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Does climate risk disclosure affect stock liquidity?

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ABSTRACT

This study empirically examines the effects of climate risk disclosure on stock liquidity at the firm-quarter level. Using panel data from 5161 U.S. listed firms from 2007 to 2022, we employ a two-way fixed effects (TWFE) model to estimate the causal impact of firm-level climate risk disclosure on stock liquidity. Our findings reveal that climate risk disclosure significantly enhances stock liquidity in the current and subsequent quarters. These results remain robust across various model specifications, sample variations, and periods. Specifically, disclosures related to opportunity and physical risks have a more pronounced effect on current stock liquidity, while regulatory risk disclosures exert a more substantial influence on future stock liquidity. Furthermore, firms with greater information transparency and proactive commitment to climate change amplify the positive effects of climate risk disclosure on stock liquidity. These findings highlight the critical role of corporate climate risk disclosure in shaping market dynamics and improving liquidity.

1. Introduction

Climate risks associated with natural disasters and extreme weather events have recently gained significant attention. This growing awareness is evident not only in academic circles but also among investors, who increasingly recognize the profound implications of climate change for their investment strategies (Krueger et al., 2020; Agoraki et al., 2024), in shaping decision-making for both private and institutional investors (Krueger et al., 2020; Reboredo and Ugolini, 2022) and in influencing the pricing dynamics of financial assets (Monasterolo and de Angelis, 2020; Bolton and Kacperczyk, 2021). These risks encompass physical impacts from natural disasters, as well as opportunities and regulatory risks arising from shifting regulatory, technological, and consumer trends that are driving the transition to a low-carbon economy. The rising concern over climate risks has also entered corporate finance, with investors now accounting for climate risk exposure when assessing their portfolio companies (Li et al., 2024; Liu et al., 2025). There is a growing consensus that climate risks pose significant financial implications for firms, underscoring the need for improved disclosure practices (Krueger et al., 2020; Vestrelli et al., 2024).

The effectiveness of financial markets heavily relies on timely and accurate information regarding firms' risk exposures, with climate risk emerging as a crucial and pertinent factor (Bekaert et al., 2007). As climate change increasingly threatens financial stability, the transparent disclosure of climate risks becomes important for regulatory measures to maintain financial stability (Krueger

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et al., 2020; Battiston et al., 2021; Ilhan et al., 2023). Policymakers and institutions have established various standards and principles to encourage a firm's climate risk disclosure. For instance, initially institutionalized by the Task Force on Climate-related Financial Disclosures (TCFD) to enhance corporate innovation through climate risk disclosure in 2017, this practice has created an industry benchmark for climate risk reporting. This normative shift has also been emphasized by legislative advancements such as the US Securities and Exchange Commission's (SEC) requirement for stringent climate risk disclosures for listed companies in 2024. It also aligns with comparable regulatory enhancements by the Hong Kong Exchanges and Clearing Limited (HKEX) in China, aimed at improving disclosure quality and transparency. Therefore, understanding how capital markets respond to firms' climate risk disclosures is beneficial for investment decisions and adjustments made by investors and the public. However, existing literature still lacks comprehensive insights into how the impact of climate risk disclosure on stock liquidity evolves at the firm-quarter level.

This study investigates the relationship between climate risk disclosure and stock liquidity, emphasizing the essential role of information transparency and a firm's commitment to addressing climate change. Based on the work of Sautner et al. (2023), we utilize earnings conference calls to evaluate climate risk disclosure at the firm level. This method provides a fresh perspective on measuring the firm-level climate risk disclosure index across different types of climate risk. Signaling theory indicates that a firm's dedication to societal or environmental concerns positively impacts market perceptions (Spence, 1973; Karasek and Bryant, 2012; Li and Gallagher, 2022). This disclosure sheds light on firms' awareness of potential climate-related risks and their mitigation strategies. Increased transparency from such disclosures enhances investors' perceptions of a firm's risk management practices, long-term sustainability, and overall openness (Jacoby et al., 2019). Investors may view these disclosures as a signal of firms' commitment to tackling climate challenges, which can enhance firms' credibility and reputation among stakeholders.

To examine the prolonged effects of climate risk disclosure on stock liquidity, we utilize financial data from 5161 U.S. firms listed between 2007 and 2022, and also leverage variations in stock liquidity across firms and quarters to assess these effects. The U.S. serves as a particularly relevant country for this study due to its large, diverse financial market and its leadership in regulatory and investor-driven initiatives about climate risk disclosure, making it an ideal setting to investigate the influence of such disclosures on stock liquidity. Our study employs firm-quarter data on climate risk disclosure provided by Sautner et al. (2023), and we utilize a TWFE model to estimate the impact of climate risk disclosure on stock liquidity for current and future quarters. Additionally, we explore the channels through which climate risk disclosure affects stock liquidity, specifically focusing on information transparency and the firm's attitude in response to climate change. This analysis enables us to track the dynamics of stock market liquidity each quarter from 2007 to 2022 in relation to changes in climate risk disclosure.

Our analysis shows that climate risk disclosure positively affects current and future stock liquidity. Specifically, a one standard deviation (SD) increase in climate risk disclosure is linked to a 0.019 % rise in stock liquidity for the current quarter. These results illustrate that firms with higher levels of climate risk disclosure achieve better stock liquidity performance now and in future quarters than their peers. This trend remains strong across various alternative measurement methods, instrumental variable (IV) estimations, and when excluding the potential effects of the Global Financial Crisis (GFC) and the COVID pandemic. To evaluate the effectiveness of revealing specific aspects of climate change, we categorize climate risk disclosure into three main areas: opportunities, regulatory, and physical risk disclosures. Our findings suggest that opportunities and physical risk disclosures significantly impact current stock liquidity. In contrast, regulatory risk disclosure has a more profound effect on future stock liquidity. This suggests that, regardless of the specific climate change topics addressed, firms strategically utilize earnings conference calls to demonstrate their environmental accountability, thereby enhancing stock liquidity.

The unexpected finding that climate risk disclosure positively affects stock liquidity prompts an exploration of the potential channels behind this relationship. Given that information transparency is crucial for investors and the public in making informed investment decisions, we investigate whether market information transparency amplifies the effect of corporate climate risk disclosure on stock liquidity. Additionally, since climate risk disclosure is derived from earnings call texts, we also examine the impact of firms' attitudes toward climate change in their communications with managers and the public. Our analysis reveals that climate risk disclosure enhances stock liquidity through higher levels of firm information transparency and a positive commitment to climate change communicated to enterprise managers and the public. These findings provide novel insights into how climate risk disclosure impacts stock liquidity, emphasizing the roles of market conditions and the firm's commitment to climate change.

The contributions of our work are reflected in the following aspects. First, our study significantly advances the rapidly evolving literature on the stock market consequences of climate change by introducing a novel perspective through firm-level climate risk disclosure. While much existing literature has focused on the effects of climate risk on stock returns (Venturini, 2022), stock price crash risk (Jung and Song, 2023), and firm market value (Vestrelli et al., 2024), there has been limited investigation into how firm-level climate risk disclosure specifically impacts stock performance within the highly liquid and transparent U.S. financial market. Our study shifts the emphasis from external climate risks to the internal dynamics of firm-level climate risk disclosure and estimates the cause effects of climate risk disclosure on stock liquidity. By exploring how changes in a firm's climate risk disclosures affect stock liquidity, we address a crucial aspect of capital market reactions that has not been thoroughly examined in prior research. Our study not only highlights the implications of climate risk disclosure on stock liquidity but also illuminates the firm's decision-making process in response to climate change. In summary, our research broadens the boundaries of climate change and corporate finance literature, offering new insights into the factors influencing stock liquidity.

Secondly, our study presents a novel perspective on the role of information transparency and companies' climate change commitments in the relationship between climate risk disclosure and stock liquidity. While prior research has explored the broader impacts of firm information disclosure on stock liquidity (Heflin et al., 2005; Meng-tao et al., 2023), there has been limited focus on how climate risk disclosure influences stock liquidity. Our study addresses this research gap and enhances the existing literature. In contrast to the growing body of research that highlights how exposure to climate change may negatively impact market returns, investment

efficiency, and innovation (Agoraki et al., 2024; Li et al., 2024), our analysis specifically targets publicly traded firms operating in the U.S. stock market and focuses on stock liquidity performance at the firm-quarter level. We investigate whether climate risk disclosure can enhance stock liquidity in the current and subsequent future quarters within the framework of information asymmetry. Our empirical findings show that firms with more significant information transparency and a proactive commitment to climate change demonstrate improved stock liquidity in current and future quarters. These results significantly broaden the application of signaling theory in corporate finance, providing firms with strong incentives to prioritize transparency in disclosing climate-related risks.

Finally, our study contributes to the empirical literature on the impact of climate change on stock markets at the firm-quarter level. This work extends the existing literature on climate change's effects on stock markets by shifting the focus from aggregate market reactions to adjustments at the firm level (Agoraki et al., 2024; Giglio et al., 2021). While much of the current research focuses on physical or opportunity risks, concluding that extreme weather events and local regulations can influence firm stock performance (Gong et al., 2023; Pankratz and Schiller, 2024), these studies often depend on objective measures of climate risk. Such measures may not fully capture firms' subjective initiatives in response to climate change. Inspired by the work of Sautner et al. (2023), we utilize a big data text analysis approach to construct a climate risk disclosure index based on firm-level earnings conference calls. This method enables us to dynamically capture firms' decision-making and responses to climate change. By doing so, we provide a more nuanced analysis of the complexities of climate risk within firms, deepening our understanding of the implications of climate change on financial markets. Additionally, we examine the predictive effect of current climate risk disclosure on stock liquidity in subsequent quarters, enriching the empirical analysis and supporting our conclusions. This approach enhances the reliability of our findings and offers valuable insights into the longer-term impacts of climate risk disclosure on stock market performance.

The remainder of this paper is organized as follows. Section 2 presents a literature review and hypothesis development. Section 3 details the research design and data description. This is followed by presenting empirical results in Section 4, and Section 5 investigates potential mechanisms. Section 6 provides a related discussion and concludes in Section 7.

2. Literature review and hypothesis development

2.1. The association of climate risk disclosure and stock liquidity

Stock liquidity is a cornerstone of efficient capital markets, facilitating price discovery, information dissemination, and optimal resource allocation. It serves as a key indicator of a firm's operational robustness and capital market performance (Merton, 1987; Cheung et al., 2023; Muchenje, 2025). A growing body of research has examined how climate risks and environmental regulations affect firms' financial and operational outcomes. For example, Qiu et al. (2025) demonstrate that climate risk exposure reduces stock market liquidity, underscoring the importance of considering heterogeneous regulatory environments in emerging market. Similarly, Li et al. (2025) show that China's emission trading scheme significantly enhances firm-level carbon disclosure, revealing how market-based regulatory instruments can alter corporate transparency and environmental performance. These findings highlight that stock market responses to climate change are deeply intertwined with the regulatory and policy environment, underscoring the complementary roles of institutional regulation in shaping the impact of climate risk disclosure on stock outcomes.

Additionally, the existing literature also identifies three broad categories of stock liquidity determinants from the perspective of macroeconomic, microeconomic, and behavioral. On the macroeconomic front, existing studies highlight the influence of monetary policy (Zhang et al., 2019; Lyu and Hu, 2024), market uncertainty (Chung and Chuwonganant, 2014; Wang et al., 2022), and geopolitical risks (Fiorillo et al., 2023; Khraiche et al., 2023), underscoring how systemic shocks can disrupt stock liquidity. At the micro level, firm-specific characteristics such as corporate governance (Prommin et al., 2014; Ali et al., 2018), foreign ownership (Ng et al., 2016; Li et al., 2022), and ESG performance (Wang et al., 2023; Krueger et al., 2024) have been shown to affect stock liquidity by shaping firm transparency, risk perception, and investor confidence. Behavioral studies further emphasize the role of investor sentiment: optimistic sentiment tends to enhance stock liquidity, while pessimistic sentiment reduces it (Chiu et al., 2018; Gaies et al., 2022).

Despite this rich literature, limited attention has been paid to how climate risk disclosure, a growing dimension of corporate transparency, affects stock liquidity. This gap is notable given that climate change represents one of the most salient long-term risks to firms and investors alike. As climate-related risks intensify, firms face mounting pressure to disclose their exposure and management strategies, and significantly affect stock market stability (Battiston et al., 2021; Pankratz and Schiller, 2024). While existing research has examined the macroeconomic implications of climate risk, including effects on output (Chang et al., 2023), labor productivity (Zhao et al., 2024), and energy transition (Lee et al., 2024), firm-level studies remain limited. Some scholars have explored its impact on investment efficiency (Xu et al., 2024), corporate performance (Sun et al., 2023), and asset pricing (Gong et al., 2023), including evidence of a climate risk premium (Bansal et al., 2016; Bolton and Kacperczyk, 2021). However, little is known about the potential liquidity effects of disclosing such risks at the firm level, mainly due to challenges in measuring firm-specific climate exposure and disclosure quality.

Drawing on limited attention theory and signaling theory, we posit that climate risk disclosure can improve stock liquidity. Investors operate under attention constraints (Barber and Odean, 2008; Chen and Wu, 2022) and firms that effectively communicate climate-related information may better capture investor attention (Azuma and Higashida, 2024; Xu et al., 2024). Moreover, disclosure acts as a credible signal of climate governance and risk management capacity, enhancing firms' reputational capital (Moshirian et al., 2017). A transparent climate strategy can attract long-term, socially responsible investors, who value sustainability and provide more stable capital flows, thereby enhancing stock liquidity (Kumari, 2019; Krueger et al., 2020). Informed by this theoretical foundation, we propose the following hypothesis:

Hypothesis 1. *Firm-level climate risk disclosure enhances stock liquidity.*

2.2. Information transparency

From the perspective of information asymmetry theory, disparities in available information can significantly influence stock liquidity (Glosten and Milgrom, 1985; Hu and Prigent, 2019; Bilyay-Erdogan et al., 2024). Reducing such asymmetry through greater transparency is critical to improving market functioning, as it enhances investor confidence in the accuracy of firm valuation (Jacoby et al., 2019). Prior research demonstrates that transparent firms are better able to bridge information gaps between themselves and investors, fostering trust and facilitating more active trading (Chen et al., 2007; Hu and Prigent, 2019). Increased trading activity reduces bid-ask spreads and deepens liquidity by lowering uncertainty in pricing (Wei and Zheng, 2010; Li et al., 2021). Moreover, when investors gain access to high-quality, timely information, they are better equipped to assess firm fundamentals, which in turn improves decision-making efficiency and stimulates trading volume and stock liquidity improvement (Lang et al., 2012; Blanco et al., 2024).

Importantly, climate risk disclosure offers a dimension of transparency that traditional financial reporting often lacks. While conventional disclosures emphasize past financial performance, they typically overlook forward-looking risks, such as those associated with climate change. Climate-related disclosures provide investors with critical insights into firms' environmental exposure and governance practices (Krueger et al., 2020; Li et al., 2024), enabling a more holistic assessment of firm value (Lin and Wu, 2023). From a signaling theory perspective, firms facing elevated climate risks may voluntarily disclose such information to signal strong governance capacity and social responsibility in markets characterized by limited transparency. These disclosures reduce uncertainty and information asymmetry, particularly for sustainability-focused investors, thereby encouraging trading and enhancing stock liquidity (Elshandidy and Neri, 2015). Accordingly, we propose:

Hypothesis 2. *The positive effect of firm-level climate risk disclosure on stock liquidity is more substantial for firms with higher information transparency.*

2.3. Climate change commitment

Recent research emphasizes the importance of firms' risk management commitment in shaping their market performance. According to Ma et al. (2019), firms that actively engage in risk management tend to gain greater investor trust, thereby enhancing their stock liquidity. This trust arises from the belief that proactive firms are more capable of identifying, evaluating, and mitigating potential risks, thus preserving long-term profitability and reducing downside uncertainties (Acharya and Pedersen, 2005; Pfajfar et al., 2022; Li et al., 2023). In contrast, firms that exhibit passivity in addressing risks may face diminished investor confidence, leading to lower trading volumes and less liquid stocks (Naseer et al., 2025).

Extending this logic to the climate change context, we posit that firms demonstrating stronger commitments to climate change are likely to amplify the positive effect of climate risk disclosure on stock liquidity. First, firms that foster stakeholder engagement through mechanisms such as inclusive and transparent earnings conference calls involving management, boards, and institutional investors, send a clear signal of genuine climate governance commitment (Cheng et al., 2021). Such engagements are positively perceived in capital markets and enhance climate resilience, which translates into improved investor sentiment and greater stock liquidity (Lewellen and Lewellen, 2022; Ilhan et al., 2023). Second, firms that take proactive climate actions often produce more detailed, comprehensive, and forward-looking disclosures, embedding climate considerations into core strategies, operations, and risk management frameworks (Darnall et al., 2010; Sautner et al., 2023). These high-quality disclosures further reduce information asymmetry and support more efficient pricing in capital markets. Therefore, we propose the following hypothesis:

Hypothesis 3. *The positive effect of firm-level climate risk disclosure on stock liquidity is more substantial for firms with a proactive commitment to climate change.*

3. Research design and data description

3.1. Sample and data

This paper selects the U.S. listed firms as our research sample to examine the impact of climate risk disclosure on stock liquidity in a developed market. We focus on U.S. firms to mitigate the potential influence of cultural and geographical differences that could arise in a cross-country analysis. Our study uses a diverse range of data sources. First, the firm-quarter-level climate risk disclosure data is obtained from Sautner et al. (2023), encompassing various climate risk disclosure indices such as opportunity risk, regulatory risk, and physical risk. Second, U.S. stock prices and trading volume data are sourced from the Compustat database. We use daily U.S. stock price and trading data to calculate stock liquidity performance at the firm-quarter level based on Eq. (2). Financial data for U.S. firms is also extracted from the Compustat database, enabling us to control for changes in firm characteristics in our estimation model. The data are merged using firm ID (CUSIP) and quarter index, and continuous variables are winsorized at the 1st and 99th percentiles each quarter to reduce the potential impact of outliers. Our final dataset is an unbalanced panel consisting of 5161 firms, yielding 182,047 firm-quarter observations, spanning from 2007 to 2022 across various U.S. states.

3.2. Variable construction

3.2.1. Stock liquidity

Illiquidity is a crucial indicator that reflects the efficiency loss due to transaction cost and price volatility in the stock market. A widely used illiquidity measurement is the ratio of absolute return to trading volume proposed by Amihud (2002). Based on this measurement, we can derive the firm's liquidity performance from stock market illiquidity indicators. Building on the daily measurement of stock liquidity from Roosenboom et al. (2014), we calculate firms' stock liquidity at the quarterly level using the simple average method. The detailed metric function is defined as follows:

$$ILLIQ_{i,t} = \frac{1}{Days_{i,t}} \sum_{d=1}^{Days_{i,t}} \frac{|R_{i,t,d}|}{Volume_{i,t,d}} \tag{1}$$

$$LIQ_{i,t} = -\ln(ILLIQ_{i,t}) \tag{2}$$

Where $R_{i,t,d}$ represents the return rate of stock i on day d of quarter t, $Volume_{i,t,d}$ denotes the corresponding daily trading volume of stock i on the trading day of quarter t, and $Days_{i,t}$ indicates the number of trading days of stock i in quarter t. We finally calculate stock illiquidity at the firm-quarter level, as shown in Eq. (1), and then measure the stock liquidity according to Eq. (2). $LIQ_{i,t}$ indicates the liquidity performance of stock i for each quarter in year y. A higher value of $LIQ_{i,t}$ signifies greater market liquidity, reduced stock price volatility, and improved price recognition. This formula provides a quarterly average of the daily liquidity measurements, offering a comprehensive view of the firm's stock liquidity over the specified period.

3.2.2. Climate risk disclosure

Our paper utilizes firm-level climate change risk exposure, determined through a bigram analysis of quarterly earnings conference calls conducted by Sautner et al. (2023). Over the past two decades, earnings conference calls have become vital channels for firms to engage with stakeholders, investors, and analysts. The climate change risk index measures firm-level climate exposure based on these communications, including statements and responses, capturing significant variations in firms' attitudes and actions towards climate change risk over time. Building on the work of Sautner et al. (2023), our study identifies three critical aspects of climate risk disclosure. The first is opportunity risk disclosure, which relates to climate-oriented disruptive innovation in firms' transition process to become "green".[1] The second is the regulatory risk disclosure, which originates from the changes in regulations and policies that aim to minimize the firms' footprint on climate change concerns.[2] The third is the physical risk disclosure, which stems from a firm's exposure to CO_2 emissions or natural climate issues.[3] Appendix 1 shows the evolutionary characteristics of firm-level climate risk disclosure, and indicates that firms' climate risk disclosure levels gradually increase, then stabilize and finally experience a surge in 2020.

The construction of firm-level climate change exposure mirrors the methodology employed by Hassan et al. (2019) in measuring firm-level political risks. This approach utilizes bigram analysis to assess the frequency of key phrases (e.g., "climate risk," "climate risk uncertainty"), indicating potential firm climate risk exposure. It adopts a multidimensional perspective, incorporating physical, regulatory, and opportunity climate issues at the firm level. Recent literature, including studies by Ben-Amar et al. (2022), Hossain and Masum (2022), and Li et al. (2024) has embraced and integrated this measure, demonstrating its effectiveness in depicting the degree of firm climate change exposure at the firm level. Additionally, one drawback of this measure is that some firms may overlook climate change issues in their conference calls, resulting in zero reported climate risk exposure for specific firm-year observations. This limitation is mitigated by the multi-dimensional and multi-indicator nature of the measure, which ensures a comprehensive assessment of enterprise climate change exposure.

By adopting this approach, we aim to provide valuable insights into the varying impacts of climate risk disclosure on stock liquidity, emphasizing the significance of integrating climate risk considerations into corporate decision-making and stock performance analysis. As shown in Appendix 2, we illustrate the correlation between climate risk disclosure and stock liquidity across different risk types. The

[1] Opportunity risks refer to the potential for firms to benefit from addressing climate-related issues, such as innovation, new market opportunities, or improved sustainability practices. These risks are often tied to a firm's proactive stance on climate change and its potential to capitalize on emerging opportunities in green technologies, eco-friendly products, or carbon reduction efforts. For example, a firm that invests in renewable energy sources or energy-efficient technologies may face opportunity risks related to the evolving regulatory and market demand for such products. Firms in the electric vehicle (EV) sector are examples of firms that have benefited from climate-related opportunities due to increased demand for sustainable transportation solutions.

[2] Regulatory risks arise from changes in laws, regulations, or policies addressing climate change. These may include stricter environmental standards, carbon taxes, emissions regulations, or mandatory disclosures related to environmental performance. For example, a firm in the fossil fuel sector may face regulatory risks from stricter emissions regulations or government policies aimed at reducing carbon emissions. For instance, the European Union's Emissions Trading System (ETS) may create regulatory risks for firms whose operations generate high carbon emissions, potentially resulting in higher operational costs due to the need for emission allowances.

[3] Physical risks pertain to the direct impacts of climate change on a firm's operations, such as extreme weather events (e.g., floods, hurricanes, wildfires), changes in weather patterns (e.g., droughts), or rising sea levels. These risks can affect supply chains, manufacturing facilities, and infrastructure. For example. A firm with manufacturing facilities located in coastal areas may face risks related to rising sea levels or flooding, potentially damaging infrastructure and disrupting operations. A specific example is a company like Tesla, which has faced disruptions in its supply chain due to extreme weather events, such as hurricanes affecting raw material suppliers.

first figure shows a positive relationship between climate risk disclosure and stock liquidity, primarily driven by opportunity risk disclosure. The second figure indicates that firms with a positive attitude toward climate change exhibit a positive correlation with stock liquidity, whereas firms with a negative attitude show the opposite trend. In summary, we have preliminarily confirmed that firm-level climate risk disclosure positively correlates with stock liquidity.

3.2.3. Control variables

To account for potential factors that may affect a firm's stock liquidity, and inspired by the research of Agoraki et al. (2024) and Apergis and Dastidar (2024), we control for the following firm characteristic variables: (1) Firm size ($Size_{i,t}$); (2) Return on Assets ($ROA_{i,t}$); (3) Firm strength ($Asset_{i,t}$); (4) Market-to-book ratio ($MB_{i,t}$); (5) Firm leverage ($Leverage_{i,t}$); (6) Short-term investment ($Invest_{i,t}$); (7) Research and Development (R&D) expenditures ($R\&D_{i,t}$); and (8) Cash holding ($Cash_{i,t}$). Appendix 3 provides detailed variable definitions and data sources.

3.3. Estimation strategy

In this sector, we construct the estimation function to analyze the effect of climate risk disclosure on stock liquidity at the firm-quarter level. Specifically, we estimate the following regression specification, employing a TWFE model that allows us to isolate the impact of disclosure while accounting for firm-specific characteristics and broader market-wide factors that could influence liquidity. The identification strategy is as follows:

$$LIQ_{i,t} = \beta_0 + \beta_1 CRD_{i,t} + \beta_x Controls_{i,t} + \delta_i + \gamma_t + \varepsilon_{i,t} \tag{3}$$

Besides, considering the predicting effect of climate risk disclosure on stock liquidity, and following Li et al. (2024), we design Eq. (4) to predict the stock market liquidity response to climate risk disclosure in the future period. This methodology is crucial for analyzing the impact of climate risk disclosure on stock liquidity, as it enables us to capture not only the immediate effects but also the dynamic market adjustments over the quarter. We estimate the model as:

$$LIQ_{i,t+h} = \beta_0 + \beta_1 CRD_{i,t} + \beta_x Controls_{i,t} + \delta_i + \gamma_t + \varepsilon_{i,t+h} \tag{4}$$

Where i donates the firm and t donates the quarter, respectively. $LIQ_{i,t}$ indicates the firm's stock liquidity at the current quarter. $LIQ_{i,t+h}$ is the firm's liquidity performance in quarter $t+h$ (h ranges from 1 to 5). $CRD_{i,t}$ represents climate risk disclosure, comprising indicators for physical, opportunity, and regulatory risks. β_1 is the core estimated coefficient that illustrates the impact of climate risk disclosure on stock liquidity. $Controls_{i,t}$ is a vector of firm characteristic including firm size, return of asset, total asset, market-to-book ratio, leverage, short investment, R&D expenditures, and cash holding at the end of quarter. δ_i is captured unobserved liquidity-specific firm fixed effects, and γ_t is quarter fixed effects that absorb the unobserved influence factors over at the quarter level. $\varepsilon_{i,t}$ and $\varepsilon_{i,t+h}$ are the random disturbance terms, and we cluster robust standard error at the firm level.

3.4. Descriptive statistics

In Table 1, we present the descriptive statistics for the main variables in our study. The mean value of stock liquidity (SD) is 18.838 (3.562), indicating that firm liquidity remains positive and shows substantial variation across U.S. listed firms. Additionally, the mean value of climate risk disclosure (SD) in our sample is 0.749 (1.961), suggesting that most firms disclose their climate risk is limited. The different types of climate change risks, including opportunity, regulatory, and physical risks, exhibit a decreasing trend in risk disclosure among U.S. listed firms. Regarding firm characteristic controls, all values fall within the normal range, and there are no extreme values that might lead to biased estimation results. Detailed definitions and data sources for all variables included in our analysis are provided in Appendix 3.

Table 1
Descriptive statistics.

Type	Variable	Observation	Mean	Std.	Min	Max
Key variables	$LIQ_{i,t}$	182,047	18.838	3.562	6.537	25.439
	$CRD_{i,t}$ ($\times 10^3$)	182,047	0.749	1.961	0	18.976
	$CRD^{op}_{i,t}$ ($\times 10^3$)	182,047	0.217	0.823	0	9.037
	$CRD^{rg}_{i,t}$ ($\times 10^3$)	182,047	0.030	0.166	0	2.502
	$CRD^{ph}_{i,t}$ ($\times 10^3$)	182,047	0.006	0.046	0	0.560
Firm control variables	$Size_{i,t}$	182,047	0.468	0.499	0	1
	$ROA_{i,t}$	182,047	−0.019	0.096	−1.143	0.203
	$Asset_{i,t}$	182,047	6.610	2.254	0.597	12.339
	$MB_{i,t}$	182,047	0.149	0.967	0	21.324
	$Leverage_{i,t}$	182,047	0.230	0.234	0	1.183
	$Invest_{i,t}$	182,047	4.346	2.079	0.020	9.958
	$R\&D_{i,t}$	182,047	1.193	1.803	0	7.947
	$Cash_{i,t}$	182,047	4.075	2.012	0.008	9.531

4. Empirical results

4.1. Basic results

In this sector, we first explore the relationship between climate risk disclosure and stock liquidity and then provide the results of predicting the effect of current climate risk disclosure on further stock liquidity. The detailed results are shown in Tables 2 and 3.

Table 2 presents our findings regarding the impact of climate risk disclosure on stock liquidity, reported across different modeling specifications. In particular, column (1) shows the results without firm control variables and fixed effects. Column (2) includes firm and quarter fixed effects, while column (3) incorporates firm characteristics. Finally, column (4) includes all variables: firm fixed effects, quarter fixed effects, and firm characteristics. The results across all modeling specifications indicate that climate risk disclosure positively affects stock liquidity performance. According to the core coefficient for climate risk disclosure (CRD_{it}) in column (4), one SD increase in climate risk disclosure is associated with a 0.019 % increase in stock liquidity in the current quarter. These results directly support our first hypothesis that climate risk disclosure decreases information asymmetry between insiders and outsiders, producing more significant stock liquidity incentives. This underscores the importance of considering climate change risk in evaluating a firm's liquidity and potential stock performance.

Regarding firm characteristic controls, our findings indicate that key firm characteristics such as ROA, total assets, short-term investments, R&D investment, and cash holdings positively affect firm liquidity. In contrast, firm size, market-to-book ratio, and leverage have a negative impact on stock liquidity. Specifically, a higher ROA or total assets suggests strong capital power and return growth for corporate operations, which benefits stock liquidity performance. Investment in R&D and cash holdings indicate a firm's potential for technological innovation and financial resilience, contributing to improved stock liquidity performance (Kang et al., 2017). Conversely, a higher market-to-book ratio and leverage are associated with an antagonistic relationship in stock liquidity. These results are consistent with previous findings by Fang et al. (2009) and Armanious and Zhao (2024). In summary, our basic results provide new evidence for the positive effect of climate risk disclosure on stock liquidity, and Hypothesis 1 is confirmed.

Table 3 presents the results of a regression analysis that examines the predicting effect of current climate risk disclosure on a firm's liquidity in subsequent quarters. Across columns (1) to (5), all coefficients for CRD_{it} are positive and statistically significant at the 1 % level. This indicates that climate risk disclosure has a significantly positive impact on stock liquidity in the following quarter. A one standard deviation increase in firm-level climate risk disclosure in quarter t is associated with a 0.019 % increase in stock liquidity in $t+1$ and about a 0.015-percentage-point increase in stock liquidity in the following quarters ($t+2$, $t+3$, $t+4$, $t+5$). Although the

Table 2
Impact of climate risk disclosure on stock liquidity.

Dep Var	$LIQ_{i,t}$			
	(1)	(2)	(3)	(4)
$CRD_{i,t}$	0.222***	0.027***	0.026***	0.019***
	(0.004)	(0.006)	(0.002)	(0.005)
$Size_{i,t}$			0.026*	-0.151***
			(0.014)	(0.039)
$ROA_{i,t}$			0.998***	0.669***
			(0.049)	(0.116)
$Asset_{i,t}$			1.100***	1.184***
			(0.004)	(0.027)
$MB_{i,t}$			-0.247***	-0.170***
			(0.004)	(0.017)
$Leverage_{i,t}$			-0.625***	-0.840***
			(0.019)	(0.074)
$Invest_{i,t}$			0.044***	0.097***
			(0.008)	(0.024)
$R\&D_{i,t}$			0.240***	0.064***
			(0.003)	(0.011)
$Cash_{i,t}$			0.239***	0.077***
			(0.008)	(0.023)
Constant	18.672***	18.818***	10.284***	10.489***
	(0.009)	(0.004)	(0.018)	(0.165)
Firm FE	NO	YES	NO	YES
Quarter FE	NO	YES	NO	YES
Within R^2	0.015	0.888	0.760	0.307
N	182,047	182,047	182,047	182,047

Notes: This table shows the baseline results of climate risk disclosure on stock liquidity at the firm-quarter level. $LIQ_{i,t}$ indicates quarterly-level stock liquidity performance of U.S. listed firms. The key explanatory variable is climate risk disclosure measured by Sautner et al. (2023). Column (1) results from OLS estimation, and Column (2) adds firm and quarter fixed effects based on TWFE estimation. Column (3) contains firm characteristic control variables without fixed effects, and column (4) includes firm characteristic control variables, and the estimates are based on both firm and quarter fixed effects. Standard errors are clustered at the firm level and shown in parentheses, *p < 0.1; **p < 0.05; ***p < 0.01, respectively.

Table 3
Predicting effect of climate risk disclosure on stock liquidity.

Dep Var	$LIQ_{i,t+h}$				
	h= 1	h= 2	h= 3	h= 4	h= 5
	(1)	(2)	(3)	(4)	(5)
$CRD_{i,t}$	0.019***	0.017***	0.015***	0.015***	0.013**
	(0.004)	(0.005)	(0.005)	(0.005)	(0.005)
$Size_{i,t}$	-0.142***	-0.135***	-0.137***	-0.135***	-0.134***
	(0.039)	(0.039)	(0.039)	(0.040)	(0.042)
$ROA_{i,t}$	0.999***	1.206***	1.181***	1.105***	0.975***
	(0.130)	(0.137)	(0.140)	(0.142)	(0.148)
$Asset_{i,t}$	1.084***	0.967***	0.866***	0.765***	0.678***
	(0.028)	(0.029)	(0.030)	(0.031)	(0.032)
$MB_{i,t}$	-0.166***	-0.147***	-0.123***	-0.113***	-0.093***
	(0.018)	(0.018)	(0.019)	(0.020)	(0.021)
$Leverage_{i,t}$	-0.862***	-0.827***	-0.784***	-0.717***	-0.665***
	(0.078)	(0.081)	(0.084)	(0.086)	(0.090)
$Invest_{i,t}$	0.076***	0.060**	0.049**	0.045*	0.041*
	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)
$R\&D_{i,t}$	0.066***	0.055***	0.058***	0.052***	0.056***
	(0.011)	(0.011)	(0.011)	(0.011)	(0.012)
$Cash_{i,t}$	0.090***	0.088***	0.076***	0.066***	0.055**
	(0.023)	(0.023)	(0.022)	(0.022)	(0.022)
Constant	11.217***	12.081***	12.847***	13.584***	14.234***
	(0.171)	(0.176)	(0.184)	(0.191)	(0.199)
Firm FE	YES	YES	YES	YES	YES
Quarter FE	YES	YES	YES	YES	YES
Within R^2	0.274	0.227	0.183	0.144	0.114
N	175,361	170,067	164,767	160,365	154,678

Notes: This table presents the results from firm-level regressions testing the relation between the change in climate risk exposure and the change in stock liquidity while controlling for firm characteristics, and firm and quarter fixed effects. The key explanatory variable is the change in stock liquidity in different subsequent periods ($t + 1$, $t + 2$, $t + 3$, $t + 4$, $t + 5$) on the lagged change in climate risk disclosure (in quarter t). All specifications include firm and quarter fixed effects. Standard errors are clustered at the firm level and shown in parentheses, *p < 0.1; **p < 0.05; ***p < 0.01, respectively.

magnitude of the coefficient slightly decreases when extending the horizon of stock liquidity ($h = 1, h = 2, h = 3, h = 4, h = 5$), this reduction does not imply a reversal in the predictive effect. Our findings align with those of Li et al. (2024), highlighting that firms' climate change behaviors influence investors' expectations of future returns.

Table 4
2SLS estimates of climate risk disclosure on stock liquidity.

Dep Var	$CRD_{i,t}$	$LIQ_{i,t}$
	(1)	(2)
	First-stage	Second-stage
$CRD_{i,t}$		0.122**
		(0.053)
$Mean\_CRD_{i,t}$	0.058***	
	(0.014)	
Constants	0.012***	-0.006
	(0.001)	(0.001)
Controls	YES	YES
Firm FE	YES	YES
Quarter FE	YES	YES
N	182047	182047

Notes: This table reports the results of 2SLS estimations of climate risk disclosure on stock liquidity. Our study adopts the value of industry average climate risk disclosure that excludes the firm itself (industry mean of climate risk disclosure) as an IV in our estimation. Kleibergen-Paap rk LM statistic value is 123.84, and the rejection of the original hypothesis. Kleibergen-Paap rk Wald F statistic value is 6996.18, which means the IV passes through under the identification test and weak identification test. We also control a series of firm-level characteristic variables, respectively. Standard errors are clustered at the firm level and shown in parentheses, *p < 0.1; **p < 0.05; ***p < 0.01, respectively.

4.2. Addressing protentional endogeneity

4.2.1. Instrumental variable approach

One challenge in our study is that stock liquidity may be influenced by other unobservable economic factors correlated with climate change when exposed to greater climate change risk. This introduces potential endogeneity concerns, which could lead to underestimating the effect of climate risk disclosure on stock liquidity. To address this issue, we construct an IV approach based on the industry average of climate risk disclosure ($Mean\_CRD_{i,t}$) to mitigate the potential endogeneity problem. We employ the IV method to estimate the effect of climate risk disclosure on stock liquidity. Table 4 presents the estimates from the 2SLS estimation. Our results support the baseline model, indicating that climate risk disclosure increases stock liquidity and is positively associated with firms' stock liquidity. This approach strengthens the validity of our findings by effectively addressing potential biases arising from endogeneity issues.

4.2.2. Accounting for selection bias

To address potential sample selection bias arising from unobservable factors that might influence both the regression outcomes and climate risk disclosure. Our study follows the methodology outlined by Agoraki et al. (2024) and implements a two-stage Heckman selection model. This approach helps mitigate the potential bias by first modeling the likelihood of a firm being included in the sample, and then adjusting the main regression analysis based on this selection process. In the first stage, we estimate a Probit model to determine the probability of a firm being included in the sample, based on relevant firm characteristics and other factors. The inverse Mills ratio (IMR) derived from this model is then included as an additional regressor in the second stage, where we re-estimate the relationship between climate risk disclosure and stock liquidity. The results of this two-stage Heckman selection model are presented in Table 5. Importantly, the coefficient for $CRD_{i,t}$ remains significantly positive, aligning with our baseline estimations reported in Table 2. The findings suggest that our benchmark regression results are robust and not significantly influenced by sample selection bias, thereby addressing concerns related to potential endogeneity.

4.2.3. The role of Paris agreement on the relationship between climate risk disclosure and stock liquidity

The Paris Agreement, adopted during the UN Climate Change Conference in Paris in 2015, is a legally binding global treaty aimed at addressing climate change. Its implementation marks a significant shift in climate change risk attitudes among governments worldwide and is a strong signal for firms to pursue low-carbon development or transformation programs (Aldy et al., 2016). By incorporating the Paris Agreement into our research design, we aim to establish a causal link between firm-level climate change risk disclosure and stock liquidity across varying contexts of climate change policy implementation. The results, presented in Table 6, indicate that the interaction term ($CRD_{i,t} \times Paris_i$)'s coefficient between climate risk disclosure and the Paris Agreement is significantly negative in the current quarter and the following two quarters. However, this effect loses significance in later periods. These findings suggest that while the Paris Agreement plays a crucial role in shaping corporate responses to climate risk, its influence on stock liquidity is more pronounced in the immediate aftermath of its implementation, with the effect diminishing over time. In addition, the coefficients for $CRD_{i,t}$ remain significantly positive in columns (1) to (6), reinforcing the robustness of our results.

Table 5
Mitigate selection bias.

Dep var	$LIQ_{i,t}$	
	(1)	(2)
	First step	Second step
$CRD_{i,t}$		0.019***
		(0.005)
Constant	11.225***	11.216***
	(0.170)	(0.171)
Controls	YES	YES
Firm FE	YES	YES
Quarter FE	YES	YES
Within R^2	0.274	0.274
N	175,361	175,361

Notes: This table reports the results of the two-stage Heckman selection model. The first stage regression predicts the probability of stock liquidity based on the previous quarter ($t-1$) and random selection samples. The second stage regression estimates the impact of climate risk disclosure on stock liquidity, underlying the first regression model. Standard errors are clustered at the firm level and shown in parentheses, *p < 0.1; **p < 0.05; ***p < 0.01, respectively.

Table 6
The crucial role of the Paris Agreement.

Dep Var	$LIQ_{i,t+h}$					
	h= 0	h= 1	h= 2	h= 3	h= 4	h= 5
	(1)	(2)	(3)	(4)	(5)	(6)
$CRD_{i,t}$	0.041***	0.036***	0.029***	0.024***	0.019***	0.017**
	(0.007)	(0.006)	(0.007)	(0.007)	(0.007)	(0.007)
$CRD_{i,t} \times Paris_i$	-0.031***	-0.024***	-0.018**	-0.012	-0.006	-0.005
	(0.007)	(0.007)	(0.008)	(0.008)	(0.008)	(0.008)
Constant	10.501***	11.226***	12.088***	12.852***	13.587***	14.236***
	(0.165)	(0.170)	(0.176)	(0.184)	(0.191)	(0.199)
Controls	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Quarter FE	YES	YES	YES	YES	YES	YES
Within R^2	0.308	0.275	0.227	0.183	0.145	0.114
N	182,047	175,361	170,067	164,767	160,365	154,678

Notes: This table presents results after considering the Paris Agreement. We include the interaction term between climate risk disclosure and the Paris Agreement. We report the results from regression analysis of stock market liquidity in different lead time periods (t, $t+1$, $t+2$, $t+3$, $t+4$, $t+5$) on the lagged climate risk disclosure (in quarter t), in the columns (1) to (6). *Paris* is not in our estimation, because the dummy variable is absorbed by fixed effects. We also control a series of firm-level characteristic variables and add firm and quarter fixed effects, respectively. Standard errors are clustered at the firm level and shown in parentheses, *p < 0.1; **p < 0.05; ***p < 0.01, respectively.

4.3. Robustness test

4.3.1. Alternative proxied for stock liquidity

This robustness test analysis replicates the results from Tables 2 and 3 by substituting the stock liquidity measure with an alternative metric—zero liquidity ($Zero\_LIQ_{i,t}$), defined as the proportion of days with zero return during the quarter. In this context, a higher value of zero liquidity indicates lower stock liquidity. The results, presented in Table 7, show that the coefficient for climate risk disclosure remains statistically significant and negative at the 1 % level for the current period (t) and at the 5 % level for the following quarters ($t+1$, $t+2$) in columns (2) and (3). This suggests that climate risk disclosure reduces stock illiquidity, thereby improving stock liquidity. These findings align with our baseline regression results, further reinforcing the notion that climate risk disclosure positively influences stock liquidity. In the later quarters ($t+3$, $t+4$, $t+5$), the coefficients of $CRD_{i,t}$ remain negative but lose statistical significance. This indicates that while the improvement in stock liquidity persists, its effect diminishes over time. Nonetheless, these differences in the methodology for calculating stock liquidity do not alter the core findings of the analysis.

4.3.2. Alternative proxies for climate risk disclosure

This subsection provides additional robustness checks by substituting the climate risk disclosure measure with the Climate Policy Uncertainty (CPU) Index constructed by Gavriilidis (2021). The CPU Index is based on a search of articles in eight leading U.S. newspapers and a statistical analysis of word frequency, capturing monthly changes in climate policy uncertainty. This index reflects changes in the external climate change environment that firms face, helping to assess how firms respond to fluctuations in climate policy risk. The results presented in Table 8 show that climate policy uncertainty has significantly different effects on stock liquidity across different quarter periods. Specifically, for the current and first-quarter ahead (t, $t+1$), the coefficients of $CPU_{i,t}$ are significantly negative at the 1 % level, indicating that firms' stock liquidity declines when they face significant changes in climate policy uncertainty

Table 7
Alternative proxied for stock liquidity.

Dep Var	$Zero\_LIQ_{i,t+h}$					
	h= 0	h= 1	h= 2	h= 3	h= 4	h= 5
	(1)	(2)	(3)	(4)	(5)	(6)
$CRD_{i,t}$	-0.055***	-0.032**	-0.029**	-0.006	-0.007	-0.004
	(0.014)	(0.013)	(0.013)	(0.013)	(0.013)	(0.012)
Constant	17.467***	16.265***	14.941***	13.825***	12.683***	11.311***
	(0.644)	(0.654)	(0.655)	(0.668)	(0.671)	(0.677)
Controls	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Quarter FE	YES	YES	YES	YES	YES	YES
Within R^2	0.577	0.582	0.584	0.584	0.587	0.588
N	182,047	175,361	170,067	164,767	160,365	154,678

Notes: This table reports the results of additional robustness tests with zero liquidity as the alternative measurement of stock liquidity. A larger zero liquidity indicates stock illiquidity. All specifications include the firm-level characteristic control variables, firm, and quarter fixed effects. Standard errors are clustered at the firm level and shown in parentheses, *p < 0.1; **p < 0.05; ***p < 0.01, respectively.

Table 8
Alternative proxies for climate risk disclosure.

Dep Var	$LIQ_{i,t+h}$					
	h= 0	h= 1	h= 2	h= 3	h= 4	h= 5
	(1)	(2)	(3)	(4)	(5)	(6)
$CPU_{i,t}$	-0.084***	-0.043***	-0.005	0.051***	0.087***	0.152***
	(0.014)	(0.014)	(0.015)	(0.015)	(0.016)	(0.017)
Constant	10.295***	10.959***	11.675***	12.287***	12.823***	13.282***
	(0.147)	(0.150)	(0.153)	(0.159)	(0.164)	(0.170)
Controls	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Quarter FE	YES	YES	YES	YES	YES	YES
Within R^2	0.344	0.313	0.269	0.226	0.189	0.161
N	182,047	175,401	170,096	164,825	160,488	154,819

Notes: This table reports the results of climate policy uncertainty on stock liquidity. We calculate the quarter CPU index based on monthly data extracted from Gavriilidis (2021), who constructs the CPU index by calculating climate change-related word frequency in U.S. eight newspapers each month. The eight newspapers are Boston Globe, Chicago Tribune, Los Angeles Times, Miami Herald, New York Times, Tampa Bay Times, USA Today, and the Wall Street Journal. containing the terms {"uncertainty" or "uncertain"} and {"carbon dioxide" or "climate" or "climate risk" or "greenhouse gas emissions" or "greenhouse" or "CO2" or "emissions" or "global warming" or "climate change" or "green energy" or "renewable energy" or "environmental"} and ("regulation" or "legislation" or "White House" or "Congress" or "EPA" or "law" or "policy"} (including variants such as "uncertainties," "regulatory," "policies," etc.) from April 2007 onwards. We acquire these results by adapting the TWFE model and clustering at the firm level. All specifications include time-varying firm-level control variables. Standard errors are clustered at the firm level and shown in parentheses, *p < 0.1; **p < 0.05; ***p < 0.01, respectively.

during the current quarter. This suggests that in the short term, increased climate policy uncertainty negatively impacts firms' stock liquidity as they struggle to adapt to new policies. For further quarter periods ($t + 3$, $t + 4$, $t + 5$), the coefficients of $CPU_{i,t}$ become significantly positive, suggesting that climate policy uncertainty improves stock liquidity in the longer term. This implies that firms adjust and respond to climate change risks over time, leading to better stock liquidity as they manage the uncertainties. The contrasting results between the short-term negative and long-term positive effects indicate that firms may initially struggle with climate policy uncertainty but eventually adapt and respond effectively to the changing environment. This finding supports the idea that while climate change risks pose short-term challenges, firms can ultimately navigate them and improve their stock liquidity in the long run.

4.3.3. Additional industry fixed effects

In this section, we extend our baseline regression analysis by incorporating industry fixed effects to address potential unobserved factors associated with industry differences. We classify all firms according to the North American Industry Classification System (NAICS) codes and construct industry-type variables at the firm-quarter level. Since industries may have unique characteristics influencing stock liquidity, we add industry fixed effects to our baseline estimation model. The results in Table 9 show that a higher increase in climate risk disclosure is consistently associated with a more significant increase in stock liquidity in future periods. This relationship remains statistically significant at the 1 % level across all future periods ($t + 1$, $t + 2$, $t + 3$, $t + 4$, $t + 5$), suggesting that stock markets gradually price in changes in climate risk within firms. In summary, our findings further reinforce the robustness of our baseline results.

4.3.4. Excluding the influence of the GFC and COVID

The research period of our study spans from 2007 to 2022, a timeframe encompassing significant global events such as the GFC and

Table 9
Additional fixed effect.

Dep Var	$LIQ_{i,t+h}$					
	h= 0	h= 1	h= 2	h= 3	h= 4	h= 5
	(1)	(2)	(3)	(4)	(5)	(6)
$CRD_{i,t}$	0.019***	0.019***	0.017***	0.015***	0.015***	0.013**
	(0.005)	(0.004)	(0.005)	(0.005)	(0.005)	(0.005)
Constant	10.489***	11.217***	12.081***	12.847***	13.584***	14.234***
	(0.166)	(0.170)	(0.176)	(0.182)	(0.190)	(0.196)
Controls	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Quarter FE	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES
Within R^2	0.307	0.274	0.227	0.183	0.144	0.114
N	182,047	175,361	170,067	164,767	160,365	154,678

Notes: In this table, we add industry fixed effects based on the baseline estimation function. All specifications include time-varying firm-level control variables. Standard errors are clustered at the firm level and shown in parentheses, *p < 0.1; **p < 0.05; ***p < 0.01, respectively.

the COVID pandemic. These events profoundly impacted global financial markets, leading to substantial fluctuations in stock prices and heightened liquidity risks. Specifically, the GFC in 2008 caused severe disruptions in equity markets, while the COVID pandemic from 2020 to 2022 led to considerable volatility in stock market indices, resulting in significant losses. While our specification controls for unobserved factors that vary over time, extreme events like the GFC and COVID may still influence our results in specific years. To ensure the robustness of our empirical analysis and to eliminate the potential impacts of these sudden events, we exclude the research samples corresponding to the quarters of 2008 and 2020–2022. After re-estimating the baseline model with these exclusions, the results are presented in Table 10. The findings show that the coefficients of $CRD_{i,t}$ remain positive and statistically significant, consistent with our baseline results. This outcome reinforces and confirms the validity of our initial findings that the positive relationship between climate risk disclosure and stock liquidity persists even after accounting for the effects of the GFC and COVID, thus passing the robustness test.

4.3.5. Balance panel estimation

To address potential estimation biases arising from unbalanced panel data, including firm observation gaps over long-term periods, we employ a balanced panel data approach to reassess the impact of climate risk disclosure on stock liquidity. This method ensures that only firms with complete data across the study period are included, reducing the risk of biased results due to missing observations. In columns (1) to (3) of Table 11, the results show a significant impact of climate risk disclosure on firms' stock liquidity performance at the 5 % and 10 % significance levels. This suggests that climate risk disclosure positively influences stock liquidity in the current period. However, in columns (4) to (6) of Table 11, the estimated coefficient for climate risk disclosure on future quarter liquidity is not statistically significant, indicating a weaker or less consistent effect over time. These results indicate that the positive relationship between climate risk disclosure and stock liquidity persists even when accounting for potential biases associated with unbalanced panel data.

4.4. Heterogeneity effect

4.4.1. Climate risk types

In this section, we delve into the heterogeneous effects of various types of climate change risks, such as opportunity, regulatory, and physical risk disclosures, on firms' stock liquidity. By analyzing subindexes of climate risk exposure from Sautner et al. (2023), we examine how these distinct climate risk disclosures impact firms' stock liquidity over time.

Panel A of Table 12 investigates the effects of opportunity risk disclosure on stock liquidity. The results indicate a significantly positive impact of climate risk disclosure on stock liquidity in both the current and subsequent quarters. The magnitude of the coefficient for opportunity risk aligns with our benchmark results, though its significance diminishes over time. This suggests that while firms gain substantial benefits from climate-related market opportunities, the effects tend to wane as time progresses. Panel B of Table 12 explores the influence of regulatory risk disclosure, focusing on firms' response strategy to evolving climate-related regulations and government policies. The findings reveal that the impact of regulatory risk on firms' stock liquidity is insignificant in the first four quarters (t, $t+1$, $t+2$, $t+3$). However, it becomes significant at the 5 % level in the fifth and sixth quarters ($t+4$, $t+5$). This indicates that regulatory risks might take longer to manifest and affect liquidity, reflecting the delayed adjustment of firms to regulatory changes. Panel C of Table 12 examines physical risk disclosure, which encompasses the direct impacts of climate-related events such as natural disasters or extreme weather. The results show that physical risk exposure significantly positively affects liquidity performance across all quarters, with the impact being approximately ten times greater than that of other risks. This underscores the severe and immediate influence of physical climate risks on firms' stock liquidity.

Overall, our estimates consistently demonstrate a significantly positive impact of climate risk exposure on firms' stock liquidity across all specifications. These findings reinforce the validity of our baseline results and highlight the importance of considering different dimensions of climate risk disclosure of opportunity, regulatory, and physical risks in understanding their effects on stock

Table 10
Excluding the influence of GFC and COVID.

Dep Var	$LIQ_{i,t+h}$					
	h= 0	h= 1	h= 2	h= 3	h= 4	h= 5
	(1)	(2)	(3)	(4)	(5)	(6)
$CRD_{i,t}$	0.026***	0.024***	0.021***	0.017***	0.012**	0.008
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Constant	10.388***	11.131***	12.013***	12.793***	13.583***	14.287***
	(0.181)	(0.186)	(0.194)	(0.202)	(0.212)	(0.220)
Controls	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Quarter FE	YES	YES	YES	YES	YES	YES
Within R^2	0.287	0.257	0.210	0.166	0.127	0.097
N	148,429	143,826	139,296	134,872	130,475	126,076

Notes: This table reports the results of climate risk disclosure on firms' stock liquidity, excluding the influence of the GFC and COVID. All specifications include time-varying firm-level control variables and firm and quarter-fixed effects. Standard errors are clustered at the firm level and shown in parentheses, *p < 0.1; **p < 0.05; ***p < 0.01, respectively.

Table 11
Balance panel estimation.

Dep Var	$LIQ_{i,t+h}$					
	h= 0	h= 1	h= 2	h= 3	h= 4	h= 5
	(1)	(2)	(3)	(4)	(5)	(6)
$CRD_{i,t}$	0.011*	0.012**	0.011*	0.010	0.010	0.009
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.007)
Constant	11.560***	12.134***	12.770***	13.368***	13.936***	14.484***
	(0.304)	(0.309)	(0.314)	(0.322)	(0.331)	(0.338)
Controls	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Quarter FE	YES	YES	YES	YES	YES	YES
Within R^2	0.307	0.279	0.240	0.202	0.170	0.141
N	76,614	75,355	74,124	72,893	71,660	70,405

Notes: This table reports the balance panel results of climate risk disclosure on firms' stock liquidity. All specifications include time-varying firm-level control variables and firm and quarter-fixed effects. Standard errors are clustered at the firm level and shown in parentheses, *p < 0.1; **p < 0.05; ***p < 0.01, respectively.

Table 12
Different climate risk types.

Panel A Opportunity risk	$LIQ_{i,t+h}$					
	h= 0	h= 1	h= 2	h= 3	h= 4	h= 5
	(1)	(2)	(3)	(4)	(5)	(6)
$CRD^{op}_{i,t}$	0.024**	0.023**	0.020**	0.022**	0.021*	0.017
	(0.010)	(0.009)	(0.010)	(0.010)	(0.011)	(0.011)
Constant	10.494***	11.221***	12.085***	12.850***	13.587***	14.236***
	(0.165)	(0.171)	(0.176)	(0.184)	(0.191)	(0.199)
Controls	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Quarter FE	YES	YES	YES	YES	YES	YES
Within R^2	0.307	0.274	0.226	0.183	0.144	0.114
N	182,047	175,361	170,067	164,767	160,365	154,678
Panel B Regulatory risk	$LIQ_{i,t+h}$					
	h= 0	h= 1	h= 2	h= 3	h= 4	h= 5
	(1)	(2)	(3)	(4)	(5)	(6)
$CRD^{rg}_{i,t}$	−0.005	−0.002	0.023	0.032	0.052*	0.067**
	(0.025)	(0.025)	(0.025)	(0.026)	(0.027)	(0.029)
Constant	10.498***	11.225***	12.088***	12.852***	13.588***	14.236***
	(0.165)	(0.171)	(0.176)	(0.184)	(0.191)	(0.198)
Controls	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Quarter FE	YES	YES	YES	YES	YES	YES
Within R^2	0.307	0.274	0.226	0.182	0.145	0.115
N	182,047	175,361	170,067	164,767	160,365	154,678
Panel C Physical risk	$LIQ_{i,t+h}$					
	h= 0	h= 1	h= 2	h= 3	h= 4	h= 5
	(1)	(2)	(3)	(4)	(5)	(6)
$CRD^{ph}_{i,t}$	0.182***	0.180***	0.164***	0.137**	0.141**	0.164***
	(0.056)	(0.056)	(0.060)	(0.063)	(0.063)	(0.063)
Constant	10.497***	11.225***	12.089***	12.853***	13.590***	14.238***
	(0.165)	(0.170)	(0.176)	(0.184)	(0.191)	(0.198)
Controls	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Quarter FE	YES	YES	YES	YES	YES	YES
Within R^2	0.307	0.274	0.226	0.183	0.144	0.113
N	182,047	175,361	170,067	164,767	160,365	154,678

Notes: This table reports the results of different climate risk disclosures on stock liquidity performance. Panels A, B, and C report the results for opportunity, regulatory, and physical risks on stock liquidity, respectively. The firm climate risk disclosure index is all extracted from Sautner et al. (2023), and all specifications include time-varying firm-level control variables and firm and quarter fixed effects. Standard errors are clustered at the firm level and shown in parentheses, *p < 0.1; **p < 0.05; ***p < 0.01, respectively.

liquidity. The temporal variations in these effects underscore the need for firms to adopt strategies that address both short-term and long-term climate risks effectively.

4.4.2. Industry properties

This study investigates how changes in a firm's climate risk disclosure affect stock liquidity across different industries. As shown in Table 13, climate risk disclosure exerts a consistently positive and statistically significant impact on stock liquidity in both manufacturing and non-manufacturing sectors. This indicates that greater transparency in climate-related risks generally enhances stock liquidity, regardless of industry type. Importantly, we find no statistically significant difference in the magnitude of this effect between manufacturing and non-manufacturing firms, suggesting a broadly applicable relationship. However, a notable divergence emerges over time. In non-manufacturing sectors, the positive effect of climate risk disclosure on stock liquidity shows a gradual decline, possibly reflecting a strategic adaptation by firms and more mature investor expectations regarding climate risks. By contrast, in manufacturing sectors, the effect remains relatively stable, underscoring the sustained relevance of climate risk disclosure in improving stock liquidity.

These findings highlight the need to consider industry-specific dynamics when evaluating the financial implications of climate risk. While the general trend underscores the beneficial role of climate risk disclosure, especially in building market confidence, the evolving impact in non-manufacturing industries points to an increasingly sophisticated market response. Such insights can inform both investors and policymakers in developing targeted strategies for climate risk management.

5. Mechanism analysis

5.1. The role of information transparency

In order to investigate how information transparency moderates the effect of climate risk disclosure on stock liquidity, we incorporate an interaction term between information transparency and climate risk disclosure in the regression model. The measurement of firm informativeness ($Inform_{i,t}$), detailed in Appendix 4, captures the extent to which information about a firm's climate risk is accessible and understood by the market.

As shown in Table 14, the interaction term between climate risk disclosure and firm informativeness is consistently positive and statistically significant at the 1 % level across all specifications. This finding confirms Hypothesis 2 and highlights the amplifying role of firm informativeness in the relationship between climate risk disclosure and stock liquidity. Specifically, firms with higher levels of information transparency experience greater improvements in stock liquidity when they disclose climate-related risks. These results indicate that higher informativeness enables stock prices to incorporate new information more efficiently, thereby enhancing market liquidity. From a strategic perspective, improving firm informativeness can help companies more effectively benefit from climate risk

Table 13
Firm industry characteristic.

Panel A Manufacturing	$LIQ_{i,t+h}$					
	h= 0	h= 1	h= 2	h= 3	h= 4	h= 5
	(1)	(2)	(3)	(4)	(5)	(6)
$CRD_{i,t}$	0.017**	0.018***	0.017**	0.019**	0.019**	0.017**
	(0.007)	(0.007)	(0.007)	(0.007)	(0.008)	(0.008)
Constant	10.391***	11.151***	12.099***	12.921***	13.727***	14.427***
	(0.223)	(0.232)	(0.244)	(0.257)	(0.271)	(0.283)
Controls	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Quarter FE	YES	YES	YES	YES	YES	YES
Within R^2	0.329	0.288	0.232	0.182	0.140	0.107
N	79,976	77,837	75,735	73,641	71,540	69,456
Panel B Non-manufacturing	$LIQ_{i,t+h}$					
	h= 0	h= 1	h= 2	h= 3	h= 4	h= 5
	(1)	(2)	(3)	(4)	(5)	(6)
CRD_{it}	0.022***	0.020***	0.019***	0.014***	0.012**	0.011*
	(0.005)	(0.005)	(0.005)	(0.006)	(0.006)	(0.006)
Constant	10.568***	11.217***	11.969***	12.660***	13.317***	13.913***
	(0.241)	(0.245)	(0.250)	(0.257)	(0.266)	(0.271)
Controls	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Quarter FE	YES	YES	YES	YES	YES	YES
Within R^2	0.291	0.268	0.228	0.190	0.154	0.125
N	102,075	99,115	96,183	93,249	90,309	87,421

Notes: Industry classification is based on NAICS. The manufacturing industry includes the common keyword of manufacturing in its characteristic description, and otherwise, it includes non-manufacturing industries. All specifications include time-varying firm-level control variables and firm and quarter-fixed effects. Standard errors are clustered at the firm level and shown in parentheses, *p < 0.1; **p < 0.05; ***p < 0.01, respectively.

Table 14
The role of information transparency.

Dep Var	$LIQ_{i,t+h}$					
	h= 0	h= 1	h= 2	h= 3	h= 4	h= 5
	(1)	(2)	(3)	(4)	(5)	(6)
$CRD_{i,t}$	0.009**	0.008**	0.008*	0.006	0.004	0.003
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)
$Inform_{i,t}$	−0.179***	−0.178***	−0.177***	−0.161***	−0.148***	−0.135***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.007)
$CRD_{i,t} \times Inform_{i,t}$	0.012***	0.012***	0.011***	0.012***	0.013***	0.013***
	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)
Constant	10.920***	11.645***	12.494***	13.209***	13.905***	14.525***
	(0.161)	(0.164)	(0.169)	(0.176)	(0.184)	(0.190)
Controls	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Quarter FE	YES	YES	YES	YES	YES	YES
Within R^2	0.320	0.287	0.240	0.194	0.154	0.122
N	181,817	176,721	171,688	166,660	161,605	156,647

Notes: This table reports the moderating effect of firms' information transparency in climate risk disclosure on stock liquidity. Where $Inform_{i,t}$ indicates the information efficiency of capital markets that is calculated by $R^2_{i,t}$ according to Xu et al. (2013). Our study adopts the interaction terms of firms' climate risk disclosure and their information transparency to demonstrate the moderating role of firm informativeness. We report the results from regression analysis of stock liquidity in different lead periods (t, $t+1$, $t+2$, $t+3$, $t+4$, $t+5$) on the lagged climate risk disclosure (in quarter t). Columns (1) to (6) control the firm-level characteristic variables and add firm and quarter-fixed effects. Standard errors are clustered at the firm level and shown in parentheses, *p < 0.1; **p < 0.05; ***p < 0.01, respectively.

Table 15
The role of firms' climate change commitments.

Panel A Proactive	$LIQ_{i,t+h}$					
	h= 0	h= 1	h= 2	h= 3	h= 4	h= 5
	(1)	(2)	(3)	(4)	(5)	(6)
$CRD^{pro}_{i,t}$	0.010**	0.011***	0.011**	0.011**	0.011**	0.011**
	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)	(0.005)
Constant	10.494***	11.221***	12.085***	12.850***	13.587***	14.235***
	(0.165)	(0.171)	(0.176)	(0.184)	(0.191)	(0.199)
Controls	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Quarter FE	YES	YES	YES	YES	YES	YES
Within R^2	0.307	0.275	0.228	0.184	0.145	0.115
N	182,047	175,361	170,067	164,767	160,365	154,678
Panel B Non-proactive	$LIQ_{i,t+h}$					
	h= 0	h= 1	h= 2	h= 3	h= 4	h= 5
	(1)	(2)	(3)	(4)	(5)	(6)
$CRD^{non}_{i,t}$	−0.016**	−0.011	−0.010	−0.010	−0.010	−0.007
	(0.008)	(0.008)	(0.008)	(0.009)	(0.009)	(0.010)
Constant	10.497***	11.224***	12.088***	12.853***	13.590***	14.238***
	(0.165)	(0.170)	(0.176)	(0.184)	(0.191)	(0.198)
Controls	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Quarter FE	YES	YES	YES	YES	YES	YES
Within R^2	0.307	0.274	0.227	0.183	0.145	0.114
N	182,047	175,361	170,067	164,767	160,365	154,678

Notes: This table reports the estimated results of firms' different attitude commitments of climate risk disclosure on stock liquidity. The core attitude variables are calculated by the word frequency of proactive and non-proactive in textual analysis of earnings call transcripts, which focus on the firm's proactiveness in addressing climate change issues. Panel A shows the proactive attitude commitment, and Panel B presents the non-proactive attitude commitment. All specifications include the firm-level characteristic control variables and firm and quarter fixed effects. Standard errors are clustered at the firm level and shown in parentheses, *p < 0.1; **p < 0.05; ***p < 0.01, respectively.

disclosures. This provides a practical approach to strengthening investor confidence and achieving better liquidity outcomes in capital markets. The empirical evidence presented in Table 14 confirms Hypothesis 2, which posits that firm informativeness strengthens the positive relationship between climate risk disclosure and stock liquidity.

5.2. The role of climate change commitment

Firms' climate change commitments play a crucial role in the corporate public image for climate change risk, providing investors and shareholders with clear information on how firms respond to climate change risks. According to the literature of Sautner et al. (2023), they create two sentiment calculations by counting the number of climate change bigrams after conditioning on the presence of the positive or negative tone words in Loughran and Mcdonald (2011). Those two measures separately reflect the attitude of a firm's climate change governance while faced with lots of climate change risk, while reflecting firms' proactiveness in addressing climate issues. Therefore, we further estimate the impact of firms' different climate change commitments on equity liquidity performance.

The findings in Panel A and Panel B of Table 15 offer insights into the impact of proactive versus non-proactive climate change risk commitments on stock liquidity. Panel A reveals that the proactive climate risk disclosure coefficient ($CRD_{i,t}^{pro}$) is positive and statistically significant. This indicates that firms that actively manage and disclose their climate change risks experience improved stock liquidity. On the other hand, Panel B shows that the coefficient for non-proactive climate risk disclosure ($CRD_{i,t}^{non}$) is harmful and not statistically significant. This suggests that firms that do not actively manage their climate risks do not see the same benefits regarding stock liquidity. These firms may face a disadvantage in the market.

Our findings suggest that the market tends to discount the equity of firms that do not actively manage their climate risks. Such firms may suffer from negative reputations, worse credit ratings, and less favorable access to long-term equity markets. These firms may also face a higher probability of underinvestment and a slower speed of adjustment to the optimal level of investment, which can further hinder their financial performance and market standing (Agoraki et al., 2024). Firms that take a proactive stance on climate risk management enjoy better liquidity in the stock market and tend to perform better financially. This is consistent with emerging literature showing a positive correlation between a firm's commitment to climate change actions and financial performance (Lemma et al., 2021). Investors will likely perceive these firms more favorably, leading to improved equity liquidity and stock market performance. The evidence from Table 15 supports Hypothesis 3, that firms with proactive climate risk management strategies are better positioned to achieve favorable stock market liquidity outcomes.

6. Discussions

While prior research has extensively examined the macroeconomic effects of climate risk on national economies and firm operations, relatively little attention has been paid to its implications for stock market dynamics (Kahn et al., 2021; Kumar and Maiti, 2024). A notable limitation in the existing literature is the tendency to assume that all firms are equally affected by climate shocks. Since stock liquidity is a key indicator of a firm's operational efficiency and market health (Cho and Kim, 2021), a deeper exploration of how climate risk disclosure influences liquidity is warranted. However, the extent to which individual firms are impacted by climate change varies considerably, making it challenging to quantify these effects at the firm level. As highlighted by Sautner et al. (2023), climate-related regulations can impose significant costs on certain firms while simultaneously creating opportunities for others, depending on industry-specific characteristics. This heterogeneity underscores the need for more refined metrics to capture firm-level differences in climate risk disclosure.

Climate risk disclosure is a strategic communication tool that conveys a firm's approach to climate-related challenges, including adopting low-carbon strategies, responses to regulatory policies, and risk mitigation measures. These disclosures help bridge the information gap between firms and investors, fostering greater transparency in capital markets (Agoraki et al., 2024; Liu et al., 2024). Our study mainly focuses on the impact of climate risk disclosure on stock liquidity. We also reveal the potential mechanism of how climate risk disclosure affects stock liquidity from the perspective of stock market efficiency and firm commitment to climate change. Our finding is consistent with the emerging literature on climate risk disclosure and stock market performance that firm information disclosure to climate change is associated with better stock performance (Li et al., 2024; Liu et al., 2024). Our study also provides new evidence on how climate risk disclosure affects stock liquidity, enriching the literature on climate risk and corporate finance. Firms that actively communicate their climate commitments not only strengthen their credibility among investors but also enhance their long-term sustainability prospects. By aligning corporate strategies with broader societal expectations for environmental stewardship, firms can cultivate a culture of accountability and resilience in response to climate risks.

This study relies on climate risk disclosure data derived primarily from earnings conference calls, following the methodology of Sautner et al. (2023). While this source provides timely and firm-representative insights, it captures only part of the disclosure landscape. Future research could broaden the data foundation by incorporating additional disclosure channels such as standalone sustainability reports, annual regulatory filings, and voluntary ESG disclosures submitted to frameworks like Carbon Disclosure Project (CDP) or TCFD. This expansion would enable a more comprehensive and systematic quantification of climate risk communication, especially as firms increasingly differentiate their disclosures across formats and audiences. Moreover, cross-validating climate narratives across channels may help assess consistency and credibility, which could further influence investor interpretation and market outcomes. Developing a multi-source climate disclosure index would thus offer a more robust proxy for firms' climate transparency, better capturing their environmental positioning and allowing for richer analyses across industries and governance regimes.

While this study demonstrates a positive relationship between climate risk disclosure and stock liquidity, the potential impact of

greenwashing should be carefully considered when interpreting these results. Torelli et al. (2020) define greenwashing motivation behind ESG engagement as deliberate corporate disclosure intended to mislead stakeholders and create an overly positive ESG image. Such a motivation may increase the quantity of ESG information disclosed without corresponding engagement in substantive ESG activities (Donia et al., 2019). Consequently, the observed liquidity benefits may, in part, reflect temporary investor optimism driven by superficially impressive yet unsubstantiated climate-related claims, rather than genuine corporate transparency. Future research should therefore seek to distinguish between substantive and symbolic disclosures by incorporating verification mechanisms such as third-party assurance, alignment with science-based targets, or evidence of ex-post regulatory penalties for misrepresentation. Such measures would help ascertain whether improvements in liquidity persist only among firms with credible climate commitments, while firms engaging in greenwashing face subsequent market corrections. This line of inquiry would strengthen our understanding of the true market implications of disclosure quality, particularly in light of the increasing regulatory focus on mitigating environmental misreporting.

A deeper understanding of the institutional and regulatory contexts shaping the effect of climate risk disclosure represents a third vital research frontier in our study. Climate-related communication and action does not operate in a vacuum; its impact is mediated by the surrounding political economy, including enforcement capacity, investor activism, and policy credibility. Future studies could explore how disclosure effectiveness varies across countries with different climate policies, legal systems, or degrees of press freedom. For instance, in jurisdictions with stringent mandatory ESG rules, disclosure may be more standardized but less informative, while in voluntary regimes, credible disclosure may act as a signal of firm commitment. Similarly, the role of institutional investors or civil society in monitoring disclosures may differ across contexts. Cross-country or within-country comparative studies, especially those exploiting regulatory reforms or international initiatives like the EU taxonomy, can illuminate how institutional design and governance quality shape the link between disclosure and capital market outcomes.

Finally, our findings underscore the joint role of internal corporate governance and external regulatory frameworks in shaping the effectiveness of climate risk disclosure on stock outcomes. While disclosure is an internal governance mechanism that signals firms' commitment to transparency and accountability, its credibility and market impact are heavily conditioned by the surrounding policy environment. For instance, heterogeneous environmental regulations amplify firms' climate risk exposure and weaken stock liquidity, highlighting how external rules can exacerbate or mitigate market responses (Liu et al., 2024; Qiu et al., 2025). Similarly, Li et al. (2025) demonstrate that China's emission trading scheme strengthens corporate carbon disclosure, illustrating how market-based regulation complements internal governance efforts. Future research should therefore investigate the interaction between firms' internal governance strategies and external regulatory regimes to better understand their joint influence on corporate finance and market efficiency.

7. Conclusions and implications

This study examines the impact of climate risk disclosure on capital market performance, with a particular focus on stock liquidity. Our results show that climate risk disclosure significantly positively affects stock liquidity in both the current and subsequent quarters. These findings suggest that increased climate risk disclosure enhances stock liquidity. This relationship remains robust across various estimation methods, including those addressing potential endogeneity concerns, substituting key variables, and conducting sensitivity analyses to account for unobservable factors. Additionally, we explore the heterogeneous effects of climate risk disclosure on stock liquidity by categorizing disclosures into opportunity, regulatory, and physical risks. Among these, physical risk disclosure has the most significant impact on stock liquidity. Furthermore, our results remain consistent across different industries, with no significant variation in the effect of climate risk disclosure on stock liquidity by industry type.

Moreover, this study further explores how climate risk disclosure enhances stock liquidity. We measure firm informativeness in the stock market and distinguish firms' attitudes toward climate change at the firm-quarter level. We then examine the critical role of firm informativeness and climate change commitment in shaping the relationship between climate risk disclosure and stock liquidity. Our findings suggest that firms with higher information transparency and a proactive commitment to climate change amplify the positive effects of climate risk disclosure on stock liquidity. Therefore, we conclude that enhancing transparency in climate-related communications between enterprise managers and the public and reinforcing a firm's positive commitment to climate change can amplify the positive effect of climate risk disclosure on stock liquidity in the current and future periods.

The findings of this study have significant theoretical and practical implications for market participants, corporations, and policymakers. Our research highlights the crucial role of climate risk disclosure in shaping investment decisions, particularly emphasizing the impact of physical risk exposure on stock liquidity. For investors, this study demonstrates that rigorous assessment of corporate climate disclosures provides material insights into firms' financial resilience, as higher-quality reporting is systematically associated with enhanced stock liquidity. These findings suggest investors should incorporate climate transparency metrics into their valuation frameworks, particularly evaluating firms' exposure to transition and physical risks, to better identify liquidity premiums and mitigate climate-related portfolio risks. For corporations, climate risk disclosure represents far more than a regulatory obligation, it serves as a strategic imperative that enhances financial resilience, strengthens investor confidence, and safeguards long-term value. Existing studies demonstrate that robust climate disclosures act as a protective mechanism against stock price volatility and sudden market declines, effectively mitigating stock price crash risks (Jung and Song, 2023; Lin and Wu, 2023). By proactively communicating their environmental strategies and risk mitigation efforts, companies position themselves to attract ESG-focused capital, strengthen brand reputation, and cultivate deeper trust with stakeholders. This strategic transparency not only enhances short-term market performance but also safeguards long-term sustainability by aligning corporate practices with evolving investor expectations and global climate priorities.

For policymakers, this study provides robust empirical evidence that climate risk disclosure enhances firm-level stock liquidity by mitigating information asymmetries in capital markets. These findings suggest three critical policy interventions: first, the implementation of mandatory disclosure requirements for material climate risks, particularly those affecting firms' financial positions and operational resilience; second, the development of standardized reporting frameworks that facilitate cross-firm comparability of climate exposures and their liquidity implications; and third, the establishment of verification mechanisms to ensure disclosures accurately reflect firms' vulnerability to both physical and transition risks. Such regulatory measures would preserve the documented liquidity benefits while addressing potential greenwashing concerns, especially in climate-sensitive industries where information gaps most severely impair market efficiency. The demonstrated relationship between disclosure quality and liquidity improvements offers a compelling rationale for transitioning from voluntary to mandatory climate reporting regimes.

CRediT authorship contribution statement

Shaohai Lei: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Methodology, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Yilan Chen:** Writing – review & editing, Writing – original draft, Validation, Resources, Methodology, Investigation, Formal analysis, Conceptualization. **Dehua Xia:** Writing – review & editing, Writing – original draft, Validation, Software, Methodology, Investigation, Data curation, Conceptualization.

Informed consent

All participants in this study volunteered during the entire research process, and their consent was taken at inception.

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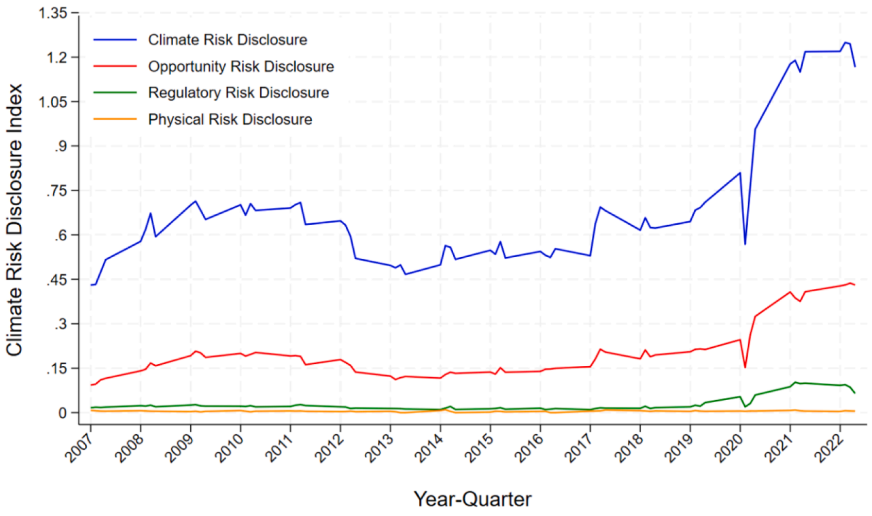
Declaration of Competing Interest

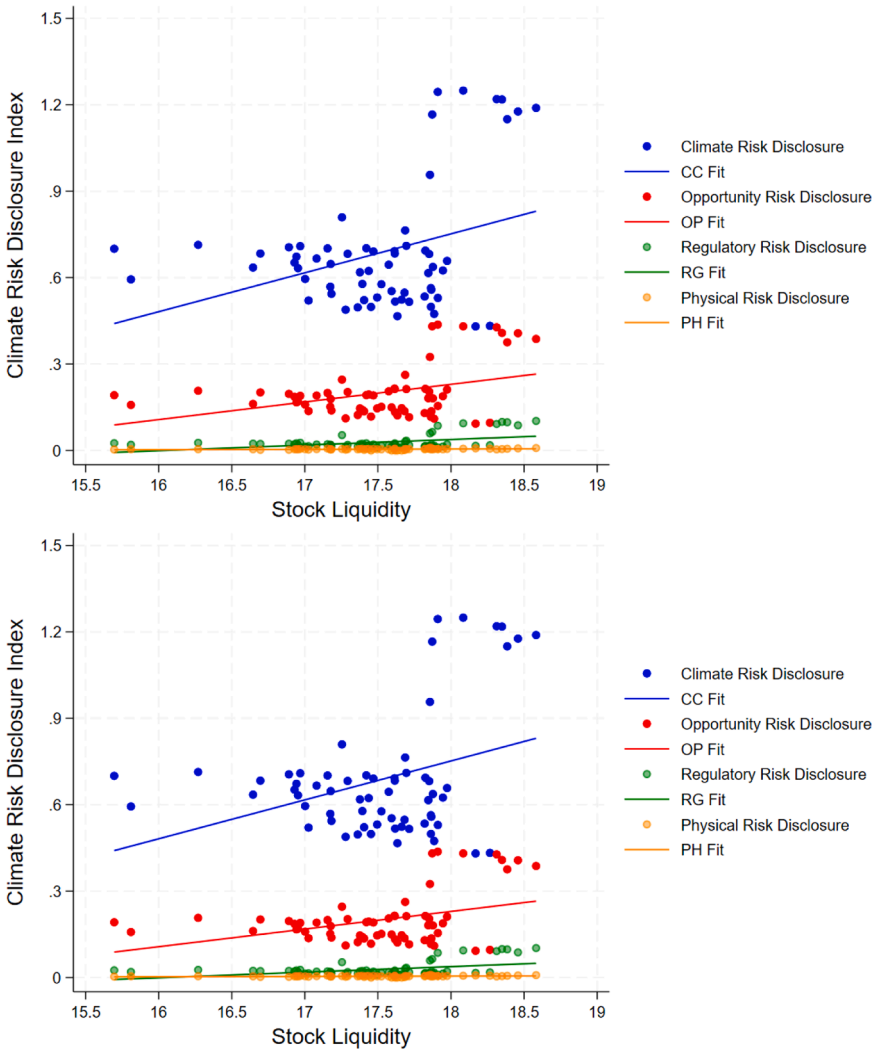
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix 1. The evolutionary characteristics of firm-level climate risk disclosure



Notes: This figure presents the evolutionary characteristics of firm-level risk disclosure at the year-quarter level. We calculate the year-quarter mean of the climate risk disclosure index at the firm level to illustrate its changes and development trends over the research period.

Appendix 2. The correlation between climate risk disclosure and stock liquidity



Notes: These two figures illustrate the correlation between climate risk disclosure and stock liquidity across different risk types.

Appendix 3. Variables' definition and measurements

Variables	Acronym	Description/ Calculation	Data source
Dependent			
Stock liquidity	$LIQ_{i,t}$	Stock liquidity at the firm-quarter level.	Compustat
Independent			
Climate risk disclosure	$CRD_{i,t}$	The frequency of mentions of the unigrams or bigrams related to all climate change discussion in the proximity of risk synonyms, divided by the total length of the transcript, and then multiplied by 10^3.	Sautner et al. (2023)
Opportunity risk climate disclosure	$CRD^{op}_{i,t}$	The frequency of mentions of the unigrams or bigrams related to opportunity risk climate discussion in the proximity of risk synonyms, divided by the total length of the transcript, and then multiplied by 10^3.	
Regulatory risk climate disclosure	$CRD^{rg}_{i,t}$	The frequency of mentions of the unigrams or bigrams related to regulation risk climate discussion in the proximity of risk synonyms, divided by the total length of the transcript, and then multiplied by 10^3.	

(*continued on next page*)

(*continued*)

Variables	Acronym	Description/ Calculation	Data source
Physical risk climate disclosure	$CRD_{i,t}^{ph}$	The frequency of mentions of the unigrams or bigrams related to physical risk climate discussion in the proximity of risk synonyms is divided by the total length of the transcript and then multiplied by 10^3.	
Firm-level controls			
Firm size	$Size_{i,t}$	A dummy variable related to the firms' size is also used; it equals one if the number of firm employees is over the sample median and zero otherwise.	Compustat
Return on assets	$ROA_{i,t}$	Net income divided by total assets.	
Firm strength	$Asset_{i,t}$	Natural logarithm of firm's total assets.	
Market-to-book ratio	$MB_{i,t}$	The market value of equity plus the book value of debt divided by total assets.	
Firm leverage	$Leverage_{i,t}$	Long-term debt is divided by shareholders' equity.	
Short-term investment	$Invest_{i,t}$	Logarithmic form of short-term investment.	
R&D expenditures	$R\&D_{i,t}$	Logarithmic form of R&D expenditures.	
Cash holding	$Cash_{i,t}$	Logarithmic form of firm's cash currency at quarter level	
Other variables			
Climate risk disclosure /Proactive attitude	$CRD_{i,t}^{pro}$	The frequency of mentions of the unigrams or bigrams related to the transition climate discussion in the proximity of proactive verbs is divided by the total length of the transcript and then multiplied by 10^3.	Sautner et al. (2023)
Climate risk disclosure /non-proactive attitude	$CRD_{i,t}^{non}$	The frequency of mentions of the unigrams or bigrams related to the transition climate discussion, which are not in the proximity of proactive verbs, is divided by the total length of the transcript and then multiplied by 10^3.	
Firm informativeness	$Inform_{i,t}$	Firm informativeness in stock market.	Compustat
Paris Agreement	$Paris_i$	A dummy variable that equals 0 for years before the signing of the Paris Agreement in 2015 and 1 for 2015 and subsequent years, indicating the post-agreement period.	Author's Calculation
Industry average climate risk disclosure	$Mean\_CRD_{i,t}$	The IV is the industry-level average of firms' climate risk disclosure indices, calculated based on all firms within the same industry.	
Climate policy uncertainty	$CPU_{i,t}$	The number of news articles related to the firm's climate risk exposure is divided by the total number of articles related to the firm.	Gavriilidis (2021)

Appendix 4. Measurement of firm informativeness

Following Gul et al. (2010) and Xu et al. (2013), we measure stock return synchronicity to indicate firm price informativeness using the following approach and estimate the linear regression to acquire R^2. To circumvent the bounded nature of R^2 within [0,1], we use a logistic transformation of $R_{i,t}^2$ according to Morck et al. (2000). Estimation function as follows:

$$R_{i,t} = \beta_1 R_{m,t} + \beta_2 R_{m,t-1} + \beta_3 R_{I,t} + \beta_4 R_{I,t-1} + \varepsilon_{it} \tag{5}$$

$$Inform_{i,t} = \ln(R_i^2/1 - R_i^2) \tag{6}$$

Where $R_{i,t}$ is represents the stock return of firm i at quarter t, $Inform_{i,t}$ measured by the R_i^2, which is our empirical measure of quarterly firm's stock price informativeness for each firm, which indicates the level of firms' information disclosure in the capital market. Greater firm informativeness indicates greater alignment between individual and market returns, less idiosyncratic information in response to individual stock fluctuations, and greater informational inefficiency in the capital market, and vice versa.

Data availability

Data will be made available on request.

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