicator represents the impact of the average daily unit turnover on the stock return decreases by 0.9%, and the liquidity of the stock is enhanced).

Table 5. Main regression results.

Indicator	(1) Liquidity	(2) Liquidity
ESG_{t-1}	0.011^{***}	0.009^{***}
	(5.565)	(5.114)
$Size_t$		0.496^{***}
		(24.062)
Lev_t		-0.007^{***}
		(−7.770)
$Lifetime_t$		0.769^{***}
		(4.221)
$Top10_t$		-0.021^{***}
		(−15.464)
Roe_t		0.008^{***}
		(8.974)
$Yvol_t$		0.001
		(1.469)
$Audit_t$		0.261^{***}
		(3.549)
_cons	8.300^{***}	5.283^{***}
	(156.839)	(9.103)
Individual FE	Control	Control
Year FE	Control	Control
Industry FE	Control	Control
N	8474	8474
R^2	0.715	0.772
adj. R^2	0.667	0.733

Note：* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

4.4. Robustness and endogeneity tests

4.4.1. Robustness test

1. Variable Replacement

To ensure the robustness of the research results, alternative variables are used for both the core explanatory variable and the dependent variable. In particular, for the dependent variable, following the approach of Yang et al. (2022b), the GAM (Gross Accumulated Momentum) indicator is used as a replacement for the Amihud illiquidity measure in the regression. By the way, the Bid-Ask spreads, which is widely used by foreign scholars to measure stock liquidity, is not fully applicable to the Chinese stock market (Zhang et al., 2014). The GAM indicator was introduced by Pástor et al. (2003), and its calculation method is as follows:

$$R^{e}_{i,d+1} = \theta_i + \varphi_i R_{i,d} + \gamma_i \mathrm{sign}\left(R^{e}_{i,d}\right) * dvol_{i,d} + \epsilon_{i,d+1} \tag{4}$$

$$GAM = -10^6|\gamma_i s| \quad (5)$$

Among them, $R^e_{i,d} = R_{i,d} - R^M_d$ represents the excess return of stock i on d^{th} day (R^M_d weighted average market return by market capitalization). The sign is the sign function, taking a value of 1 when the value inside the parentheses is greater than 0, -1 when it is less than 0, and 0 when it is equal to 0. Scholar Pástor believes that in markets with good stock liquidity, the current excess returns should be unrelated to future stock returns, meaning the coefficient in front of the sign function should be 0. Therefore, the absolute value of γ_i can be used as a reverse measure of stock liquidity, denoted as GAM. A smaller GAM value indicates better liquidity for stock i in year t. In the following regression, for convenience of coefficient observation, the GAM value is amplified by 10^6 and taken as the negative value. In this case, the larger the value, the stronger the liquidity.

The explanatory variable is replaced with the Hexun ESG Index instead of the Bloomberg ESG Index. Hexun assesses the information disclosure quality based on ESG reports released by listed companies. The assessment results are categorized into A, B, C, D, and E, corresponding to score intervals [80,100], [60,80), [40,60), [20,40), [0,20). The Hexun ESG Index and Bloomberg ESG Index are similar in that they both consider the quantity and comprehensiveness of enterprise ESG information disclosure in different aspects. While the difference is that the subdivision indicators selected and the weights assigned to them are different. Therefore, the Hexun ESG Index variable can also effectively reflect the ESG disclosure level of listed companies.

The regression results with replacement variables (see Table 6) are consistent with the main regression results.

Table 6. Robustness Test – Variable replacement.

Indicator	(1) GAM_t	(2) GAM_t	(3) $Liquidity_t$	(4) $Liquidity_t$
ESG_{t-1}	0.135**	0.121**		
	(2.390)	(2.187)		
HX_ESG_{t-1}			0.004***	0.002***
			(7.401)	(3.423)
Controls	Control	Control	Control	Control
Individual FE	Control	Control	Control	Control
Year FE	Control	Control	Control	Control
Industry FE	Control	Control	Control	Control
N	8127	8127	6933	6933
R^2	0.377	0.407	0.729	0.776
adj. R^2	0.267	0.302	0.677	0.733

Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

2. Lagged period test

To eliminate the potential result randomness caused by insufficient representativeness of the sample and explore possible lagged effects of ESG disclosure on stock liquidity, we conduct tests by lagging the core explanatory variable by one period and leading the dependent variable by one period. As shown in Table 7, regardless of whether the core explanatory variable ESG_{t-1} is lagged or the dependent variable is leading, the results remain significantly positive at a 1% level of significance. This result further validates the robustness of the main regression results.

Table 7. Robustness Test - Lagged period test.

Indicator	(1) GAM_t	(2) GAM_t	(3) $Liquidity_t$	(4) $Liquidity_t$
ESG_{t-2}	0.007***	0.005***		
	(3.260)	(2.668)		
ESG_{t-1}			0.007***	0.006***
			(3.234)	(2.784)
Individual FE	Control	Control	Control	Control
Year FE	Control	Control	Control	Control
Industry FE	Control	Control	Control	Control
N	6933	6933	6933	6933
R^2	0.727	0.776	0.726	0.763
adj. R^2	0.674	0.733	0.674	0.717

Note：* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

3. Changing Time Windows

Within the time series of the sample, there are two significant financial shocks, namely the stock market crash in 2015 and the impact of the COVID-19 pandemic in 2020. Based on this, the present study conducts regression analysis by excluding the data from 2015 and 2020 separately to assess the robustness of the main findings. The empirical results in Table 8 indicate that regardless of whether the data from 2015 or 2020 is excluded, or if both years are excluded together, the coefficient before the core explanatory variable ESG_{t-1}remains significantly positive. The economic significance of the estimated coefficients does not exhibit significant changes compared to the analysis with the original time window. Therefore, the core conclusion that "improving ESG disclosure quality enhances stock liquidity" remains unchanged.

Table 8. Robustness Test - Changing time windows

Indicator	(1) excluding 2015 $Liquidity_t$	(2) excluding 2015 $Liquidity_t$	(3) excluding 2015 $Liquidity_t$
ESG_{t-1}	0.010***	0.009***	0.010***
	(5.954)	(4.569)	(5.366)
Controls	Control	Control	Control
Individual FE	Control	Control	Control
Year FE	Control	Control	Control
Industry FE	Control	Control	Control
N	7679	7447	6651
R^2	0.804	0.771	0.804
adj. R^2	0.767	0.728	0.763

Note：* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

4.4.2. Endogeneity test

The empirical analysis in this paper using a fixed effects model with individual effect, time effect and industry effect mitigates the endogeneity bias that may be caused by omitting variables related to fixed factors but fails to address the endogeneity problem caused by other reasons, such as missing non-fixed factor variables and reverse causation. For example, Nian et al. (2022) test that enhancing a company's stock liquidity positively affects fulfilling its social responsibility. In contrast, Chang et al. (2017) come to the opposite conclusion using the data of listed companies in the U.S. as a sample. Therefore, the following endogeneity test is conducted with the help of the instrumental variable approach.

Referring to Li et al. (2022) and Li et al. (2020), we select the mean value of whether the annual report disclosed by the company in the current year is audited by the Big Four accounting firms and the quality of disclosure of other companies in the same industry in the same year as the instrumental variable. The selected instrumental variables fulfil the requirements of homogeneity and relevance. From the theoretical logic, the Big Four accounting firms emphasize the ESG practice and disclosure of companies, whether the company is audited by the Big Four will potentially affect the quality of its ESG disclosure, but the probability of affecting the liquidity of the company's stock is very small. The level of disclosure of other companies in the same industry may affect the quality of disclosure of a particular company itself (due to the similarity of accounting policies, competition, etc.). However, it is difficult to have a direct impact on the correlation on the liquidity of that company's stock. Therefore, the two instrumental variables are initially considered to meet specific requirements.

Next, we use the xtivreg2 command in Stata to obtain the instrumental variable endogeneity test results. From the results of a series of tests against the instrumental variables, the value of the Cragg-Donald Wald F-statistic is 14.00, which is greater than the critical value of 15% bias. Therefore, it is concluded that there is no weak instrumental variable problem. The Kleibergen-Paap rk LM test statistic has a value of 20.01 with a p-value of 0.00, which rejects the original hypothesis that the instrumental variables are not identifiable at the 1% significance level and passes the test of non-identifiability. The Hansen J-test has a p-value of 0.81; thus, the original hypothesis that at least one of the instrumental variables is endogenous can be rejected by the over-identification test. Therefore, the two instrumental variables selected in this paper satisfy the requirements of relevance and exogeneity and are reasonable instrumental variables. The results of the endogeneity test using instrumental variables and two-stage least squares for the core explanatory variables show that the p-value of the correlation statistic test is 0.31, which should reject the original hypothesis of endogeneity of the core explanatory variables, i.e., it proves that there is no endogeneity in the model. The test statistics obtained in this step are shown in Table 9 below:

Table 9. Results of the instrumental variables approach to testing endogeneity.

Type of Test		Test Statistic	Value of the statistic	P-value/Threshold	Conclusion
Instrumental Variables Test	Under identification test	Kleibergen-Paap rk LM	20.01	0.00	Instrumental variables are sufficient
	Weak identification test	Cragg-Donald Wald F	14.00	11.59 (Stock-Yogo 15%threshold value)	Instrumental variables meet relevance requirements
	Over identification Test	Hansen J	0.06	0.81	Instrumental variables meet exogeneity requirements
Endogeneity Test		Regression Coefficient	1.03	0.31	Core explanatory variables are not endogenous

5. Mechanisms by which ESG disclosure affects stock liquidity

Based on the interpretation of the theoretical part, referring to the mechanism testing method recommended by Jiang (2022) and adopted by Wu et al. (2022), we select two types of channels, namely, the information effect (analyst attention and media reporting) and the reputation effect, for intermediate mechanism testing. The relationship between the mediating variable (Median) and the core explanatory variable (ESG) is first verified (see formula 6). If the coefficients of the core explanatory variables are significant after the regression and there is a more significant relationship between the mediator variable and stock liquidity (Liquidity) (which is supported by a large body of theory and literature), then the mediator variable can be presumed to play an important mechanistic role in the main test. This test effectively avoids the potential endogeneity problem associated with the three-step approach to mediation effects.

$$\mathrm{Median}_{i,t} = \partial_0 + \partial_1 \mathrm{ESG}_{i,t-1} + \sum_j \beta_{j,i,t} \mathrm{Controls}_{j,i,t} + \varepsilon_{i,t} \quad (6)$$

5.1. Information Effects Analysis

Theoretically, as ESG information is an important complement to financial information, an improvement in its disclosure quality will attract more attention from analysts and the media, thus transmitting more information to market participants. To test whether the improvement in ESG disclosure quality leads to increased analyst coverage and media intensity, we follow the approach used in existing literature and measures analyst attention by the number of earnings forecasts published by securities analysts for a specific listed company and the number of research reports published by securities analysis institutions (Liu et al., 2022; Zhou et al., 2014; Luo, 2012). Media intensity is measured by the number of online and print media reports on the company. These four indicators are regressed against the core explanatory variable, ESG disclosure quality. The estimation results in Table

10 show that, after controlling for individual, time, and industry fixed effects, the coefficients of the ESG disclosure quality variable are all significantly positive. This indicates that the improvement in ESG disclosure quality significantly increases the level of analyst attention and media coverage. On average, for each one-point increase in the ESG disclosure score of a company, there is an increase of 0.14 in the number of analyst earnings forecasts and an increase of 0.31 in the number of research reports published. Additionally, there is an average increase of 3.41 online media reports and 20.27 print media reports.

Table 10. Regression results of information effect test.

Indicator	（1） Analyst Profit Forecasts Number	（2） Research Reports Number	（3） Online Media Reports Number	（4） Number of Print Media Reports
ESG	0.140***	0.310***	3.407*	20.265***
	(4.704)	(3.875)	(1.808)	(3.692)
Controls	Control	Control	Control	Control
Individual FE	Control	Control	Control	Control
Year FE	Control	Control	Control	Control
Industry FE	Control	Control	Control	Control
N	6875	6877	8456	8298
R^2	0.731	0.716	0.792	0.583
adj. R^2	0.676	0.658	0.757	0.511

Note：* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Based on signaling theory, information asymmetry, and other related theories, analysts and the media serve as important disseminators and interpreters of market information. They effectively mitigate information asymmetry between investors and companies, deepen external stakeholders' understanding of the company, and increase investor attention. Numerous studies have confirmed a positive relationship between analyst attention or media coverage and stock liquidity. Cen et al. (2021b) find a positive correlation between analyst coverage of listed companies and stock liquidity using A-share market data. Li et al. (2022), in their study on the impact of the opening of China's capital market, also identify analyst attention as an important path for improving stock liquidity. Furthermore, Holden et al. (1992) suggest that multiple analysts tracking the same stock increase the number of informed traders, intensify competition, enhance market information, reduce uncertainty for uninformed investors, and thus improve stock liquidity.

Likewise, media coverage, as another important medium of information dissemination, can also significantly influence stock liquidity. Companies that disclose ESG information through the media can meet the demands of various stakeholders and gain more market recognition (Zeng et al.,2018). Chen (2016) argues that an increase in media attention improves a company's information transparency, thereby enhancing stock liquidity. Wang Bing et al. (2017) and Li et al. (2018), focusing on social media, demonstrate the important role of online social media in enhancing stock market liquidity.

In summary, the above analysis and tests provide substantial evidence supporting Hypothesis 2, which suggests that analyst attention and media coverage play crucial intermediary roles in the relationship between ESG disclosure and stock liquidity.

5.2. Reputation effects analysis

Based on reputation and stakeholder theory, companies that disclose their ESG information can convey positive information about their environmental protection, social responsibility, and corporate governance practices to stakeholders. Improving ESG disclosure quality can enhance investors' comprehensive understanding and recognition of the company, leading to the formation of a market reputation.

To test the relationship between ESG disclosure quality and corporate reputation, this study follows the approach used by Guan et al. (2019). It constructs indicators to measure corporate reputation using a reputation evaluation system (Guan and Zhang, 2019). First, twelve reputation reference indicators[1] were selected, including industry rankings of assets, revenue, net profit, and value from a social and consumer perspective; debt ratio, current ratio, and long-term debt ratio from a creditor perspective; dividends per share, earnings per share, and whether the company is audited by one of the Big Four accounting firms from a shareholder perspective; and sustainable growth rate and proportion of independent directors from a corporate perspective. Factor analysis was then used to calculate the corporate reputation score. Finally, the scores were sorted from low to high and divided into ten groups, each assigned values ranging from 1 to 10. The obtained corporate reputation indicators were regressed against the core explanatory variable, ESG disclosure quality. The estimation results show that the coefficient of the ESG variable is 0.009, significant at the 1% level, indicating that the improvement in ESG disclosure quality significantly enhances the company's reputation.

Table 11. Regression results of the reputation effect test.

Indicator	(1) Company reputation indicator
ESG	0.009***
	(5.10)
Controls	Control
Individual FE	Control
Year FE	Control
Industry FE	Control
N	7682
R^2	0.793
adj. R^2	0.753

Note：* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

[1] These indicators include: ① From the perspective of society and consumers: industry rankings of assets, revenue, net profit, and value. ② From the perspective of creditors: asset-liability ratio, current ratio, and long-term debt ratio. ③ From the perspective of shareholders: dividends per share, earnings per share, and whether the company is audited by one of the Big Four accounting firms. ④ From the perspective of the company: sustainable growth rate and proportion of independent directors.

Establishing a good corporate reputation can enhance investor recognition and attention, thereby impacting the liquidity of stock trading. A substantial body of literature has provided evidence of the influence of reputation on stock liquidity. Blau (2017b) suggests that the establishment of social trust enhances the level of market liquidity. Battalio et al. (2007c) emphasize the important role of social reputation in market liquidity provision. Domingos et al. (2022), based on data from US listed companies, found that being listed in the Fortune magazine ranking significantly improves a company's stock liquidity, and there is a positive correlation between ranking and stock liquidity. Furthermore, existing research indicates that the reputation of lead underwriters also affects the liquidity of the underlying stocks (Li et al., 2020b), indicating the wide-ranging impact of reputation mechanisms.

Moreover, the establishment of reputation can effectively reduce the impact of negative news on a company's stock price during significant events, mitigating the risk of stock price collapse resulting from concentrated selling and reducing the direct impact of trading volume on returns, thereby enhancing non-liquidity levels. Wang et al. (2019), in their study on the impact of investor neglect on stock price collapse risk in A-share listed companies, found that reputation and reduced investor trust increase the risk of stock price collapse. Similarly, Song et al. (2017b) argue that reputation serves as an insurance mechanism and an important pathway through which ESG disclosure reduces the risk of stock price collapse.

Therefore, based on the above tests and analysis, it can be concluded that the improvement in ESG disclosure quality can enhance stock liquidity by enhancing corporate reputation, thus supporting Hypothesis 3.

6. Conclusions and outlook

6.1. Research findings

In this study, we examine the relationship between ESG information disclosure quality and stock liquidity using data from A-share listed companies from 2012 to 2021, and identify the influencing paths. The results show that improving the ESG information disclosure quality significantly enhances stock liquidity. The conclusions remain valid after conducting a series of robustness tests on the main analysis.

Further analysis of the influencing paths reveals that ESG information disclosure can affect stock liquidity through reputation and information effects. On one hand, improving the quality of ESG information disclosure helps companies enhance their reputation and increase investor confidence. On the other hand, through the catalytic effect of analysts' attention and media coverage, ESG information attracts more attention from investors, and together, they contribute to the improvement of stock liquidity, resulting in a partial transmission effect.

6.2. Policy implications

1. Recommendations for listed companies

First, listed companies should actively engage in ESG practices and enhance the quality of ESG information disclosure. With the advancement of the registration-based IPO system, the number of

newly listed companies continues to increase while the delisting rate falls behind expectations. This phenomenon indicates that more listed companies will compete for existing market funds. Therefore, it is necessary to attract investor attention and improve stock liquidity. We demonstrate the positive impact of enhancing ESG information disclosure quality on stock liquidity. Therefore, companies should actively engage in ESG practices and disclose their ESG performance comprehensively and in-depth to enhance investor attention and improve stock liquidity. Additionally, encouraging listed companies to establish internal ESG management committees and regularly review and develop ESG decisions and disclosures while actively engaging with investors on ESG information is also recommended.

Second, investors' attention to ESG information should be increased, and the role of media and other information intermediaries should be actively utilized. In addition to improving their ESG disclosure, listed companies should also pay attention to investor interest and interpretation of ESG information. For ESG information disclosure to impact the capital market, a necessary prerequisite is that investors receive the information, which leads them to make corresponding investment decisions. In this process, investor participation is an important oversight of company ESG practices. To address this, companies can establish ESG columns on their official websites and actively promote them through social media platforms. Additionally, encouraging the media and other information intermediaries to report on and supervise companies' ESG information is important. Existing research also indicates that media attention, by increasing individual investors' attention, creates market pressure and effectively supervises company communication(Ying et al.,2017).

2. Recommendations for policymakers

First, continue to improve the ESG information disclosure system and create a

favorable market information environment. ESG information, as an important supplement to corporate financial information, can increase the information content in the market, enhance transparency, and improve information asymmetry.[24] The information disclosure process also effectively supervises a company's environmental obligations, social responsibility, and internal governance improvements. It is necessary to improve the supporting system for ESG information disclosure by listed companies, explore information disclosure rules that align with the current market situation, and expand the scope and breadth of mandatory ESG information disclosure when appropriate. Encouraging voluntary disclosure of environmental, social, and governance practices by companies outside the mandatory requirements, such as providing incentives and policy preferences based on established indicators, is also recommended. Additionally, different industries and ownership forms of enterprises can explore diversified information disclosure standards.

Second, continue to promote the establishment of a unified national market. Due to the differences in regional economic development, laws, and governance environments, there are significant variations in the degree of marketisation across different regions. The level of marketisation also affects the effectiveness of ESG information disclosure and other policy implementations. The report from the 20th National Congress of the Communist Party of China emphasizes the need to "construct a unified national market, deepen the market-oriented reform of factors, and build a high-standard market system." These provide fundamental guidelines for the establishment of a unified national market. In the future, efforts should be made to promote market integration, improve policy consistency, rule consistency, and execution coordination to gradually form a fair and competitive market environment and enhance resource allocation efficiency.

3. Recommendations for investors

In this study, we demonstrate the value relevance of ESG information for companies. As investors, ESG information disclosed by companies can be used as additional investment references, paying attention to the quality of information disclosure and the actual fulfillment of ESG responsibilities.

Use of AI tools declaration

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

Conflict of interest

All authors declare no conflicts of interest.

Data Availability Statement

All data used to justify the proposed model are given in the manuscript.

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