



Are Real Estate Firms Sensitive to Climate Change Exposure?

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Abstract

Using a sample of real estate (RE) firm-year observations from 30 countries, we show that greater firm-level climate change exposure (FCCE) is associated with lower stock liquidity. Among the components of FCCE, opportunity-related exposure shows the strongest negative association with liquidity. By contrast, physical risk exposure is positively associated with liquidity after controlling for Country×Year and Sub-industry fixed effects. We further find that national climate governance moderates the relationship between FCCE and liquidity. More stringent environmental policies and long-term climate commitments, such as net-zero targets, mitigate the adverse effect of FCCE on liquidity whereas the evidence for building-sector regulations is weaker. At the firm level, environmental performance also weakens this relationship. In addition, the negative association between FCCE and liquidity is less pronounced in more carbon-intensive sectoral environments as measured by both GHG and CO₂ emissions. This result is consistent with the view that climate risk is already more fully priced in high-emission settings which reduces the additional uncertainty associated with FCCE. Overall, our results show that FCCE, corporate environmental performance and national climate governance jointly shape the stock liquidity of RE firms.

Keywords Climate change · Climate policy · Stock liquidity · Environmental performance · Real estate

JEL Classification G32 · Q54 · R33

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Introduction

Climate-related issues affect the financial performance of real estate companies and increase their exposure to equity market risk (Zhu & Fuerst, 2023). These issues create uncertainty about climate events and regulation, influencing investor behavior (Krueger et al., 2024) and complicating firm valuation, as extreme weather affects firm performance and market prices (Vestrelli et al., 2024a; Wang et al., 2025). Given their transparent reporting practices, standardized asset-level exposures, and highly liquid market structures (Downs & Zhu, 2022) real estate firms, particularly publicly traded real estate investment trusts (REITs), provide an especially suitable setting in which to examine these dynamics. In this paper, we focus on how firm-level climate change exposure (FCCE), as developed by Sautner et al. (2023), influences stock liquidity in the global real estate sector, thereby offering new insights into how climate-related risks shape financial market functioning.

Recent evidence underscores the materiality of climate exposure in real estate markets (UNEP Finance Initiative, 2021). Nearly 10% of assets held by major real estate firms worldwide are located in high-risk zones, such as coastal areas vulnerable to flooding, with potential annual damages exceeding 1% of replacement value by 2050.¹ Such exposure highlights the growing vulnerability of real estate portfolios to physical climate events and emphasizes the need to understand how these risks influence market perceptions, investor behavior, and financial stability. Stock liquidity closely tracks along with investor confidence, reflecting information asymmetries and uncertainty about firms. Heightened uncertainty over climate exposures increases trading costs, reduces market participation, and erodes liquidity. Lower liquidity signals diminished confidence, elevated perceived risk, and amplified information friction, which increase capital costs and depress asset values (Brunnermeier & Pedersen, 2009). Understanding how FCCE influences liquidity dynamics is thus critical for gauging how climate-related information is integrated into market prices and affects capital allocation in exposed sectors.

Using an international dataset of real estate firms from 2003 to 2022 across 30 countries, we find that higher FCCE is associated with lower stock liquidity. This negative association is driven primarily by opportunity-related climate exposure whereas regulatory exposure has more limited effects and physical risk is associated positively with stock liquidity across firms, potentially reflecting greater investor attention in response to geographically concentrated climate risk. These results are consistent with the view that investors may interpret opportunity-oriented disclosures such as investments in green technologies, energy-efficient retrofits or sustainable development projects as signals of greater uncertainty about firms' strategic transition and future profitability. After controlling for firm and year fixed effects, FCCE and its opportunity-related component remain marginally significant, whereas the physical-risk component does not. A series of sensitivity and robustness analyses including two-stage least squares (2SLS) estimations, alternative liquidity factor

¹ JPMorgan Private Bank (2023), How Climate Risk and Losses Are Creating High Prices for Home Insurance, <https://privatebank.jpmorgan.com/nam/en/insights/markets-and-investing/ideas-and-insights/how-climate-risk-and-losses-are-creating-high-prices-for-home-insurance>

measurement and subsample analyses confirm the stability of the negative FCCE–liquidity relationship.

National climate governance further moderates this relationship. Although environmental taxes reduce overall liquidity without specifically resolving the informational asymmetry generated by FCCE, more stringent environmental policies and long-term climate commitments such as net zero targets attenuate the adverse liquidity effects. In contrast, the ND–GAIN adaptive capacity index does not generate a significant moderating effect, which is consistent with the view that general resilience conditions do not substitute for enacted regulatory commitment in reducing investor uncertainty. Overall, these findings suggest that credible and predictable climate policy environments reduce the uncertainty surrounding climate-related risks and facilitate investors' interpretation of FCCE.

In addition, the negative FCCE–liquidity relationship weakens in environments that are more carbon intensive, as captured by both GHG and CO₂ emissions from the buildings sector relative to other sectors. This finding indicates that investors may process and price climate-related information more efficiently in settings in which climate risks are already more salient.

Finally, firm-level environmental performance exhibits heterogeneous moderating effects across its dimensions. Environmental innovation capacity significantly weakens the negative association between FCCE and stock liquidity, consistent with the view that forward-looking environmental strategies reduce informational uncertainty about firms' ability to navigate climate transition risks. In contrast, broader environmental performance dimensions, including the overall environmental pillar score, emissions management, and resource use scores, do not generate significant moderating effects, suggesting that compliance-oriented environmental performance does not sufficiently resolve the informational frictions generated by FCCE in the real estate sector.

Our study makes various theoretical and practical contributions. First, it provides the first large-scale, global analysis of the relationship between FCCE and stock liquidity. This method contrasts with previous studies limited to single-country settings, for example, China in Qiu et al. (2025) or India in Sahu and Debata (2025), or using short time spans, thereby offering a broader and more generalizable perspective.

Second, unlike Liu et al. (2024), who examine liquidity commonality (i.e., synchronicity between firm-specific and market liquidity) using the Amihud (2002) price impact ratio, our study advances this literature by focusing on firm-specific liquidity. We measure liquidity across three complementary dimensions: transaction costs (Venkataraman, 2001; Cumming et al., 2011; Chung & Zhang, 2014), price impact (Amihud, 2002), and trading activity (Datar et al., 1998; Goyenko et al., 2009), and then combine them into a single firm-level liquidity factor via factor analysis with oblique rotation (Daske et al., 2008). This methodology yields a more granular, comprehensive assessment of FCCE's impact on firm-level market functioning.

Third, we extend the literature by disentangling the different dimensions of firm-level climate change exposure (FCCE). We show that the negative association between FCCE and stock liquidity is driven mainly by opportunity-related exposure whereas physical climate exposure is positively associated with liquidity across RE firms. These results indicate that stock liquidity is related to firms' overall climate

exposure, but that this relationship differs across climate-risk dimensions. We also provide novel evidence that the market consequences of climate exposure depend critically on the surrounding environmental and institutional context. In particular, stronger climate policy frameworks reduce the adverse liquidity implications of FCCE whereas firm-level environmental innovation enhances firms' resilience to climate-related informational frictions. In contrast, the negative association remains more pronounced in settings characterized by weaker institutional support and lower climate-risk salience. Overall, these findings emphasize that the pricing of climate exposure is shaped not only by firm-level risk but also by the credibility of policy environments and the nature of firms' sustainability strategies.

The relevance of these findings is particularly timely and significant. As investors increasingly integrate climate risks into their portfolios, understanding how FCCE affects liquidity in the real estate sector involves direct implications for portfolio management, risk pricing, and financial stability. Giglio et al. (2025) report that 81% of ESG investors express strong concerns about climate risk, with ethical motives being among the primary drivers of ESG holdings. This concern is particularly acute in real estate markets, where Stroebel and Wurgler (2021) find that finance professionals are 67 times more likely to perceive climate risks as underpriced than overpriced in real estate—representing the largest mispricing gap across all asset classes surveyed. Given that RE assets represent over \$100 trillion globally and face substantial physical and transition risks, examining the interplay between FCCE and stock liquidity is crucial for policy-makers, investors, and firms. Our findings further suggest that this mispricing gap is not immutable. Credible national climate policy frameworks significantly attenuate the adverse liquidity effects of climate exposure, highlighting the role of regulatory design in facilitating more efficient climate risk pricing in real estate markets. By focusing on RE firms, our study provides policy-relevant insights into how FCCE shapes market behavior while highlighting the role of transparency, regulatory frameworks, and sustainability strategies in mitigating adverse outcomes.

The remainder of the paper is organized as follows. Section “[Literature Review and Hypotheses Development](#)” reviews the relevant literature and develops the hypotheses. Section “[Data and Sample Description](#)” presents the data and sample description. Section “[Baseline Regression Results](#)” reports the main empirical results. Section “[Possible Channels: National Climate Governance](#)” investigates the underlying mechanisms and the moderating roles of climate policies. Section “[Additional Analyses](#)” presents additional analyses, and Section “[Conclusion](#)” concludes with key implications for firms, investors, and policy-makers.

Literature Review and Hypotheses Development

FCCE and Financial Performance

Firms are increasingly exposed to financial risks induced by climate change, which can affect their asset values, cash flows, and overall performance. For example, Jung et al. (2025) show that climate-related risks undermine the financial stability of banks by increasing expected capital shortfalls through both balance-sheet expo-

asures and market risk positions. The survey evidence from Krueger et al. (2020) indicates that institutional investors view climate risks as financially material, particularly through regulatory channels. Ilhan et al. (2021) document that climate policy uncertainty affects the cost of downside tail protection, with higher costs for more carbon-intensive firms and sensitivity to spikes in public attention to climate issues. Similarly, Bolton and Kacperczyk (2021) report that firms with higher CO₂ emissions earn higher returns after accounting for standard predictors, suggesting that investors require compensation for bearing carbon-emission risks. Together, these findings highlight how climate risks influence the financial exposures of firms and underscore the importance of effective risk management and adaptive strategies.

Physical climate risks arise from acute events, such as hurricanes, floods, and wildfires—and chronic changes, including rising temperatures and droughts. A growing body of evidence shows that these risks affect firm-level financial performance. Chen et al. (2024) show that extreme weather negatively affects the stock returns of A-share listed companies in China, primarily through investor sentiment rather than direct impacts on corporate performance. He and Ma (2021) provide complementary evidence from China, demonstrating that extreme temperatures reduce firm-level stock returns, particularly for smaller, younger, more volatile, less profitable firms and those with higher levels of intangible assets. Ai and Gao (2023) demonstrate that firm exposure to extreme climate events increases both systematic and idiosyncratic volatility, particularly for firms with greater geographic dispersion or those operating in industries for which environmental issues are financially material. Huynh et al. (2020) show that severe drought conditions raise firms' cost of equity, although the effect is mitigated for firms that are geographically diversified or that maintain higher cash reserves. Finally, Kruttli et al. (2025) show that firms located in hurricane-affected regions experience large and persistent increases in option-implied volatility, reflecting market underestimation of extreme weather risk. Collectively, these studies illustrate that physical climate risks affect firm-level financial outcomes—including stock returns, volatility, and cost of capital and that the magnitude of these effects depends on firm characteristics such as size, profitability, geographic dispersion, and industry exposure.

Of the three primary components of climate risk, regulatory risks are regarded as the most immediately relevant by investors and policy-makers since environmental regulations can directly influence firms' operating costs and cash flows (Krueger et al., 2020; Stroebel & Wurgler, 2021). These risks stem from policy, legal, and market changes driven by the transition to a low-carbon economy (Svartzman et al., 2021). Svartzman et al. (2021), who examine the role of central banks, emphasize that such risks are largely systemic and unhedgeable because of radical uncertainty, thereby requiring coordinated policy responses to safeguard financial stability. Moreover, uncertainty about future regulation imposes costs on firms and investors (Pindyck, 1993; Brogaard & Detzel, 2015) and can become embedded in the cost of capital even in the absence of new legislation. Consistent with this interpretation, Seltzer et al. (2022) report that firms exposed to greater climate regulatory uncertainty face higher bond yield spreads and an increased cost of debt, highlighting the tangible financial consequences of regulatory risk for corporate financing decisions. Overall, these findings illustrate that regulatory climate risks not only are a source of uncer-

tainty but also have concrete financial consequences, affecting firms' costs of capital, financing strategies, and investment decisions.

Opportunity-related factors capture the potential for corporate investment in environmental and social activities, such as renewable energy, green infrastructure, or ESG-related innovation. Although these strategies may provide long-term resilience and signal managerial foresight, they often require significant upfront investment and can introduce short-term volatility. Albuquerque et al. (2020) report that firms with strong ESG ratings showed greater stock resilience and lower volatility during the COVID-19 crash, suggesting that ESG-oriented investments attract stability-seeking investors. Moreover, Krüger (2015) investigates how stock markets react to positive and negative events related to a firm's corporate social responsibility (CSR). The author shows that markets react strongly to CSR events, perhaps reflecting both investor appetite for goodness and investor concern about agency risk. Together, these studies suggest that opportunity-related climate strategies can support long-term value but also entail financial risk and uncertainty.

FCCE and Stock Liquidity: Evidence from the Real Estate Sector

Evidence suggests that the real estate sector is particularly exposed to climate risk because it relies on fixed, location-specific assets and energy-intensive operations. Physical risks such as flooding, wildfires, or sea-level rise can directly damage properties and disrupt cash flows, especially rental income. Regulatory transitions, for example, via carbon pricing or energy-efficiency requirements, may limit investment flexibility and increase compliance costs. Moreover, opportunity-driven initiatives, such as energy retrofits or green building certifications, can increase long-term value but require significant upfront investments and introduce short-term financial uncertainty. The literature on real estate also indicates that Real Estate Investment Trust (REITs) and other real estate firms may price in these risks; for example, Kozak et al. (2025) report that property-level climate risk is reflected in REITs' equity and bond risk premia. These findings highlight the complex ways in which climate risk affects both the valuation and the financing of real estate. Given all of these financial implications, examining how climate risk translates into stock market activity, particularly through stock liquidity, remains important.

Stock liquidity reflects the ease with which securities can be traded without causing large price fluctuations, capturing both market depth and transaction costs (Amihud, 2002; Easley et al., 2010). High liquidity signals efficient price discovery and strong investor confidence whereas low liquidity reflects information asymmetry, higher perceived risk, and reduced market participation (Brunnermeier & Pedersen, 2009).

Most of the research on stock liquidity has focused on corporate governance, macroeconomic conditions and investor characteristics (Ammari et al., 2023; Li et al., 2023) whereas the potential impact of external environmental risks such as climate change has received relatively little attention (Chung & Zhang, 2014). Some evidence suggests that investor sentiment can influence stock liquidity under extreme conditions; for example, Ammari et al. (2023) report that during the COVID-19 pandemic, the effect of Twitter sentiment on stock liquidity was nonlinear and depended

on the severity of the pandemic, highlighting how external shocks and perceived uncertainty can affect trading behavior. Theoretically, exposure to climate and environmental risks can generate greater uncertainty about future profitability. This uncertainty could increase risk aversion, reduce trading activity, and widen bid-ask spreads, ultimately impairing stock liquidity.

Disclosure practices also play a crucial role in shaping stock liquidity and overall market efficiency. The limited reporting of climate- or sustainability-related exposures exacerbates information asymmetry, which can constrain trading activity and widen bid-ask spreads (Grewal et al., 2021). Evidence from the Sustainability Accounting Standards Board (SASB) standards shows that firms that voluntarily disclose more financially material sustainability information, as identified by SASB, exhibit greater price informativeness. In contrast, the disclosure of non-SASB information is not associated with informativeness. These effects are more pronounced for firms with greater exposure to sustainability issues, weaker sustainability ratings, greater institutional or socially responsible investment ownership, and coverage by analysts with lower portfolio complexity. Conversely, transparent disclosure of related risks reduces uncertainty and enhances trading efficiency, enabling investors to price climate risk more accurately (Fama, 1970). According to the efficient market hypothesis, security prices in well-functioning markets should fully reflect all available information, allowing firms to make informed investment decisions and allowing investors to allocate capital efficiently. In sectors such as real estate, which are particularly exposed to tangible assets and regulatory risks, such transparency may be especially important: the clear disclosure of climate-related risks can improve price informativeness and stock liquidity by reducing information asymmetry and enabling risk assessments that are more precise.

The real estate sector is asset and energy intensive, making firms particularly sensitive to multiple dimensions of climate risk, including physical hazards such as flooding and operational risks related to energy efficiency (Fuerst & Warren-Myers, 2021; Eichholtz et al., 2012). Although current risks (e.g., flood exposure) are often reflected in property valuations, future risks (e.g., sea-level rise) may be underpriced because of limited information, highlighting the sector's complex climate sensitivity. Physical risks (e.g., floods, hurricanes, wildfires, or heatwaves) can damage properties, reduce revenues, and increase operational and insurance costs, introducing uncertainty in future cash flows. Capital markets do not fully anticipate these impacts, suggesting that firms with greater physical exposure may exhibit lower stock liquidity (Pankratz et al., 2023). Regulatory and transition risks, including carbon pricing, green building standards, and emission reporting requirements, create uncertainty about future regulations and business opportunities. Investors may perceive these risks as potential costs, which can reduce trading activity and affect stock liquidity or financing costs (Cepni et al., 2024; Painter, 2020). Opportunity-related initiatives, such as investments in renewable energy, green certifications, or sustainable retrofits can enhance long-term value and signal managerial foresight. However, these initiatives often involve upfront costs and uncertain short-term payoffs, which can increase information asymmetry, heighten investor uncertainty, and potentially reduce trading activity (Albuquerque et al., 2020; Krüger, 2015).

Real estate firms facing greater physical and transition climate risks tend to exhibit lower market valuations and higher risk premia (Qiu et al., 2025). Although direct evidence on stock liquidity remains limited, the research indicates that liquidity commonality, the tendency for liquidity to comove across REITs or with broader markets, can amplify the impact of climate risk on trading conditions. Hoesli et al. (2017) demonstrate that liquidity commonality is particularly pronounced during periods of market stress and is driven by demand-side factors, implying that climate-related shocks may propagate across REIT markets and further constrain liquidity. Accordingly, we propose the following hypotheses:

H1. *FCCE is associated negatively with stock liquidity in the real estate sector.* **H2.** *The effect of FCCE on stock liquidity differs across its subdimensions, reflecting the effects of distinct informational content of physical, regulatory, and opportunity-related climate risks on investor uncertainty and market pricing.*

Moderating Role of National Climate Governance

National Climate Governance comprises country-level climate policy proxies capturing two key dimensions: mitigation, aimed at reducing greenhouse gas emissions, and adaptation, aimed at managing vulnerability to physical climate impacts. These regulatory frameworks and associated measures can shape investor perceptions and market behavior (Cepni et al., 2024; Rentschler et al., 2017; Lee & Alam, 2024). In particular, stricter mitigation policies may influence firms' incentives toward low-carbon investment, reallocate capital, and alter perceived risk. For example, higher environmental taxes can encourage firms to adopt greener technologies, increasing short-term cost uncertainty while providing clearer long-term regulatory signals to investors (Lee & Alam, 2024).

Adaptation policies capture a country's capacity to manage physical climate shocks (Pagano et al., 2021; Barrios, 2023). Investors respond both to the presence and effectiveness of these strategies. Firms operating in more resilient environments, or with greater preparedness, tend to experience smaller stock price declines during climate-related events (Hsiang, 2014; Carleton et al., 2022). Greater adaptive capacity therefore reduces the economic and financial losses associated with climate disasters, helping to stabilize market reactions (Pagano et al., 2021).

Together, these mechanisms suggest that both mitigation and adaptation policies can moderate the relationship between FCCE and stock liquidity by shaping how climate risks are perceived, processed, and incorporated into market valuations. We therefore postulate that:

H3. *Country-level climate mitigation and adaptation policies as well as environmental conditions shape the relationship between FCCE and stock liquidity.*

Moderating Role of Firm-Level Environmental Performance

Beyond the direct effect of FCCE on stock liquidity, a growing body of literature suggests that firm-level environmental performance may shape the way investors process and price climate-related risks (Bolton & Kacperczyk, 2021; Sautner et al.,

2023). The theoretical link between environmental performance and the sensitivity of liquidity to climate change exposure operates through two main channels: information asymmetry reduction and investor attention. First, firms with stronger environmental performance tend to disclose more comprehensive and credible climate-related information, reducing the information gap between insiders and outside investors (Grewal et al., 2021; Ilhan et al., 2023). An upsurge in climate risk disclosure enhances overall transparency and reduces information asymmetry (Guastella et al., 2022; Jeanne et al., 2023; Vestrelli et al., 2024b), which supports stock liquidity by enabling risk assessments that are more precise (Fama, 1970). This view suggests that firms with higher environmental performance reflected in actual emissions reductions, energy efficiency improvements, or green certifications provide investors with clearer signals about their climate risk profile, improving trading activity.

Second, environmental performance may influence stock liquidity through an investor attention channel. Firms that actively manage and communicate their climate-related risks attract greater scrutiny from institutional investors, ESG-oriented funds, and analysts, increasing coverage and trading interest (Ardia et al., 2023; Krüger, 2015). This heightened attention can improve price discovery and reduce adverse selection costs, thereby supporting liquidity. Investors increasingly incorporate firms' climate change exposure into the risk premium they demand (Sautner et al., 2023), implying that environmental performance, by shaping the perceived credibility of climate risk management, directly affects the cost of adverse selection faced by market makers and the willingness of investors to trade.

In the real estate sector specifically, firm-level environmental performance is particularly relevant given the sector's reliance on energy-intensive and location-specific assets. Green building certifications, energy retrofit programs, and sustainable property management practices represent substantive environmental investments that can reduce physical and regulatory risk exposure while signaling managerial quality to outside investors (Eichholtz et al., 2012; Fuerst & Warren-Myers, 2021).

The theoretical link among climate policies, sectoral environmental conditions, and the sensitivity of stock liquidity to firm-level climate exposure is not necessarily monotonic (Pastor et al., 2021). On the one hand, stronger environmental performance can attenuate the negative effect of climate exposure on liquidity by reducing informational frictions and signaling credible risk management. On the other hand, high environmental performance could also reflect a greater underlying exposure to climate risks, as firms facing more severe physical or regulatory pressures may invest more heavily in environmental management (Engle et al., 2020; Hong et al., 2019). These two channels, risk mitigation and risk salience, generate opposing predictions about the moderating role of firm-level environmental performance, making this question ultimately an empirical one. Building on this discussion, we propose the following hypothesis:

H4. *Firm-level environmental performance moderates the FCCE–liquidity relationship, whereby stronger performance mitigates the negative liquidity effects of climate exposure by reducing uncertainty about firms' climate risk management capacity.*

Data and Sample Description

In this section, we describe the data sources and the sample selection process. We then explain how we construct the key variables, including our main measures of firm-level climate change exposure, stock liquidity, and firm-level control variables. Finally, we present descriptive statistics for all of the variables used in the empirical analysis.

Data Sources and Sample Selection

Our primary sample includes publicly listed firms from the Sautner et al. (2023) database, which provides firm-level climate change exposure data. Using our dataset of International Securities Identification Numbers (ISINs) for international equity markets, we extract financial and stock market data from the LSEG database. We then merge these datasets and focus on firms within the real estate (RE) sector, distinguishing across several subindustries given their direct exposure to climate-related risks and heightened vulnerability to environmental shocks.²

We supplement the firm-level data with a range of country-level variables. Stock market turnover is obtained from the World Federation of Exchanges (WFE), and short-term interest rates are obtained from the Organisation for Economic Co-operation and Development (OECD). The climate-related country indicators include the Climate Change Performance Index (CCPI), provided by Germanwatch, the New Climate Institute, and the Climate Action Network as well as carbon dioxide (CO₂) emissions per capita from the Global Carbon Budget (2025). Greenhouse gas (GHG) and CO₂ emissions data are sourced from the International Monetary Fund (IMF). For the analysis of climate policy moderators, we collect information on countries' environmental policy instruments from the OECD Policy Instruments for the Environment (PINE) database and the OECD Environmental Policy Stringency index. We further complement the dataset with firm-level environmental performance information from LSEG ESG database.

All of the continuous variables are winsorized at the 1st and 99th percentiles to limit the influence of outliers. To ensure sufficient data coverage and reduce potential bias from sparsely represented markets, we exclude countries with fewer than five observations. The sample size varies across specifications because of differences in variable availability across countries and years. Each table reports the corresponding number of observations. Our final sample consists of 2,664 firm-year observations covering 383 firms across 30 countries over the period 2003–2022.

FCCE Measures

We use the FCCE data proposed by Sautner et al. (2023). This proxy aggregates all three key dimensions of climate change exposure: opportunity, regulatory and physical. The values range from zero to one, and higher values indicate greater exposure to climate change at the firm level (Choi, 2024). By design, this measure cap-

² In Appendix 16, we report summary statistics by RE subindustry.

tures the attention that managers and analysts devote to climate-related themes on earnings calls, conditional on the underlying environment in which firms operate. It therefore reflects discussed or perceived exposure rather than an exogenous index of actual physical or transition risk. This attention-based nature is central to our setting, as stock market liquidity responds to publicly discussed information rather than to latent risks that have not yet entered the public domain. We acknowledge, however, that firms with high underlying exposure but low disclosure may receive low FCCE scores, a limitation we discuss when interpreting our results.

FCCE appears to be a meaningful indicator of firms' involvement in the low-carbon transition (Sautner et al., 2023). Firms with greater exposure are more likely to invest in green technologies, engage in sustainable innovation and develop environmentally oriented patents. In addition, these measures provide information on market expectations, as they are associated with the pricing of equities and options, reflecting investor assessments of climate-related financial risks (Liu et al., 2024).

Measures of Stock Liquidity

To capture multiple dimensions of stock liquidity, we employ three complementary measures reflecting the price impact of trades, the implicit cost of trading and trading activity. The first measure is the relative spread (RSPD), which is commonly used in the literature to approximate the cost of executing market orders (Chung & Zhang, 2014; Cumming et al., 2011; Venkataraman, 2001). It is defined as the difference between the best ask and bid prices relative to the midpoint price, averaged over the trading days in a year:

$$RSPD_{i,t} = \frac{1}{D_{i,t}} \sum_{d=1}^{D_{i,t}} \frac{Ask_{i,d,t} - Bid_{i,d,t}}{(Ask_{i,d,t} + Bid_{i,d,t})/2} \quad (1)$$

To enhance interpretability, we take the natural logarithm of RSPD and multiply by -1 , yielding our first liquidity proxy, $Inv\ RSPD$, where higher values indicate greater stock liquidity.

The second measure is based on the Amihud illiquidity ratio (Amihud, 2002), which quantifies the daily price response to trading volume. It is calculated as the ratio of the absolute stock return to the dollar trading volume for each trading day and then averaged over the year for each stock:

$$Amihud_{i,t} = \frac{1}{D_{i,t}} \sum_{d=1}^{D_{i,t}} \frac{|R_{i,d,t}|}{VOLD_{i,d,t}} \quad (2)$$

where $R_{i,d,t}$ is the return of stock i on day d of year t , $VOLD_{i,d,t}$ is the corresponding dollar trading volume, and $D_{i,t}$ is the number of trading days in year t with nonzero volume. Smaller values of Amihud's ratio indicate higher liquidity, as prices are less sensitive to trades. Like the relative spread, we take the natural logarithm of the

scaled Amihud ratio and multiply it by -1 to obtain Inv Amihud, where higher values correspond to higher liquidity.

The third measure is stock turnover, which is widely used as a proxy for trading activity and stock liquidity in the finance literature (Datar et al., 1998; Goyenko et al., 2009). Specifically, it is computed as the ratio of daily trading volume (in number of shares traded) to shares outstanding, averaged over the year for each stock.³

$$\text{Turnover}_{i,t} = \frac{\text{Trading Volume}_{i,t}}{\text{Outstanding shares}_{i,t}} \quad (3)$$

To reduce measurement error and provide a comprehensive measure of stock liquidity, we combine Inv Amihud, Inv RSPD and Turnover into a single liquidity factor using a factor analysis with oblique rotation (Daske et al., 2008). This factor serves as the main dependent variable in our analyses, with higher values indicating better stock liquidity.⁴ A detailed description of all of the variables is provided in Appendix 14.

Firm-Level Control Variables

Following prior research (Brogaard et al., 2017; Goyal & Wang, 2013), we include a comprehensive set of firm-level controls to account for observable characteristics that may influence stock liquidity.

Size is measured as the natural logarithm of one plus the firm's total assets. The market-to-book ratio represents the ratio of the market value to the book value of equity, reflecting growth opportunities. Return on equity (ROE) is defined as net income divided by total equity, capturing profitability. Leverage is the ratio of total debt to total assets, indicating financial risk and potential constraints on firm operations. Momentum is calculated as the average of monthly returns over the past year, controlling for return dynamics that may affect trading activity. Capital expenditures (Capital Exp) corresponds to the ratio of capital expenditures divided by total assets, reflecting investment intensity. Property, plant, and equipment (PPE/TA) is the ratio of property, plant & equipment to total assets, capturing asset tangibility. Beta measures the stock's sensitivity to systematic risk relative to the overall market, and Volatility is defined as the standard deviation of daily stock returns over the year, both controlling for risk-related impacts on stock liquidity. Sales growth is included as a proxy for firm performance, and EPS growth is expected future profitability, which may influence investor attention and trading activity. Recent studies document that institutional investors exhibit stronger demand for climate risk disclosure (Ilhan et al., 2023; Zhao et al., 2026) and that institutional ownership is an important determinant of REIT trading activity and performance (Cheung et al., 2015; Das et al., 2015). Therefore, we control for institutional ownership, measured as the natural logarithm

³ We thank the referee for suggesting the inclusion of this complementary dimension of stock liquidity.

⁴ As a robustness check, we construct an alternative liquidity factor using a principal component analysis (PCA). The corresponding results are reported in Appendix 15.

of one plus the percentage of traded shares held by institutional investors. We also control for environmental expenditure, which captures firms' environmental engagement and broader climate-related practices. Firms with stronger environmental strategies may differ in how they perceive and communicate climate risk, which may be reflected in the extent of their climate-related disclosures.⁵ Detailed definitions of all of the control variables are provided in Appendix 14.

Descriptive Statistics

Table 1 presents the construction and validation of the liquidity factor based on a factor analysis with an oblique rotation (Daske et al., 2008) approach applied to three standard liquidity proxies: Inv RSPD, Inv Amihud, and Turnover. The results reported in Panel A of Table 1 show positive and statistically significant correlations between the extracted liquidity factor and each of its underlying components, confirming that the factor effectively captures a common variation across different liquidity dimensions. In particular, the highest correlation is observed with Inv RSPD, followed by Inv Amihud and Turnover, suggesting that the first factor is driven primarily by transaction costs and the price impact dimensions of liquidity while incorporating trading activity information. Panel B of Table 1 reports the factor loadings from the factor analysis, which are all positive, further confirming that the three proxies load in the same direction on a single underlying liquidity dimension. Panel C of Table 1 shows that the first principal component has an eigenvalue of 1.730 and explains 57.7% of the total variance, indicating that a substantial share of the variation in liquidity measures is captured by a single common factor.⁶ This finding alleviates concerns about measurement error in individual proxies and supports the use of a unique liquidity factor. Overall, these results validate the construction of a robust and economically relevant liquidity factor that aggregates different dimensions of stock liquidity into a single measure.

Table 2 presents the descriptive statistics of our main variables. The mean of FCCE exposure (FCCE) is 0.688 with a standard deviation of 1.194, indicating substantial heterogeneity across real estate companies in our sample. This variation suggests that not all firms are equally exposed to climate-related risks and opportunities. Concerning liquidity measures, the average values of Inv RSPD and Inv Amihud are 6.342 and 8.887, respectively, which are in line with prior studies on stock liquidity (Brockman et al., 2009; Chung et al., 2010). Turnover has a mean of 1.185, suggesting a moderate level of trading activity across firms in the sample.

In Table 3, we present further details about the distribution of our sample by country, reporting the number of firm-year observations; the average value of FCCE; the average value of the Liquidity Factor; and the average values of Inv Amihud, Inv RSPD, and Turnover. The first two columns show that sample coverage is higher in developed markets, particularly the United States, Canada, the United Kingdom,

⁵ We thank the referee for suggesting the inclusion of these important control variables.

⁶ An eigenvalue measures the amount of variance in the original variables that is captured by a given principal component in factor analysis.

Table 1 Construction and Validation of the Liquidity Factor**Panel A: Correlation matrix**

	Liquidity factor	Inv RSPD	Inv Amihud	Turnover
Liquidity factor	1.000			
Inv RSPD	0.848***	1.000		
Inv Amihud	0.740***	0.467***	1.000	
Turnover	0.681***	0.402***	0.211***	1.000

Panel B: Principal-component factor analysis

Variable	Loading (Factor 1)
Inv RSPD	0.848
Inv Amihud	0.740
Turnover	0.681

Panel C: Factor statistics

Eigenvalue (Factor 1)	1.730
Variance explained (%)	57.7%
Observations	2,664

This table presents the construction and validation of the liquidity factor using oblique rotation (Daske et al., 2008) approach applied to three standard liquidity proxies: Inv RSPD, Inv Amihud, and Turnover. Panel A reports the correlation matrix between the liquidity factor and its underlying proxies. Panel B reports the factor loadings from the first principal component used to extract the common liquidity factor. Panel C reports the eigenvalue of the first principal component, the proportion of variance explained, and the number of observations used in the estimation. Statistical significance is denoted by ***, **, and * at the 1%, 5%, and 10% levels, respectively

and Australia. The United States has the greatest representation, with 141 firms and 1,231 firm-year observations, followed by Canada (32 firms, 201 observations). The third column highlights that FCCE varies considerably across countries. Real estate firms in emerging or environmentally vulnerable economies such as the Philippines, Chile and South Africa exhibit higher FCCE whereas those in developed markets such as the United States, Canada, and the United Kingdom display relatively lower exposure. The fourth column presents the sample mean of the Liquidity Factor and indicates notable cross-country differences: highly developed markets such as Japan, the United Kingdom, and the United States exhibit higher stock liquidity, whereas smaller or less liquid markets such as Austria, Belgium, Israel, and Finland exhibit relatively lower liquidity metrics. Inv Amihud and Inv RSPD show a similar pattern, reflecting variations in trading costs and price impacts across markets. Turnover exhibits substantial cross-country variation, with relatively higher values observed in markets such as the United States, Brazil, Italy, and the Netherlands, reflecting differences in trading activity across markets. Overall, these descriptive statistics underscore substantial cross-country heterogeneity in both FCCE and stock liquidity. They suggest that developed financial markets generally provide higher stock liquidity, whereas firms in emerging or environmentally sensitive economies tend to face greater climate-related risks. These patterns provide a solid foundation for examining the impact of FCCE on stock liquidity in the real estate sector at the firm level.

Table 4 presents the correlation coefficients among the main variables used in this study. The correlation between FCCE and the Liquidity Factor is -0.085, providing

Table 2 Descriptive Statistics

Variable	N	Mean	SD	P25	Median	P75
Climate Change Exposure Measures						
FCCE	2,664	0.688	1.194	0.093	0.299	0.746
FCOE	2,664	0.163	0.482	0.000	0.000	0.147
FCRE	2,664	0.052	0.209	0.000	0.000	0.000
FCPE	2,664	0.010	0.057	0.000	0.000	0.000
Liquidity Measures						
Inv RSPD	2,664	6.342	1.304	5.354	6.380	7.399
Inv Amihud	2,664	8.887	2.555	7.691	9.068	10.292
Turnover	2,664	1.185	1.093	0.429	0.917	1.633
Liquidity Factor	2,664	0.069	0.953	-0.540	0.206	0.826
Firm-Level Control Variables						
Size	2,664	15.868	1.757	14.698	15.562	16.575
Market-to-Book	2,664	1.947	2.344	0.925	1.270	2.120
ROE	2,664	0.300	2.393	0.080	0.123	0.206
Leverage	2,664	0.410	0.154	0.315	0.413	0.501
Momentum	2,664	0.010	0.028	0.000	0.010	0.018
Capital Exp	2,664	7.126	8.666	1.850	4.265	9.220
PPE/TA	2,664	0.725	0.297	0.683	0.852	0.926
Beta	2,664	0.957	0.533	0.580	0.890	1.241
Volatility	2,664	0.080	0.096	0.048	0.064	0.090
Sales Growth	2,664	-0.106	3.566	-0.104	0.003	0.098
EPS Growth	2,664	0.616	8.361	-0.317	0.009	0.393
Instit Ownership	2,664	3.938	0.768	3.561	4.179	4.555
Env Expenditure	2,664	0.910	3.755	0.000	0.000	0.000
Additional Firm-Level Variables						
Env Pillar Score	2,167	44.424	30.192	15.960	46.470	71.650
Emission Score	2,167	47.140	33.328	15.510	49.860	77.200
Env Innovation Score	2,167	31.119	32.551	0.000	26.110	67.340
Resource Use Score	2,167	46.508	33.927	12.340	48.560	78.040
Country-Level Control Variables						
Market Turnover	1,912	4.586	0.757	4.246	4.604	5.058
Short-Term Interest Rate	1,912	1.212	1.613	0.170	0.534	1.987
CCPI	1,912	38.971	17.377	25.030	43.060	52.930
CO ₂ Emissions per Capita	1,912	14.194	4.170	13.817	15.639	16.812
Additional Country-Level Variables						
Environmental Tax Revenue	2,664	55.390	187.988	0.000	0.000	0.000
Environmental Policy Stringency	1,977	2.759	0.736	2.417	2.917	3.028
Net Zero Target	1,196	3.578	4.017	0.000	0.000	8.000
Building Sector Climate Policy	1,196	7.039	1.016	6.875	7.500	7.500
ND-GAIN Adaptation Index	2,324	49.409	9.586	41.530	48.503	56.817
GHG Emissions	2,607	0.798	0.436	0.609	0.683	1.035
CO ₂ Emissions	2,607	0.804	0.453	0.578	0.683	1.032

This table presents descriptive statistics for all variables used in the empirical analysis, including climate change exposure measures, liquidity variables, firm-level and country-level controls, and additional environmental indicators. Reported statistics include the number of observations, mean, standard deviation, and selected percentiles (P25, median, and P75). All variables are defined in Appendix 14

Table 3 Summary statistics of climate change exposure and liquidity by market

Country	N	FCCE	Liquidity factor	Inv RSPD	Inv Amihud	Turnover
Australia	178	1.253	-1.047	4.216	7.980	0.656
Austria	15	0.751	-0.417	6.117	7.421	0.533
Belgium	14	0.345	-0.327	6.164	7.838	0.480
Bermuda	15	0.723	-0.469	5.638	8.366	0.279
Brazil	30	0.440	-0.137	5.629	8.825	1.713
Canada	201	0.536	-0.881	5.109	7.182	0.444
Cayman Islands	42	0.691	-0.082	5.797	9.857	0.484
Chile	7	2.221	-0.068	4.403	12.945	0.326
China	6	0.687	0.372	6.438	10.421	1.001
Finland	11	0.688	-0.506	6.221	6.933	0.322
France	75	0.818	-0.182	6.373	8.131	0.507
Germany	92	0.827	-2.087	5.017	1.532	0.004
Hong Kong	72	0.775	0.261	6.159	10.859	0.507
India	57	0.306	0.172	6.253	10.080	0.649
Israel	15	0.407	-0.063	6.452	8.796	0.264
Italy	23	0.389	-0.421	5.663	7.423	1.560
Japan	91	1.458	0.883	6.131	13.803	0.880
Luxembourg	21	0.596	-1.617	4.658	3.190	1.706
Mexico	47	1.024	-0.433	5.312	9.142	0.371
Netherlands	11	0.974	-0.417	6.011	7.116	1.125
New Zealand	40	0.866	-1.351	4.469	6.295	0.195
Philippines	13	3.376	-0.099	5.266	11.152	0.160
Singapore	58	0.552	-0.453	5.422	8.640	0.568
South Africa	17	1.882	-0.227	5.711	9.127	0.663
Spain	19	0.708	-0.334	6.495	7.155	0.439
Sweden	28	1.732	0.182	6.481	9.741	0.558
Switzerland	39	0.605	-0.099	6.578	8.134	0.511
United Arab Emirates	7	0.580	-0.420	5.154	9.309	0.629
United Kingdom	189	0.995	0.604	6.419	11.889	0.743
United States	1,231	0.452	0.586	7.228	9.118	1.875
Total	2,664	0.688	0.069	6.342	8.887	1.185

This table reports country-level summary statistics of firm-level climate change exposure (FCCE) and liquidity measures. The sample comprises 2,664 firm-year observations over the period 2003–2022. For each market, the table reports the number of observations (N), mean FCCE, and average liquidity measures (Liquidity factor, Inv Amihud, Inv RSPD and Turnover). Markets with fewer than five observations are excluded. The final row reports full-sample averages

preliminary support for H1. This negative association suggests that higher FCCE is associated with slightly lower stock liquidity in the real estate sector, which is consistent with the notion that firms facing greater climate change exposure may experience reduced stock liquidity. Overall, these descriptive statistics offer an initial indication of the relationship between FCCE and stock liquidity in the real estate sector. The next section investigates this relationship more rigorously using multiple regression models that control for firm size, profitability, leverage, and other relevant characteristics.

Table 4 Correlation Matrix

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]
Liquidity factor	[1]	1.000													
FCCE	[2]	-0.085***	1.000												
Size	[3]	0.304***	0.142***	1.000											
Market-to-book	[4]	0.222***	-0.054***	-0.104***	1.000										
ROE	[5]	-0.036*	-0.015	-0.042**	0.050***	1.000									
Leverage	[6]	0.112***	-0.072***	-0.162***	0.206***	0.014	1.000								
Momentum	[7]	0.076***	-0.007	-0.038*	0.039**	-0.009	-0.046**	1.000							
Capital Exp	[8]	0.092***	-0.047**	-0.210***	-0.014	-0.040**	0.127***	0.095***	1.000						
PPE/TA	[9]	0.042**	0.013	-0.173***	-0.153***	-0.144***	0.254***	-0.009	0.266***	1.000					
Beta	[10]	0.156***	-0.052***	0.040**	-0.040**	0.104***	0.005	0.048**	-0.118***	-0.103***	1.000				
Volatility	[11]	-0.091***	-0.027	-0.037*	0.003	0.051***	0.028	-0.055***	-0.087***	-0.103***	0.008***	1.000			
Sales Growth	[12]	-0.001	-0.001	0.014	0.014	0.000	-0.009	0.004	0.012	-0.008	-0.013	-0.003	1.000		
EPS Growth	[13]	0.013	-0.015	-0.005	0.011	-0.005	-0.041**	0.000	-0.002	0.011	0.027	0.005	0.008	1.000	
Instit Ownership	[14]	0.511***	-0.088***	-0.271***	0.242***	-0.080***	0.207***	0.039**	0.203***	0.123***	0.080***	-0.030	-0.005	0.016	1.000
Env Expenditure	[15]	0.074	0.050***	0.181***	-0.029	-0.010	-0.020	0.001	-0.052***	0.059***	-0.005	-0.016	0.014	-0.008	-0.040** 1.000

This table presents Pearson correlation coefficients between the liquidity factor, firm-level climate change exposure (FCCE), and firm-level control variables. The sample comprises 2,664 firm-year observations from 2003 to 2022. Statistical significance is denoted by ***, **, and * at the 1%, 5%, and 10% levels, respectively. All variables are defined in the Appendix 14

Baseline Regression Results

FCCE and Stock liquidity

In this section, we conduct regression analyses to examine the relationship between stock liquidity and FCCE while controlling for various other factors known to be correlated with stock liquidity. Specifically, we estimate the following baseline model:

$$\text{Liquidity Factor}_{i,t} = \alpha + \beta.FCCE_{i,t} + \gamma.\text{Controls}_{i,t} + \text{Fixed Effects} + \epsilon_{i,t} \quad (4)$$

where Liquidity Factor_{*i,t*} is the dependent variable that aggregates the Inv Amihud, Inv RSPD and Turnover for firm *i* in year *t*, and FCCE_{*i,t*} is the measure of FCCE for firm *i* in year *t*, which is our main explanatory variable. Controls_{*i,t*} is a vector of control variables, including size; market-to-book ratio; return on equity (ROE); leverage; momentum; capital expenditures to total assets; plant, property & equipment to total assets (PPE/TA); beta; volatility; sales growth; EPS growth; institutional ownership and environmental expenditure. The variable descriptions are presented in Appendix 14. We include country-by-year (*Country*×*Year*) and *RE subindustry* fixed effects to control for common shocks and co-movements with the broader stock market as well as for the influence of country-level climate policies and investor sentiment on stock liquidity. These fixed effects are implemented to isolate the impact of FCCE on stock liquidity by accounting for potential confounding factors. Standard errors are clustered at the firm level.

We begin by estimating the baseline regression model to examine the relationship between FCCE and stock liquidity in real estate firms. Table 5 reports the results. Consistent with H1, we find a statistically significant negative relationship between FCCE and stock liquidity. Specifically, a one-standard- deviation increase in FCCE corresponds to an approximately 4.5% decline in the standard deviation of stock liquidity. These findings suggest that greater exposure to climate-related risks heighten investor uncertainty and information asymmetry, thereby reducing trading activity and impairing market efficiency in the real estate sector.

Although a 4.5% decline in the standard deviation of liquidity may appear modest in standardized terms, stock liquidity is a highly persistent and relatively low-volatility outcome variable in the real estate sector. Consequently, even incremental changes carry economic relevance through their cumulative effects on trading costs, trading activity and price impact. The estimated coefficient should therefore not be interpreted as evidence of large, immediate, discrete shifts in stock liquidity but rather as reflecting a systematic and persistent contribution of climate-related exposure to market frictions at the margin.

The economic relevance of these findings is reinforced by three considerations. First, the relationship is robust across firms from 30 countries characterised by substantial heterogeneity in institutional environments, regulatory frameworks and climate policy contexts suggesting that the baseline mechanism linking climate exposure to stock liquidity operates broadly across different national settings, even if its magnitude may vary with the institutional environment in which firms operate. Second, even relatively modest firm-level liquidity effects may become economi-

Table 5 Firm-level climate change exposure and stock liquidity

	Liquidity Factor			
	(1)	(2)	(3)	(4)
FCCE	-0.045*** (-4.09)			
FCOE		-0.036*** (-4.78)		
FCRE			-0.020* (-1.71)	
FCPE				0.018*** (2.90)
Size	0.662*** (18.21)	0.660*** (18.05)	0.662*** (18.27)	0.660*** (18.04)
Market-to-book	0.075*** (2.82)	0.075*** (2.79)	0.076*** (2.78)	0.076*** (2.77)
ROE	-0.008 (-1.05)	-0.008 (-1.05)	-0.007 (-0.94)	-0.008 (-1.00)
Leverage	-0.012 (-0.43)	-0.011 (-0.38)	-0.013 (-0.44)	-0.011 (-0.38)
Momentum	0.022 (1.13)	0.023 (1.19)	0.022 (1.10)	0.022 (1.12)
Capital Exp	0.005 (0.45)	0.006 (0.49)	0.005 (0.43)	0.005 (0.39)
PPEToTA	0.026 (1.19)	0.023 (1.07)	0.026 (1.19)	0.024 (1.11)
Beta	0.034* (1.79)	0.037* (1.91)	0.036* (1.88)	0.038* (1.95)
Volatility	-0.061*** (-2.98)	-0.061*** (-2.95)	-0.061*** (-2.95)	-0.060*** (-2.93)
Sales Growth	0.011 (1.06)	0.011 (1.08)	0.011 (1.12)	0.011 (1.14)
EPS Growth	-0.003 (-0.85)	-0.003 (-0.82)	-0.003 (-0.82)	-0.003 (-0.76)
Instit Ownership	0.140*** (3.35)	0.142*** (3.36)	0.139*** (3.30)	0.139*** (3.30)
Env Expenditure	0.020* (1.66)	0.019 (1.56)	0.020 (1.58)	0.020 (1.57)
Constant	-0.000 (-0.00)	-0.000 (-0.00)	-0.000 (-0.00)	-0.000 (-0.00)
Country× Year FE	Yes	Yes	Yes	Yes
RE Sub Industry FE	Yes	Yes	Yes	Yes

Table 5 (continued)

	Liquidity Factor			
	(1)	(2)	(3)	(4)
Observations	2664	2664	2664	2664
Adjusted R^2	0.875	0.875	0.874	0.874

This table presents the results on the relationship between firm-level climate change exposure and stock liquidity. It uses four distinct proxies to capture different dimensions of climate exposure: overall firm-level climate change exposure (FCCE), as well as three more granular components: operational (FCOE), regulatory (FCRE), and physical (FCPE) exposure. FCOE captures opportunity-related exposure, FCRE reflects regulatory exposure by measuring the frequency of climate regulation-related terms, and FCPE captures exposure to physical climate risks such as natural disasters and extreme climate events. The dependent variable is the liquidity factor, constructed using oblique rotation (Daske et al., 2008) approach applied to three standard liquidity proxies: Inv RSPD, Inv Amihud, and Turnover. Control variables include firm characteristics such as size, market-to-book, return on equity (ROE), leverage, momentum, capital expenditure, property, plant and equipment to total assets (PPE/TA), beta, volatility, sales growth, earnings per share growth, institutional ownership and environmental expenditure. All specifications include country-by-year fixed effects (Country $\times$ Year FE) and RE sub-industry fixed effects. All variables included in the regressions, including FCCE, the liquidity factor and all control variables, are standardized for easier interpretation. T-statistics are reported in parentheses, and standard errors are clustered at the firm level. Statistical significance is indicated by ***, **, and * at the 1%, 5%, and 10% levels, respectively. Detailed definitions and data sources are provided in Appendix 14

cally significant in aggregate as persistent frictions accumulate across a large number of firms, markets and time periods. Third, given the well-established role of stock liquidity in shaping firms' financing conditions and cost of capital (Amihud, 2002; Brunnermeier & Pedersen, 2009), persistent reductions in liquidity associated with FCCE may carry broader implications for capital allocation and market efficiency that extend well beyond the liquidity level itself.

Accordingly, the policy implications of our findings should be interpreted in the following light: improvements in climate-related disclosure, transparency and governance are more likely to generate gradual and cumulative gains in market efficiency than to produce large immediate shifts in liquidity. This framing is consistent with the broader literature on the slow-moving nature of climate risk pricing (Stroebel & Wurgler, 2021) and underscores the importance of sustained and credible policy commitment over discrete regulatory interventions.

In Columns (2)-(4), we decompose FCCE into its three components : opportunity-related (FCOE), regulatory-related (FCRE), and physical risk-related (FCPE), to identify which dimension drives the association with stock liquidity, thereby testing Hypothesis 2. The results reveal significant heterogeneity across sub-dimensions, which is consistent with the view that investors differ across climate risk dimensions when forming expectations about firms' future prospects and trading conditions.

Opportunity-related exposure (FCOE) has a statistically significant negative effect on stock liquidity at the 1% level, indicating that firms whose climate exposure is concentrated in opportunity-related dimensions, such as investments in green technologies, energy-efficient retrofits, or sustainable development initiatives, face greater investor uncertainty about strategic transitions and future profitability, leading to reduced trading activity, wider bid-ask spreads and higher price impact. Regulatory-related exposure (FCRE) also exhibits a negative and marginally significant effect at the 10% level, consistent with the view that regulatory uncertainty intro-

duces additional informational frictions for market participants. In contrast, physical risk-related exposure (FCPE) is positively and significantly associated with stock liquidity at the 1% level, potentially reflecting increased investor attention and portfolio rebalancing in response to geographically concentrated climate change exposure, particularly in real estate markets in which physical hazards are asset specific and more directly observable.

Taken together, the baseline results support the first two hypotheses. The significant negative association between FCCE and stock liquidity confirms Hypothesis 1. The heterogeneous effects across sub-dimensions are consistent with Hypothesis 2: opportunity-related exposure drives the strongest negative effect, regulatory exposure exhibits a more moderate and marginally significant impact, while physical exposure displays a positive association with liquidity.

We interpret this heterogeneity as reflecting distinct informational channels. Opportunity-related exposure captures firms' sensitivity to evolving regulatory and transition risks, characterised by greater uncertainty and more heterogeneous investor beliefs, which amplify informational frictions and widen bid-ask spreads. When we re-estimate the decomposed model with firm and year fixed effects (Appendix Table 12), physical exposure is no longer significantly positive and turns slightly negative whereas opportunity-related exposure remains negative and marginally significant at the 10% level. Thus, the overall pattern is consistent with a rich informational story. FCCE affects liquidity through the distinct ways in which different types of climate information shape investor beliefs and trading incentives.

Addressing Endogeneity: Instrumental Variable Approach

Reverse causality may be a concern in our setting, as firms with lower stock liquidity might increase their climate-related disclosure to attract institutional investors or enhance market perception. Similarly, omitted variable bias could arise from unobservable firm characteristics, such as governance quality or strategic orientation, which may jointly affect both FCCE and stock liquidity.

To address potential endogeneity, we estimate a two-stage least squares (2SLS) regression using peer exposure to climate change risk (Peer FCCE) as an instrumental variable for FCCE. Specifically, for each firm i in RE subindustry s at year t , this variable is defined as the leave-one-out average climate change exposure (Sautner et al., 2023) of all other firms in the same RE subindustry, excluding firm i . This instrument captures variation in FCCE driven by RE subindustry peers. Peer FCCE is unlikely to affect an individual firm's stock liquidity directly, as it reflects the climate exposure of other firms in the RE subindustry rather than firm-specific trading conditions, governance decisions, or disclosure strategies. Although peer exposure may influence the broader information environment, its impact on stock liquidity is likely to be indirect and to operate mainly through a firm's own climate change exposure. Therefore, the 2SLS approach isolates the exogenous variation in FCCE driven by peer effects.

As shown in Table 6, the first-stage regression confirms that Peer FCCE is associated positively and significantly with FCCE at the 1% level, suggesting that the instrument is relevant and sufficiently strong. In the second stage, the coefficient of

Table 6 Instrumental variable approach

	<i>1st Stage</i>	<i>2nd Stage</i>
	FCCE	Liquidity_factor
	(1)	(2)
Peer FCCE	0.124*** (4.106)	
FCCE		-0.362** (-2.427)
Size	0.026 (0.848)	0.664*** (31.889)
Market-to-book	-0.010 (-0.538)	0.090*** (7.671)
ROE	-0.010** (-2.115)	-0.001 (-0.216)
Leverage	-0.020 (-0.987)	-0.025* (-1.746)
Momentum	0.007 (0.817)	0.026 (1.345)
Capital Exp	-0.006 (-0.422)	0.004 (0.486)
PPEtoTA	0.121* (1.864)	0.107** (2.472)
Beta	-0.067*** (-3.074)	0.003 (0.176)
Volatility	-0.019** (-2.523)	-0.069*** (-3.019)
Sales Growth	-0.020 (-1.555)	0.005 (0.581)
EPS Growth	-0.004 (-1.508)	-0.005 (-1.148)
Instit Ownership	0.015 (0.445)	0.181*** (8.298)
Env Expenditure	0.033 (1.486)	0.030*** (2.819)
Constant	-0.088 (-1.214)	-1.157*** (-22.723)
Country× Year FE	Yes	Yes
Observations	2,631	2,631

Table 6 (continued)

	<i>1st Stage</i>	<i>2nd Stage</i>
R-squared	0.441	0.829
Kleibergen-Paap F		16.863 (p-value=0.000)

This table presents the results of the instrumental variable (IV) two-stage least squares (2SLS) regression estimation. The instrument, Peer FCCE, is defined as the leave-one-out peer exposure to climate change risk. For each firm i in sub-industry s at year t , it is the average climate change exposure (Sautner et al., 2023) of all other firms in the same sub-industry, excluding firm i itself. The dependent variable is the liquidity factor, constructed using the oblique rotation approach (Daske et al., 2008) applied to three standard liquidity proxies: Inv RSPD, Inv Amihud, and Turnover. The main independent variable is FCCE, which captures firm's exposure to climate change risk. Control variables include firm characteristics such as size, market-to-book, return on equity (ROE), leverage, momentum, capital expenditure, property, plant and equipment to total assets (PPE/TA), beta, volatility, sales growth, earnings per share growth, institutional ownership and environmental expenditure. We include country-by-year fixed effects (Country $\times$ Year FE). All variables included in the regressions, including FCCE, the liquidity factor and all control variables, are standardized for easier interpretation. Variable definitions and data sources are provided in Appendix 14. T-statistics are reported in parentheses. Standard errors are robustly clustered. Statistical significance is indicated by ***, **, and * at the 1%, 5%, and 10% levels, respectively

the instrumented FCCE remains negative and statistically significant at the 5% level, reinforcing the baseline finding that higher FCCE is associated with lower stock liquidity. Notably, the magnitude of the 2SLS coefficient is approximately 8 times larger than the corresponding OLS estimate. This difference may be consistent with attenuation bias in the OLS estimates, potentially driven by measurement error, reverse causality, or unobserved heterogeneity in firms' disclosure incentives. Overall, these results provide stronger evidence consistent with a causal interpretation of the relationship between FCCE and stock liquidity, supporting Hypothesis 1 and highlighting climate change exposure as an important determinant of stock liquidity in the real estate sector.

Sensitivity Analysis

To ensure the robustness of our main findings, we conduct several additional tests using alternative specifications and sample restrictions.

In Table 7, we report the results. First, in Specification (1), we include firm and year fixed effects to control for time-invariant firm heterogeneity. The coefficient on FCCE remains negative and statistically significant at the 10% level, although economically smaller, indicating that the baseline relationship is not driven solely by unobserved firm-specific characteristics.

In Specification (2), we extend the baseline model with several country-level control variables capturing macro-financial and environmental conditions, including stock liquidity (market turnover), a monetary policy indicator (short-term interest rate), climate policy performance (CCPI), and country-level CO₂ emissions per capita. Because these variables vary at the country-year level, we replace the baseline *country $\times$ year* fixed effects with *RE subindustry $\times$ year* fixed effects in this specification to avoid absorbing the additional macro-level controls. The coefficient on FCCE remains negative and statistically significant at the 5% level, suggesting that the relationship between climate exposure and stock liquidity is robust to broader

Table 7 Sensitivity analysis

	Liquidity Factor		
	Coeff.	Adjusted R ²	N
(1) Firm and Year Fixed effects		0.927	2,664
FCCE	-0.013* (-1.68)		
(2) Country-level control variables		0.659	1,912
FCCE	-0.078** (-2.29)		
Market turnover	0.163* (1.71)		
Short-term interest rate	0.013 (0.24)		
CCPI	-0.163* (-1.87)		
CO ₂ per capita	-0.143* (-1.83)		
(3) US Country Only		0.795	1,231
FCCE	-0.033* (-1.72)		
(4) US Country Excluded		0.872	1,426
FCCE	-0.036*** (-2.76)		
(5) GFC period excluded		0.878	2,508
FCCE	-0.044*** (-4.01)		
Firm-level Control variables	Yes		

This table presents sensitivity analyses of the relationship between firm-level climate change exposure and stock liquidity. For brevity, the table reports only the coefficients on the main variable of interest (FCCE) and the additional control variables included in each specification. Other firm-level controls are identical to those used in the baseline regressions (Table 5), including size, market-to-book, return on equity (ROE), leverage, momentum, capital expenditure, property, plant and equipment to total assets (PPE/TA), beta, volatility, sales growth, earnings per share growth, institutional ownership and environmental expenditure. The dependent variable is the liquidity factor, constructed using oblique rotation (Daske et al., 2008) approach applied to three standard liquidity proxies: Inv RSPD, Inv Amihud, and Turnover. In specification (1), we include firm and year fixed effect. In specification (2), we add country-level control variables, including stock market liquidity (market turnover), a monetary policy indicator (short-term interest rate), climate policy performance (CCPI), and country-level CO₂ emissions per capita. In specification (3), the sample is restricted to firms located in the United States. In specification (4), U.S. firms are excluded. In specification (5), the baseline regression is re-estimated after excluding the Global Financial Crisis (GFC) period. All specifications include country $\times$ year fixed effects and RE sub-industry fixed effects, except specification (1) which includes Firm and year fixed effects and specification (2) which includes RE sub-industry $\times$ year fixed effects. All variables included in the regressions, including FCCE, the liquidity factor and all control variables, are standardized for easier interpretation. Detailed definitions and data sources are provided in Appendix 14. T-statistics are reported in parentheses. Standard errors are clustered at the firm level in all specifications. Statistical significance is indicated by ***, **, and * at the 1%, 5%, and 10% levels, respectively

country-level determinants of liquidity and environmental risk. Among the additional controls, market turnover is associated positively with stock liquidity, whereas stronger climate policy performance and higher CO₂ emissions per capita are associated with lower stock liquidity.

In Specifications (3) and (4), we examine whether the results are driven by the large proportion of U.S. firms in the sample. When the sample is restricted to U.S. firms only, the coefficient on FCCE remains negative but decreases in magnitude and becomes significant at the 10% level only. In contrast, the negative relationship remains economically and statistically significant at the 1% level when U.S. firms are excluded. These findings suggest that the FCCE-liquidity relationship is comparatively weaker in the U.S. market, which is characterized by higher stock liquidity, stronger investor protection, and a more mature information environment. In highly developed and transparent markets such as the United States, climate-related information may already be incorporated into prices more efficiently, thereby reducing its marginal impact on stock liquidity. Conversely, in less mature or less transparent markets, investors may face greater uncertainty when processing climate-related information, which may amplify the liquidity effects associated with FCCE. Overall, these results suggest that climate-related exposure affects stock liquidity differently across markets depending on the level of market transparency and informational efficiency.⁷

Finally, in Specification (5), we exclude the global financial crisis (GFC) period (2008–2009) to ensure that the results are not driven by extreme market conditions. The coefficient on FCCE remains negative and significant at the 1% level, confirming that the baseline findings are robust to the exclusion of crisis years.

Overall, these robustness checks reinforce our conclusions. Higher FCCE is associated with lower stock liquidity in real estate firms, and this relationship remains broadly robust across alternative specifications, subsamples and market conditions.

Possible Channels: National Climate Governance

To better understand the FCCE–liquidity relationship, we examine whether national climate governance frameworks moderate the negative effect of FCCE on stock liquidity. To this aim, we use five country-level proxies to capture distinct dimensions of climate policy which we organize along the fundamental distinction between mitigation (policies aimed at reducing greenhouse gas emissions) and adaptation (policies aimed at managing vulnerability to physical climate impacts). On the mitigation side, *Environmental Taxes* measure total environmental tax revenues at the country level, capturing the stringency of market-based climate policy through fiscal instruments, *Environmental Policy Stringency* is the OECD EPS index which aggregates both market-based and non-market regulatory instruments into a comparable cross-country score, *Net Zero Target* is an index of the stringency of a country's long-term

⁷ We thank the referee for this insightful comment. The weaker significance in the U.S.-only subsample is consistent with weaker marginal effects in a highly liquid and informationally efficient market in which climate-related information is incorporated more rapidly into prices.

net zero emissions target and *Building Policy* is an index of the stringency of climate policy instruments targeting the buildings sector. On the adaptation side, *ND-GAIN* is the Notre Dame Global Adaptation Initiative country index which captures a country's vulnerability to climate change and readiness to leverage investments for adaptation reflecting resilience conditions rather than enacted regulatory policy.

The relationship is estimated using the following model:

$$\text{Liquidity Factor}_{i,t} = \alpha + \beta_1 \cdot \text{FCCE}_{i,t} + \beta_2 \cdot \text{Moderator}_{i,t} + \beta_3 \cdot \text{FCCE}_{i,t} \times \text{Moderator}_{i,t} + \gamma \text{Controls}_{i,t} + \text{Fixed Effects} + \epsilon_{i,t} \quad (5)$$

where the *Moderator* variables represent country-level climate governance. Equation 5 includes the same controls as the baseline model, but we replace the baseline *country* $\times$ *year* fixed effects with *RE subindustry* $\times$ *year* fixed effects in this specification to avoid absorbing the additional macro-level controls. The coefficient β_3 is the key parameter of interest, capturing how country-level climate governance moderates the relationship between FCCE and stock liquidity.

Table 8 presents the moderating role of country-level climate policy instruments on the relationship between FCCE and stock liquidity. The direct effect of FCCE on liquidity remains negative and significant at the 1% level in columns (1), (2) and (5), confirming the baseline result. In Columns (3) and (4), the coefficient on FCCE is not statistically significant. Because the moderating variables are standardised, this coefficient captures the effect of FCCE when the moderator is at its mean, rather than its unconditional effect. A joint Wald test shows that the FCCE coefficient and its interaction with Net Zero Target are jointly significant at the 10% level indicating that the effect of FCCE on liquidity depends on the stringency of net zero commitments. Furthermore, this test is not statistically significant for Building Sector Climate Policy. By contrast, the joint test for Environmental Policy Stringency in Column (2) is strongly significant ($p = 0.001$).

Appendix Table 13 reports the marginal effect of FCCE at the 10th percentile, the mean and the 90th percentile of each moderator. The negative association between FCCE and stock liquidity is significant in settings with the least stringent net-zero commitments and building-sector climate policies but disappears where these policies are most stringent. In the same subsample, a specification without interaction terms yields an FCCE coefficient close to zero.

Column (1) reports the results for environmental taxes. The direct effect of environmental taxes on stock liquidity is negative and statistically significant at the 1% level, suggesting that stricter environmental taxation may be associated with lower liquidity in the real estate sector, potentially due to higher compliance costs or regulatory uncertainty. However, the interaction term between FCCE and environmental taxes is not statistically significant, indicating that environmental taxation does not moderate the relationship significantly between climate change exposure and stock liquidity.

In Column (2), the interaction between FCCE and the Environmental Policy Stringency Index is positive and statistically significant at the 5% level. These findings suggest that in countries with more comprehensive regulatory frameworks, investors

Table 8 Moderating role of national climate governance

	Liquidity Factor				
	(1)	(2)	(3)	(4)	(5)
FCCE	-0.079*** (-3.60)	-0.148*** (-3.58)	-0.042 (-1.45)	-0.040 (-1.28)	-0.073*** (-2.99)
Environmental Tax Revenue	-0.099*** (-3.77)				
FCCE × Environmental Tax Revenue	-0.027 (-1.11)				
Environmental Policy Stringency		0.008 (0.19)			
FCCE × Environmental Policy Stringency		0.069** (2.23)			
Net Zero Target			0.045 (0.67)		
FCCE × Net Zero Target			0.058** (2.13)		
Building Sector Climate Policy				-0.028 (-0.39)	
FCCE × Building Sector Climate Policy				0.095** (2.03)	
ND-GAIN Adaptation Index					-0.049*** (-2.77)
FCCE × ND-GAIN Adaptation Index					-0.002 (-0.15)
Constant	-0.250 (-1.55)	-0.337* (-1.81)	-0.835*** (-4.58)	-0.848*** (-4.83)	-0.304* (-1.73)
Control Variables	Yes	Yes	Yes	Yes	Yes
RE Sub-Industry × Year FE	Yes	Yes	Yes	Yes	Yes
Observations	2,664	1,977	1,196	1,196	2,324
Adjusted R^2	0.592	0.608	0.472	0.471	0.580

This table presents the moderating effect of National Climate Governance on the relationship between FCCE and stock liquidity. Each column introduces a distinct policy proxy entered separately alongside its interaction with FCCE. Columns (1) to (4) examine mitigation-oriented instruments: environmental tax revenues (*Environmental Tax Revenue*); the *Environmental Policy Stringency* index; an OECD index of the stringency of a country's long-term *Net Zero Target* (zero when no target is in place) and an OECD index of the stringency of *Building Sector Climate Policy* instruments, which predominantly reflects mitigation-oriented building energy standards and decarbonisation mandates, both from the OECD PINE database. The last column examines the adaptation-oriented measures: the *ND-GAIN Adaptation Index*, which captures a country's vulnerability to climate change and readiness to leverage investments for adaptation. The dependent variable is the liquidity factor constructed using an oblique rotation (Daske et al., 2008) approach applied to three standard liquidity proxies: Inverse Relative Spread (Inv RSPD), Inverse Amihud Illiquidity (Inv Amihud), and Turnover. Although omitted from the table for brevity, all regressions include the control variables reported in Table 5: firm size, market-to-book ratio, return on equity (ROE), leverage, momentum, capital expenditure, property plant and equipment scaled by total assets (PPE/TA), beta, volatility, sales growth, earnings-per-share growth, institutional ownership, and environmental expenditure. All specifications include RE sub-industry-by-year fixed effects (RE Sub-Industry × Year FE). All variables, including FCCE, the liquidity factor, moderator variables, and control variables, are standardized to facilitate interpretation. Detailed variable definitions and data sources are provided in Appendix 14. *t*-statistics are reported in parentheses, and standard errors are clustered at the firm level. Statistical significance is denoted by ***, **, and * at the 1%, 5%, and 10% levels, respectively. Joint Wald tests of the null that the FCCE coefficient and the interaction term are both zero are: Environmental Policy Stringency (col. 2), $F = 6.74$, $p = 0.001$; Net Zero Target (col. 3), $F = 2.56$, $p = 0.080$; Building Sector Climate Policy (col. 4), $F = 2.12$, $p = 0.122$. Marginal effects of FCCE at representative moderator values are reported in Appendix Table 13.

face less uncertainty when they are pricing climate-exposed firms, as the policy environment provides clearer signals about the transition path.

Column (3) indicates that broader climate policy commitments also play an important moderating role. The interaction term between FCCE and Net Zero Target is positive and statistically significant at the 5% level. This finding suggests that countries with stronger long-term climate commitments, such as net zero targets, which reflect the stringency of a country's long-term decarbonization objectives, provide a more predictable and transparent regulatory environment. This institutional context helps reduce uncertainty surrounding climate-related risks, thereby attenuating the negative impact of firm-level climate exposure on stock liquidity.

Column (4) provides weaker evidence of a similar moderating effect for building-sector climate regulation. Although the direct effect of Building Policy is not statistically significant, the interaction term between FCCE and Building Policy is positive and significant at the 5% level but FCCE and the interaction term are not jointly significant ($p = 0.122$). These results suggest that stricter climate-related regulations in the building sector such as energy efficiency standards, minimum energy performance standards and bans or phase-outs of fossil fuel equipment may attenuate the adverse liquidity effects associated with climate exposure. A possible explanation is that such regulations enhance the clarity and credibility of transition-related information thereby improving investors' ability to assess climate transition risks in the RE sector.

The adaptation proxy, captured by the ND-GAIN index, which measures a country's adaptive capacity and physical resilience yields no significant moderating effect on the relationship between FCCE and stock liquidity. This null result is theoretically informative and consistent with the asymmetry between mitigation and adaptation in real estate climate policy. Mitigation instruments are substantially more numerous and more developed than adaptation measures in this sector implying that investors are more likely to price regulatory commitment through the lens of mitigation policy than through broader resilience conditions. An important asymmetry in the underlying policy landscape warrants attention when these results are interpreted. Drawing on the Climate Policy Radar database, we document that climate legislation relevant to the real estate sector is overwhelmingly mitigation oriented: of the 161 climate-related documents identified for the buildings and urban sectors across our sample countries, 151 correspond to mitigation instruments, primarily energy-efficiency standards, green-building codes, and decarbonization mandates whereas only 10 constitute adaptation measures.

On the mitigation side, the significant interactions with *Environmental Policy Stringency* and *Net Zero Target*, together with the weaker evidence for *Building Policy*, suggest that formal regulatory commitment reduces the informational uncertainty surrounding climate-exposed firms: when the transition trajectory is defined clearly through enacted policy, investors can price firm-level climate exposure more readily, reducing adverse selection and supporting liquidity.

On the adaptation side, the absence of a significant *ND-GAIN* interaction is consistent with the near-absence of enacted adaptation legislation in the real estate sector. Since physical climate risk in property markets remains largely unaddressed by formal policy, a country's general adaptive capacity does not translate into the kind

of regulatory commitment that would reduce informational uncertainty for investors. The dominance of mitigation over adaptation instruments in our legislative data thus provides a natural explanation for the asymmetry observed across our five policy proxies.

Overall, these results support Hypothesis 3 and suggest that credible and well-designed climate policy frameworks can partially mitigate the adverse effects of FCCE on stock liquidity. More broadly, the results indicate that national climate policies improve the informational environment surrounding climate-related risks, thereby reducing uncertainty and facilitating investors' interpretation and pricing of firms' climate exposure.

Additional Analyses

The Role of Environmental Emissions in the Real Estate Sector

Relative sectoral emission intensity provides important context for understanding the financial implications of FCCE. We focus on two complementary measures, GHG emissions and CO₂ emissions, in the real estate sector relative to those in other sectors, as these measures capture the carbon intensity of the sector relative to overall economic activity and improve cross-country comparability by mitigating concerns that raw emissions may simply reflect differences in sector size. These indicators reflect the extent to which firms operate in more carbon-intensive environments and may shape investors' assessments of climate-related risks and the informativeness of climate exposure. The relationship is estimated using the previous model where the *Moderator* variables represent environmental emissions in the real estate sector. We include the same controls as the baseline model but we replace the baseline *country* $\times$ *year* fixed effects with *RE subindustry* $\times$ *year* fixed effects in this specification.

Column (1) of Table 9 reports the interaction between FCCE and GHG emissions, whereas Column (2) reports the results for CO₂ emissions. In both specifications, the direct effects of GHG and CO₂ emissions on stock liquidity are positive, with statistical significance at the 10% level for CO₂ emissions. This finding indicates that, on average, more carbon-intensive real estate sectors are associated with improved stock liquidity. This result may reflect greater investor attention or more developed disclosure and monitoring environments in such markets. The interaction terms between FCCE and both GHG and CO₂ emissions are also positive and significant at the 5% level, suggesting that in more carbon-intensive contexts the negative effect of FCCE on stock liquidity is attenuated.

A possible interpretation is that the moderating effect of sectoral emissions reflects two opposing channels. On the one hand, in high-emission environments, investors and institutions may be more accustomed to processing climate-related information and regulatory developments, which reduces the incremental uncertainty associated with firm-level climate exposure. In addition, sectors that are more carbon intensive are often subject to stronger disclosure requirements and regulatory scrutiny, thereby improving the overall information environment and facilitating the pricing of climate risks.

Table 9 The Role of Environmental Emissions in the Real Estate Sector

	Liquidity_factor (1)	Liquidity_factor (2)
FCCE	-0.084*** (-3.36)	-0.084*** (-3.32)
GHG Emissions	0.071 (1.54)	
FCCE × GHG Emissions	0.049** (2.45)	
CO2 Emissions		0.082* (1.87)
FCCE × CO2 Emissions		0.050** (2.52)
Constant	-0.234 (-1.31)	-0.224 (-1.26)
Control Variables	Yes	Yes
RE Sub Industry× Year FE	Yes	Yes
Observations	2607	2607
Adjusted R^2	0.592	0.593

This table presents the role of environmental emissions in the real estate sector on the relationship between FCCE and stock liquidity. The environmental emissions are measured through GHG emissions and CO2 emissions. GHG emissions (CO2 emissions) represent annual greenhouse gas emissions (CO2 emissions) from the buildings sector relative to other sectors. The dependent variable is the liquidity factor, constructed using oblique rotation (Daske et al., 2008) approach applied to three standard liquidity proxies: Inv RSPD, Inv Amihud, and Turnover. Although omitted from the table for brevity, the results include control variables as shown in Table 5. All variables included in the regressions, including FCCE, the liquidity factor, moderator variables and all control variables, are standardized for easier interpretation. Variable descriptions and data sources are provided in Appendix 14. All specifications include RE sub-industry-by-year fixed effects (RE sub-industry × Year FE). T-statistics are reported in parentheses, and standard errors are clustered at the firm level. *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively

On the other hand, lower-emission sectors may reflect better underlying environmental performance, which is also associated with lower climate-related cash-flow uncertainty and reduced sensitivity of liquidity to FCCE. Importantly, these two channels are not contradictory but suggest that sectoral emissions may influence the sensitivity of liquidity to FCCE through different mechanisms, leading to potentially nonmonotonic effects. This finding is consistent with H3 which predicts that environmental conditions shape the relationship between FCCE and stock liquidity.

The Role of Firm-level Environmental Performance

To complement our main analysis on FCCE, we examine whether firm-level environmental performance, distinct from climate change exposure, is associated with stock liquidity and whether it moderates the relationship between FCCE and liquidity. We consider firm-level dimensions of environmental performance, including the environmental pillar score and its subcategories: emissions, resource use, and environmental innovation. The relationship is estimated using the equation 5, where the *Moderator* variables capture these firm-level environmental performance. We include the same

control variables as in the baseline model, along with *country* $\times$ *year* and RE subindustry fixed effects, given that the moderators vary at the firm level.

Table 10 presents the results on the relationship between firm-level environmental performance and stock liquidity as well as the different interactions with FCCE. Across all specifications, FCCE remains negative and statistically significant, confirming the baseline relationship between climate exposure and lower stock liquidity.

Table 10 Firm-level environmental performance and stock liquidity

	Liquidity factor			
	(1)	(2)	(3)	(4)
FCCE	-0.037*** (-2.75)	-0.034** (-2.49)	-0.037*** (-2.94)	-0.048*** (-3.55)
Env Pillar Score	0.017 (0.94)			
FCCE $\times$ Env Pillar Score	-0.011 (-0.78)			
Emission Score		0.027 (1.54)		
FCCE $\times$ Emission Score		-0.017 (-1.19)		
Resources Use Score			0.021 (1.24)	
FCCE $\times$ Resources Use Score			-0.012 (-1.01)	
Env Innovation Score				-0.016 (-0.97)
FCCE $\times$ Env Innovation Score				0.020** (2.22)
Constant	0.041 (0.77)	0.042 (0.80)	0.038 (0.72)	0.032 (0.60)
Control Variables	Yes	Yes	Yes	Yes
Country $\times$ Year FE	Yes	Yes	Yes	Yes
RE Sub Industry FE	Yes	Yes	Yes	Yes
Observations	2167	2167	2167	2167
Adjusted R^2	0.887	0.887	0.887	0.887

This table examines whether environmental performance moderates the relationship between FCCE and stock liquidity. The dependent variable is the liquidity factor, constructed using oblique rotation (Daske et al., 2008) approach applied to three standard liquidity proxies: Inv RSPD, Inv Amihud, and Turnover. The analysis considers corporate environmental performance, including Environmental Pillar Score and its categories namely: Emission Score, Resource Use Score and Environmental Innovation Score. Interaction terms between FCCE and each environmental category score are included to assess their moderating effects on stock liquidity. Although omitted from the table for brevity, all regressions include the control variables reported in Table 5, namely firm size, market-to-book ratio, return on equity (ROE), leverage, momentum, capital expenditure, property, plant, and equipment scaled by total assets (PPE/TA), beta, volatility, sales growth, earnings-per-share growth, and environmental expenditure. All specifications include country-by-year fixed effects (Country $\times$ Year FE) and RE subindustry fixed effects. All variables included in the regressions, including FCCE, the liquidity factor, moderator variables and all control variables, are standardized for easier interpretation. Detailed variable definitions and data sources are provided in Appendix 14. T-statistics are reported in parentheses, and standard errors are clustered at the firm level. Statistical significance is denoted by ***, **, and * at the 1%, 5%, and 10% levels, respectively

When we turn to firm-level environmental performance, neither the overall Environmental Pillar Score (Env Pillar Score) nor its underlying dimensions is associated statistically significantly with stock liquidity. This result suggests that environmental performance alone is insufficient to explain cross-sectional differences in stock liquidity.

When examining moderating effects, we find limited evidence of uniform mitigation. The interactions between FCCE and the Environmental Pillar Score, emission score, and resource use score are not statistically significant, indicating that broad ESG performance measures and incremental improvements in operational environmental efficiency do not systematically alter the relationship between FCCE and liquidity.

The only category of the Environmental Pillar that exhibits a significant moderating effect is environmental innovation, whose interaction with FCCE is positive and significant at the 5% level. This result suggests that firms with stronger environmental innovation capacity experience a weaker negative impact of climate exposure on stock liquidity. A possible interpretation is that environmental innovation reduces the perceived uncertainty associated with climate exposure by signaling adaptability and transition readiness. This finding provides partial support for H4. In particular, firm-level environmental performance moderates the FCCE-liquidity relationship but only through the specific channel of environmental innovation rather than through broader measures of environmental performance.

Overall, these results suggest that firm-level environmental performance does not uniformly reduce the uncertainty associated with climate exposure. Instead, the moderating effect depends on the nature of the environmental activity. Environmental innovation influences the relationship between FCCE and liquidity significantly, potentially because innovative environmental initiatives attract greater investor attention and increase the salience of climate-related information. In contrast, broader measures of environmental performance, including emissions reduction, resource use efficiency, and overall environmental performance, do not alter the effect of FCCE significantly on stock liquidity. These findings suggest that different sustainability practices affect investor perceptions through distinct channels and should not be treated as a homogeneous construct when the market consequences of climate exposure are assessed.

FCCE and individual components of stock liquidity

We further report results using individual liquidity dimensions as additional evidence. This decomposition allows us to assess whether specific components of stock liquidity are more sensitive to FCCE, thereby providing further insights into the channels through which climate change exposure affects stock liquidity. To this end, we re-estimate the baseline model by replacing the dependent variable with Inv RSPD, Inv Amihud, and Turnover. We include the same control variables as in the baseline specification, along with country $\times$ year and RE subindustry fixed effects.

Table 11 reports the results. Columns (1) and (2) show that FCCE is associated negatively and significantly with both Inv RSPD and Inv Amihud, with coefficients statistically significant at the 1% and 5% levels, respectively. In contrast, although the

coefficient of FCCE on turnover is negative, it is not statistically significant. Overall, these results are consistent with our baseline findings and suggest that the negative association between climate change exposure and stock liquidity is robust to individual liquidity dimensions based on transaction costs, price impact and trading activity.

Alternative Liquidity Factor

To further validate our baseline results, we construct an alternative common liquidity factor using principal component analysis (PCA) based on the three standardized liquidity dimensions: inverse relative bid-ask spread (Inv RSPD), inverse Amihud illiquidity (Inv Amihud), and stock turnover (Turnover).

Results are reported in Appendix 15. Panel A of Appendix 15, which presents the correlation structure, further indicates a strong alignment between the alternative factor and each individual liquidity proxy. Panel C of Appendix 15 shows that the first principal component explains 61.48% of the total variation in the underlying measures and exhibits positive and substantial loadings across all components, confirming that it captures a common dimension of stock liquidity.

Panel D of Appendix 15 shows that FCCE remains negatively and significantly associated at the 1% level with the PCA-based liquidity factor. These results are consistent with our baseline findings and confirm that the adverse effect of climate change exposure on stock liquidity is not driven by a specific liquidity proxy but holds when liquidity is measured as a common latent factor extracted from multiple dimensions of market trading frictions.

Conclusion

The present study explores the relationship between FCCE and stock liquidity using an international sample of real estate firms from 2003 to 2022.

Our results reveal a persistent and statistically significant negative association between FCCE and stock liquidity, suggesting that greater climate change exposure increases information asymmetry and investor uncertainty, thereby reducing market efficiency. After decomposing FCCE into its subdimensions, opportunity-related exposure emerges as the primary driver of this negative effect, indicating that investors perceive climate-related opportunities as complex and difficult to price in the short term. Conversely, physical risk exposure is associated positively and statistically significantly with stock liquidity, potentially reflecting increased investor attention and trading activity in response to geographically concentrated physical climate risks, as well as portfolio rebalancing and hedging demand in markets for which such risks are more salient. As previously discussed, this differentiation across risk dimensions is identified in the cross-section and does not survive a firm and year fixed-effects specification. This asymmetry between opportunity-related and physical exposure is consistent with selective disclosure incentives: real estate firms have clear incentives to emphasize transition opportunities and green initiatives on earnings calls while remaining more reluctant to draw attention to physical risks that could raise concerns about asset values. As a result, opportunity-related expo-

Table 11 FCCE and individual components of stock liquidity

	Inv RSPD	Inv Amihud	Turnover
	(1)	(2)	(3)
FCCE	-0.057*** (-4.60)	-0.023** (-2.14)	-0.010 (-0.68)
Size	0.462*** (11.86)	0.734*** (24.16)	0.147*** (3.57)
Market-to-book	0.075*** (3.26)	0.079*** (3.16)	-0.036 (-1.42)
ROE	0.001 (0.08)	-0.010* (-1.95)	-0.015** (-2.18)
Leverage	-0.030 (-1.12)	-0.027 (-0.97)	0.091** (2.57)
Momentum	0.013 (0.85)	0.027 (1.21)	0.007 (0.72)
Capital Exp	0.007 (0.46)	0.011 (1.48)	-0.021 (-0.94)
PPEtoTA	0.025 (1.22)	0.026 (1.21)	-0.010 (-0.34)
Beta	0.011 (0.55)	-0.017 (-1.02)	0.189*** (4.88)
Volatility	-0.016 (-0.85)	-0.107*** (-3.59)	0.014 (0.54)
Sales Growth	0.010 (0.88)	0.008 (1.18)	0.004 (0.70)
EPS Growth	-0.009* (-1.66)	0.005 (1.65)	-0.004 (-0.44)
Ln(1+Instit. Owner.)	0.042 (1.00)	0.148*** (4.79)	0.205*** (5.00)
Ln(1+Env. Exp.)	0.010 (0.76)	0.021** (2.18)	0.021 (1.29)
Constant	-0.000 (-0.00)	-0.000 (-0.00)	0.000 (0.00)
Country× Year FE	Yes	Yes	Yes
RE Sub Industry FE	Yes	Yes	Yes
Observations	2664	2664	2664
Adjusted R^2	0.830	0.922	0.662

This table presents the relationship between firm-level climate change exposure (FCCE) and individual components of stock market liquidity that is: inverse relative price dispersion (Inv RSPD), inverse Amihud illiquidity, and turnover. The main explanatory variable is FCCE, which measures firm's exposure to climate change-related risks. Control variables include firm characteristics such as size, market-to-book, return on equity (ROE), leverage, momentum, capital expenditure, property, plant and equipment to total assets (PPE/TA), beta, volatility, sales growth, earnings per share growth, institutional ownership, and environmental expenditure. All specifications include country-by-year fixed effects (Country × Year FE) and RE sub-industry fixed effects. All variables included in the regressions, including FCCE, the liquidity factor and all control variables, are standardized for easier interpretation. Detailed variable definitions and data sources are provided in Appendix 14. T-statistics are reported in parentheses, and standard errors are clustered at the firm level. Statistical significance is denoted by ***, **, and * at the 1%, 5%, and 10% levels, respectively

Table 12 Climate exposure and its components under firm and year fixed effects

	FCCE	FCOE	FCRE	FCPE
Coefficient	−0.013*	−0.011*	−0.006	−0.007
<i>t</i> -statistic	(−1.68)	(−1.69)	(−1.34)	(−1.37)
Control Variables	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	2,664	2,664	2,664	2,664
Adjusted R^2	0.927	0.927	0.927	0.927

This table re-estimates the specifications of Table 5, replacing country-by-year and RE sub-industry fixed effects with firm and year fixed effects. Each column reports the coefficient on the exposure measure indicated. All regressions include the control variables of Table 5. All variables are standardized. *t*-statistics are reported in parentheses and are computed as in Table 7, Specification (1). Statistical significance is denoted by ***, **, and * at the 1%, 5%, and 10% levels, respectively

Table 13 Marginal effects of FCCE

Moderator value	Net Zero Target	Building Sector Climate Policy
10th percentile	−0.093** (−2.14)	−0.114* (−1.95)
Mean	−0.042 (−1.45)	−0.040 (−1.28)
90th percentile	0.033 (0.88)	0.035 (0.99)
Joint test FCCE = FCCE×Moderator = 0	$F = 2.56$ ($p = 0.080$)	$F = 2.12$ ($p = 0.122$)
Observations	1,196	1,196

This table reports the marginal effect of FCCE on the liquidity factor at the 10th percentile, the mean and the 90th percentile of each moderator in the estimation sample, based on Table 8, Columns (3)–(4). For Net Zero Target, the 10th percentile corresponds to the absence of a net zero target (value of 0, 54% of observations) and the 90th percentile to a value of 8.75. For Building Sector Climate Policy, the 10th and 90th percentiles correspond to values of 6.25 and 7.84. In the same sample, the FCCE coefficient in the specification without interaction is 0.001 ($t = 0.03$). *t*-statistics based on standard errors clustered at the firm level are reported in parentheses. Statistical significance is denoted by ***, **, and * at the 1%, 5%, and 10% levels, respectively

sure may overweight the communication of favorable climate strategy news while physical exposure may understate the true extent of downside risk. We interpret this asymmetry as informative rather than problematic: stock market liquidity responds most strongly to the climate-related content that firms choose to foreground, with transition-related disclosures generating greater uncertainty and belief heterogeneity among investors. Additional analyses based on individual liquidity dimensions confirm these findings and show that the negative effect of FCCE is most pronounced for transaction costs and measures based on price impacts, whereas its effect on turnover is not statistically significant. The results when an alternative PCA-based aggregate liquidity factor is used further corroborate the baseline evidence, showing that FCCE consistently reduces stock liquidity when liquidity is measured as a common latent factor across multiple trading frictions.

Further analyses highlight the critical importance of environmental and institutional contexts in shaping these effects. At the country level, the relationship between

Table 14 Variable Names and Definitions (Part I)

Variables	Description	Sources
Panel A: Climate Change Exposure Measures		
FCCE	The firm-level climate change exposure measure developed by Sautner et al. (2023) employs a machine-learning approach. It assesses the relative frequency of climate change-related bigrams in corporate discussions during earnings conference calls. Multiplied by 1000 for clarity.	Sautner et al. (2023)
FCOE	Opportunity-related measure capturing frequency of bigrams about climate change opportunities. Multiplied by 1000 for exposition.	Sautner et al. (2023)
FCRE	Regulatory-related measure capturing frequency of bigrams about regulatory aspects of climate change. Multiplied by 1000 for exposition.	Sautner et al. (2023)
FCPE	Physical-related measure capturing frequency of bigrams about physical aspects of climate change. Multiplied by 1000 for exposition.	Sautner et al. (2023)
Panel B: Liquidity Measures		
Inv RSPD	Inverse of the relative spread: difference between best ask and bid quotes as a fraction of the midpoint price.	LSEG
Inv Amihud	Inverse of Amihud's illiquidity measure (absolute return divided by volume).	LSEG
Turnover	The number of shares traded over outstanding shares.	LSEG
Liquidity Factor	Aggregation of liquidity proxies into a single factor using the Principal Factor Method (PCF) applied to three liquidity proxies (Inv RSPD, Inv Amihud, and Turnover). Higher values indicate improved liquidity.	Authors' calculations
Panel C: Control Variables at the Firm Level		
Size	Natural logarithm of one plus the firm's total assets.	LSEG
Market-to-Book	Ratio of market to book value.	LSEG
ROE	Ratio of net income divided by total equity.	LSEG
Leverage	Ratio of total debt to total assets.	LSEG
Momentum	Average of monthly returns over the last year.	LSEG
Capital Exp	Ratio of capital expenditures to total assets.	LSEG
PPE/TA	Ratio of property, plant & equipment to total assets.	LSEG
Beta	60-month rolling regression using natural logarithmic returns for the default datatype and the corresponding local index.	LSEG
Volatility	Standard deviation of stock returns.	LSEG
Sales Growth	Sales growth rate.	LSEG
EPS Growth	Earnings per share growth.	LSEG
Instit Ownership	Natural logarithm of one plus percent of traded shares held by institutions.	LSEG
Env Expenditure	Natural logarithm of one plus firm environmental expenditures.	LSEG
Panel D: Additional Variables at the Firm Level		
Peer FCCE	Leave-one-out peer exposure to climate change risk. For each firm i in RE sub-industry s at year t , it is the average climate change exposure (Sautner et al., 2023) of all other firms in the same sub-industry, excluding firm i itself. The measure is standardized (mean = 0, SD = 1) at the sub-sector $\times$ year level.	Authors' calculations
Env Pillar Score	The environmental pillar ESG score reflects a company's overall environmental performance, sustainability initiatives, and eco-efficiency.	LSEG
Emission Score	Company's commitment and effectiveness in reducing environmental emissions.	LSEG
Resource Use Score	Company's performance and capacity to reduce materials, energy, or water use.	LSEG

Table 14 (continued)

Variables	Description	Sources
Env Innovation Score	Environmental innovation category score reflecting a company's capacity to reduce environmental costs and burdens for its customers, thereby creating new market opportunities through new environmental technologies, processes, or eco-designed products.	LSEG
Variable Names and Definitions (Part II)		
Panel E: Control Variables at the Country Level		
Market Turnover	Natural logarithm of one plus stocks traded, turnover ratio of domestic shares (%).	WFE
Short-Term Interest Rate	Rates at which short-term borrowings are effected between financial institutions, or the rate at which short-term government paper is issued or traded in the market.	OECD
CCPI	Climate Change Performance Index: measures the climate mitigation performance of the 60 largest greenhouse-gas-emitting countries. A weighted composite of four categories: GHG emissions (40%), renewable energy (20%), energy efficiency (20%), and climate policy (20%), scored on a 0–100 scale where higher values indicate stronger climate performance.	German-watch, New Climate Institute, Climate Action Network
CO ₂ Emissions per Capita	Carbon dioxide emissions from burning fossil fuels and industrial processes, including transport, electricity generation, and heating, but excluding land-use change.	Global Carbon Budget (2025)
Panel F: Additional Variables at the Country Level		
Environmental Tax Revenue	Revenue from environmentally related taxes on natural resource management, including taxes on water extraction, forest products, hunting and fishing, mining royalties, and excavation taxes; expressed in millions USD. Fees and charges related to water supply are excluded.	PINE
Environmental Policy Stringency	A country-specific and internationally comparable measure of the stringency of environmental policy, ranging from zero (least stringent) to six (most stringent). The index focuses on climate change and air pollution mitigation policies.	OECD
Net Zero Target	Stringency of a country's long-term net-zero GHG emissions target, measured across multiple dimensions including whether the target is enshrined in law, the ambition of the target year, and the gases covered. A value of 0 indicates no net-zero target is in place.	PINE
Building Sector Climate Policy	Aggregate stringency index (0–10 scale) of regulatory instruments — such as energy efficiency standards, minimum energy performance standards, and bans or phase-outs of fossil fuel equipment — applied to the buildings sector.	PINE
ND-GAIN Adaptation Index	Country-level index measuring a country's vulnerability to climate change impacts and its readiness to leverage private and public investments for adaptation. Computed as the difference between a readiness sub-index capturing economic, governance, and social capacity and a vulnerability sub-index capturing exposure, sensitivity, and adaptive capacity across six sectors (food, water, health, ecosystem services, human habitat, and infrastructure). Scores are rescaled to a 0–100 range, with higher values indicating lower vulnerability and greater adaptive capacity.	Notre Dame Global Adaptation Initiative (ND-GAIN)
GHG Emissions	Annual GHG emissions from the buildings sector relative to other sectors.	IMF
CO ₂ Emissions	Annual CO ₂ emissions from the buildings sector relative to other sectors.	IMF

Table 15 Alternative common liquidity factor: principal component analysis and validation

Panel A: Correlation matrix

	Alternative Liquidity Factor	Inv RSPD	Inv Amihud	Turnover
Alternative Liquidity Factor	1.000			
Inv RSPD	0.869***	1.000		
Inv Amihud	0.721***	0.476***	1.000	
Turnover	0.754***	0.518***	0.260***	1.000

Panel B: Principal Component Loadings (PC1)

Variable	Loading
Inv RSPD	0.640
Inv Amihud	0.531
Turnover	0.556

Panel C: Factor statistics

Eigenvalue (PC1)	1.844
Variance explained (%)	61.48
Observations	2,664

Panel D: Regressions Using Alternative Liquidity Factor (PCA-based)

	Alternative Liquidity Factor
	(1)
FCCE	-0.046*** (-4.12)
Constant	-0.000 (-0.00)
Control Variables	Yes
Country× Year FE	Yes
RE Sub Industry FE	Yes
Observations	2664
Adjusted R^2	0.821

This table presents the construction and validation of an alternative common liquidity factor based on principal component analysis (PCA) applied to standardized liquidity measures. Panel A reports the correlation matrix between the alternative liquidity factor and its underlying liquidity proxies: inverse relative bid-ask spread (Inv RSPD), inverse Amihud illiquidity (Inv Amihud), and stock turnover (Turnover). Panel B reports the loadings associated with the first principal component (PC1), which is used to extract the common liquidity factor. Panel C presents the eigenvalue of the first principal component, the proportion of variance explained, the cumulative variance explained, and the number of observations used in the estimation. Panel D reports the relationship between firm-level climate change exposure (FCCE) and the alternative liquidity factor. Control variables include firm characteristics such as size, market-to-book ratio, return on equity (ROE), leverage, momentum, capital expenditure, property, plant and equipment scaled by total assets (PPE/TA), beta, volatility, sales growth, earnings per share growth, institutional ownership, and environmental expenditure. All specifications include country-by-year fixed effects (Country × Year FE) and RE sub-industry fixed effects. All variables included in the regressions, including FCCE, the liquidity factor and all control variables, are standardized for easier interpretation. Detailed variable definitions and data sources are provided in Appendix 14. T-statistics are reported in parentheses, and standard errors are robustly clustered. Statistical significance is denoted by ***, **, and * at the 1%, 5%, and 10% levels, respectively

FCCE and liquidity is moderated by national climate policy frameworks. Although environmental taxes reduce overall liquidity without specifically resolving the informational asymmetry generated by FCCE, broader regulatory stringency and

Table 16 Summary statistics by RE sub-industry

Industry	Obs.	FCCE	Liquidity Factor	Inv RSPD	Inv Amihud	Turn-over
Real Estate Holding & Development	583	0.901	-0.441	5.665	8.223	0.543
Office REITs	338	0.786	0.158	6.386	9.242	1.201
Other Specialty REITs	122	0.905	0.391	6.832	8.947	1.854
Retail REITs	388	0.467	0.092	6.412	8.767	1.293
Diversified REITs	275	0.724	-0.001	6.094	9.242	0.954
Industrial REITs	154	0.788	0.153	6.223	9.739	0.994
Storage REITs	52	0.401	0.566	7.117	9.499	1.589
Real Estate Services	110	0.334	0.093	6.345	8.519	1.731
Residential REITs	260	0.566	0.215	6.674	8.845	1.314
Health Care REITs	185	0.357	0.428	6.980	9.098	1.556
Hotel & Lodging REITs	99	0.289	0.338	6.818	8.558	2.015
Infrastructure REITs	28	0.716	1.315	7.977	11.576	1.607
Security Services	17	3.775	0.442	6.925	8.352	2.604
Timber REITs	46	0.918	0.660	7.226	9.347	2.054
Not filled	7	0.580	-0.420	5.154	9.309	0.629
Total	2,664	0.688	0.069	6.342	8.887	1.185

This table reports summary statistics of firm-level climate change exposure (FCCE) and liquidity measures across RE sub-industries defined using the LSEG Industry Level 5 (INDM5) classification. For each RE sub-industry, the table reports the number of observations, the average FCCE, and three liquidity proxies: the liquidity factor, the inverse RSPD, the inverse Amihud illiquidity measure, and turnover

long-term climate commitments such as net zero targets attenuate the negative impact of FCCE on liquidity with weaker evidence for sector-specific building policies. In contrast, the ND-GAIN adaptive capacity index does not generate a significant moderating effect, consistent with the asymmetry between mitigation and adaptation in real estate climate policy: mitigation instruments are substantially more numerous and more developed than adaptation measures in this sector, implying that investors price regulatory commitment primarily through the lens of mitigation policy rather than through broader resilience conditions. At the sectoral level, higher GHG and CO₂ emissions from the buildings sector are associated with a weaker negative relationship between FCCE and stock liquidity, suggesting that greater familiarity with carbon-intensive environments reduces informational frictions related to FCCE. Complementary evidence from firm-level environmental performance reveals heterogeneous moderating effects across environmental performance dimensions. Environmental innovation capacity mitigates the negative impact of FCCE on stock liquidity significantly, which is consistent with the view that forward-looking environmental strategies reduce informational uncertainty about firms' ability to navigate climate transition risks. In contrast, broader environmental performance dimensions, including the overall environmental pillar score, emissions management, and resource use scores, do not generate significant moderating effects, suggesting that compliance-oriented environmental performance does not sufficiently resolve the informational frictions generated by FCCE in the real estate sector.

Overall, the findings contribute to the growing literature on climate change's financial consequences by showing that FCCE affects not only valuation and risk but also secondary market functioning. Although climate exposure reduces stock liquidity, its impact varies substantially across institutional environments and firm-level environmental practices. For firms, these results suggest that targeted investment in credible environmental innovation and transparent disclosure practices may be more effective in improving stock liquidity outcomes than generic ESG improvements are. For investors, incorporating both FCCE and granular environmental indicators including the nature of firms' sustainability strategies and the regulatory environment in which they operate enhances climate risk assessment and portfolio resilience. For policy-makers, the evidence highlights the importance of consistent and credible climate policy frameworks that improve information environments and reduce market frictions; in particular, enacted regulatory commitments, through broader environmental policy stringency or long-term net zero targets and, to a lesser extent, sector-specific building standards are associated with weaker adverse liquidity implications of climate exposure in RE markets.

In conclusion, climate change poses environmental, regulatory, and financial challenges that directly affect stock liquidity. By integrating firm-level exposure, national policy contexts and corporate environmental practices, this study provides a comprehensive view of how climate risk is transmitted through financial markets in the real estate sector. A limitation of our analysis is that the FCCE measure reflects discussed rather than actual exposure: firms with high underlying climate risk but low disclosure propensity may receive lower scores, which may not fully capture the true extent of their climate change exposure. Future research could extend this framework to other sectors or examine how evolving disclosure standards and regulatory regimes further shape stock liquidity dynamics over time.

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Data Availability This study uses financial and ESG data obtained from Refinitiv Datastream, which are available only through institutional subscription. The firm-level climate change exposure dataset (FCCE) used in this paper, originally constructed by Sautner et al. (2023) and updated by the co-authors, is available from the corresponding author.

Declarations

Competing Interests The authors declare that they have no competing financial or non-financial interests that could have appeared to influence the work reported in this paper.

Research Involving Human Participants and/or Animals This article does not contain any studies involving human participants or animals performed by any of the authors.

Informed Consent This study does not involve human participants; therefore, informed consent was not required.

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