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Climate Change Exposure, Financial Development, and the Cost of Debt: Evidence from EU Countries

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Author Contribution

- **Vu Quang Trinh:** Project lead; Conceptualization; Formal analysis; Investigation; Methodology; Project administration; Resources; Software; Roles/Writing - original draft; Writing - review & editing; Funding for using professional proof-reading service.
- **Hai Hong Trinh:** Data curation; Conceptualization; Project administration; Resources; Roles/Writing - original draft; Writing - review.
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Abstract

Utilising climate-related narratives in conference call transcripts to measure firm-level exposure to climate risks, we examine the association between such exposure and the corporate cost of debt financing. Using a sample of 21 European countries from 2001 to 2020, we find that firms exposed to greater climate change experience higher debt costs. The impact is even more extreme when using climate-related opportunity and regulatory exposure measures. We further find critical economic channels through which the higher debt costs occur: financial development and credit supplies. Specifically, our findings hold only for firms in weakly developed financial markets and institutions as measured by the new broad-based multi-dimensional financial development indices. We also find some other conditioning factors. (1) The higher the carbon intensity level, the greater the debt cost a firm with more climate change exposure must pay. (2) Debtholders appear to punish firms with high environmental and social disclosure that are exposed to more climate change. (3) The findings are more pronounced in financially constrained firms.

Keywords: *Climate change exposure; Cost of debt; Multidimensional financial development; Carbon risk; Carbon intensity; ES; Financial Constraints*

1. Introduction

Recurrent natural disasters caused by global warming have adversely affected public health, individual savings, labour productivity, and business practices (Rao et al., 2022; De Sherbinin et al., 2011; Dell et al., 2009). Governments worldwide have ratified several intergovernmental

agreements (e.g., the Tokyo Protocol, Paris Agreement, and United Nations Sustainable Development Goals) and domestic environmental policies (e.g., mandatory information disclosure and eco-friendly production) to diminish climate-related risks. Still, firm-level responses to climate issues appear varied because of unequal institutional development, environmental externalities, and proximity to environmental hazards (Aguilera et al., 2021; Hsu et al., 2021). Recently, the burgeoning climate finance literature has documented evidence showing that climate hazards (e.g., the physical, regulatory, and transition risks of climate change) have considerable impacts on corporate investment, financing strategies, and dividend policy (see, among others, Dang et al., 2022; Nguyen et al., 2022; Reboredo and Ugolini, 2022; Zhu and Hou, 2022; Bolton and Kacperczyk, 2021; Jung et al., 2018; Balachandran and Nguyen, 2018).[1] These effects may be greater for companies in regions susceptible to extreme environmental events and conditions, such as sea level rise, droughts, flooding, wildfires, and hurricanes. However, there is limited empirical research on debtholders' risk assessment of firms' vulnerability and exposure to climate change.

We use managerial narratives in conference call transcripts as a new and disaggregated proxy for firm-level exposure to climate change recently developed by Sautner et al. (2023). Our study examines the association between climate change exposure and corporate cost of debt for EU countries. Prior research has primarily focused on how outsiders, such as creditors, passively absorb and respond to environmental information disclosed by firm management in corporate annual reports, corporate social responsibility (CSR) reports, and environmental reports, or to information released by non-governmental organisations (Javadi and Masum, 2021). However, accounting studies have questioned the information value of unregulated, voluntary environmental reporting that may be motivated by managers' desire to enhance their public image and accumulate reputational capital (Eliwa et al., 2021). Discretionary disclosure of climate change risks may not adequately inform stakeholders about enterprises' susceptibility to environmental concerns (Matsumura et al., 2014). As a result, creditors face difficulties in grasping firms' actual exposure to climate change. Theory predicts that the agency problem and information asymmetry will

[1] For example, Dang et al. (2022) provide evidence that manufacturing firms in 11 midwestern and southeastern U.S. states dramatically adjust their capital structure by raising operating leverage following the implementation of the NOx Budget Trading Program (see also Nguyen and Phan, 2020). According to Rao et al. (2022), extreme rainfalls can pressure some Indian firms to adjust their investment strategies. In addition, mortgage lenders tend to impose higher interest rates on properties situated in regions more likely to be affected by rising sea levels (Nguyen et al., 2022). Finally, lending institutions, such as banks, impose a risk premium on loan spreads, charge higher interest rates (Herbohn et al., 2019), and incorporate more collateral requirements and stricter covenant terms into debt contracting (Jung et al., 2018) when firms have higher carbon emissions or climate-related risks, and lower awareness of climate risks.

worsen due to the administrative capture of environmental reporting practices (Bao, 2022; Chen et al., 2022; Trinh et al., 2020; Bliss and Gul, 2012). We address such issues by assessing whether and to what extent debtholders account for firms' exposure to climate change, as proxied by climate-related discussions in earnings conference call[2] transcripts (Sautner et al., 2023).

Debtholders and shareholders have conflicting interests regarding the firm's risk-taking, which includes how resources are allocated to manage climate risks (Chen and Steiner, 1999; Francis et al., 2022). Given the financial stakes of climate risks, lenders are keen to understand how senior managers respond to analysts' queries about these issues during earnings calls. Securities analysts, who increasingly consider environmental risks to enhance earnings forecast accuracy (Benlemlih et al., 2023), influence shareholders and other market participants. Their coverage and recommendations, which often prioritise short-term returns, can impact a firm's ability to meet its debt obligations and increase the risk of default (Qian et al., 2019). Consequently, lenders may view conference call transcripts as vital *supplementary* information when determining the terms of debt contracts.

Furthermore, lenders typically receive essential documents, such as borrowers' financial statements and CSR reports, when negotiating lending contracts. They may also interact with borrowers' mid-level finance managers and staff. However, it is less common for lenders to have direct conversations with top managers who allocate funds for climate-related strategies (Beretta et al., 2022; Lewis et al., 2014). Moreover, as financial institutions become increasingly concerned about firms' climate exposure (Akomea-Frimpong et al., 2022; Galletta et al., 2021; Khattak and Saiti, 2021), lenders must thoroughly assess the potential risks and opportunities related to climate change. One effective method is to consult conference call transcripts that capture top management's responses to queries about climate risks. Thus, lenders may consider these transcripts a vital source of additional insights before they finalise the terms (e.g., the interest rates) of their lending contracts.

Therefore, we argue that direct and indirect communication channels between borrowers and lenders can provide the latter with both 'hard' quantitative and 'soft' qualitative information about

[2] During earnings conference calls, external stakeholders such as financial analysts and the media can engage with a firm's management team (Larcker and Zakolyukina, 2012; Brown et al., 2004). We acknowledge that these calls may not always include creditors and debtholders—who are equally interested in the firm's historical performance and strategic plans, including its approaches to emerging or escalating climate-related risks. We also realize that lenders might directly interact with borrowers to gather information about their climate change exposure. Nevertheless, managerial discussions about climate issues are likely to influence lenders' decision-making processes. It is reasonable to expect that lenders review the content of conference call transcripts to verify information about borrowers' exposure to climate risks before finalising their lending decisions.

firms' climate-related strategies. Through these channels, lenders can gain insight into how managers plan to prevent and mitigate the adverse impact of climate change on the firm's regular operation and production, as well as its ability to generate constant free cash flow to meet debt obligations (see Bao, 2022; Bharath et al., 2011; Chen et al., 2022; Dhaliwal et al., 2011; Rahaman and Al Zaman, 2013). Although analysing a company's annual financial reports is a less expensive and more time-efficient method of determining whether it can fulfil its debt obligations or is at risk of failure, prior research has shown that even well-performing profitable firms may default on their debt. Therefore, non-financial information, including social and environmental information, appears to be crucial to creditors when they are structuring debt contracts (Eliwa et al., 2021; Qian et al., 2021; Benlemlih, 2017; Lorca et al., 2011; Anderson et al., 2004).

As previously explained, managers may use firms' environmental information to increase their reputation and legitimacy rather than to increase transparency (Adams, 2004). In this study, we assume that corporate executives are unable to respond to stakeholders' inquiries by preparing a script or crafting illustrative images similar to those in an environmental sustainability report. In particular, there are some significant reasons why a Q&A session should provide useful information that supplements the voluntary sustainability- and climate-related information disclosure. First, the top managers are usually not involved in writing sustainability and environmental reports; however, they have inside information about their company's current operating situation and the climate risks it faces. They are also familiar with its overall strategy and its climate-related project investment (Adams and McNicholas, 2007; O'Dwyer, 2005). Also, the top managers' perspectives on handling climate risks and associated opportunities influence their firm's next steps in dealing with climate challenges. The top managerial views are not necessarily reflected in the reports, but the media and analysts might enquire about them (Benlemlih et al., 2023). Second, existing evidence suggests that voluntary environmental reporting is produced in response to specific institutional pressures and a comprehensive range of stakeholders, not just shareholders (Gallego-Alvarez et al., 2017; Hess, 2007; Belal, 2002). Therefore, the information in the reports may not address the specific information demands of professional security analysts. In addition, the conference attendees (e.g., news media, securities analysts, and shareholders) should have already read the firms' environmental reports before the conference calls. The attendees are likely to ask more detailed questions about the firms' climate-

related achievements and plans to obtain insights that go beyond the voluntarily reported information.

By analysing the management's responses to the attendees' concerns during conference calls, lenders can better understand the firms' exposure to climate change, whether they have adopted effective strategies, and whether they will take prompt action to mitigate the negative impact of any emerging or escalating environmental challenges. This information helps creditors assess whether the debtors are likely to experience a shortage of free cash flows, financial distress, default risk, or even bankruptcy within the anticipated time frame. Direct mutual communication between firm management and stakeholders' representatives (i.e., analysts and media) can lessen agency problems and information asymmetry and alleviate creditors' concerns. This can boost creditors' trust as they assess risk and strive to design a debt contract with an appropriate interest rate. Moreover, existing artificial intelligence technology can accurately capture the climate change–related words and discussions recorded in firms' conference call transcripts, which are readily available on corporate websites (Sautner et al., 2023).

We propose two testable hypotheses regarding the possible associations between firm-level climate change exposure and the cost of external debt financing. On the one hand, through the lens of information asymmetry, gaining more detailed information regarding the firm's past and future under escalating climate change gives lenders an in-depth understanding of borrowers' real exposure to climate change risks and their potential losses and cash flow shortages in the future. Therefore, lenders tend to incorporate an additional risk premium into decisions and impose a higher interest rate on firms with greater exposure to climate change. On the other hand, lenders may consider the firm's vulnerability to climate change threats by analysing where their significant businesses are located and whether the borrowing firms have deployed suitable strategies to mitigate possible hazards. Furthermore, lenders can learn if firms are responding to climate change by innovating their operations to reduce their environmental externalities and comply with social expectations, thereby increasing their competitive advantage against peers. Depending on the quality and richness of managers' responses to climate-related questions from conference call attendees, lenders may offer firms a favourable (i.e., lower) interest rate.

Using a sample of 10,322 firm-year observations from 2001 to 2020, we find a positive association between firm-level climate change exposure and the cost of debt financing, which suggests that firms with greater climate change exposure are more likely to be charged more by

their creditors. The impact is even more extreme when using climate-related opportunity and regulatory exposure measures. The findings remain robust after a battery of endogeneity tests.

Our study contributes to the expanding body of literature on climate finance such as Khan et al. (2023), Morrone et al. (2022), Kling et al. (2021), Palea and Drogo (2020)Hung et al. (2018), Jung et al. (2018), and Chava (2014). These works examine the effect of a firm's susceptibility to climate risks on its financing strategies, capital structure, and overall performance. Many of these studies explore how a firm's exposure to climate-induced threats like storms, wildfires, and floods impacts the cost of external financing, as highlighted by Kling et al. (2021) and Huang et al. (2018). Recent research also finds that corporate disclosures of ecological impacts, such as greenhouse gas emissions, affect borrowing costs (Morrone et al., 2022). However, it is difficult to gauge the impacts of climate exposure and greenhouse gas emissions on individual firms (Sautner et al., 2023; Giglio et al., 2021). Challenges arise from the multifaceted nature of climate impacts, which stem from various sources.[3] Therefore, it is vital to develop nuanced, disaggregated measures that can capture this variability across companies. Such measures should also reflect market assessments and attention regarding how climate change affects individual companies, as this information is crucial for market participants involved in resource allocation and price discovery. In this study, we employ data from a systematic approach devised by Sautner et al. (2023) to analyse the transcripts of firms' earnings conference calls.[4] These data provide time-varying insights into how participants worldwide perceive the exposure of individual firms to various aspects of climate change.

We further contribute to the finance literature by examining conditional factors that drive our main results. Specifically, we explore the effects of financial development on corporate financing decisions by building on prior research showing that well-developed financial markets typically feature lower costs of external finance, facilitating corporate debt (e.g., bank loans) and equity

[3] For example, "while physical climate changes and regulations implemented to combat global warming can impose costs on some firms, climate change can provide opportunities for other firms, such as those operating in renewable energy, electric cars, or energy storage" (see Sautner et al., 2023, p.1450).

[4] This process enables detection of management's spontaneous reactions to stakeholders' climate-related questions and concerns. For example, stakeholders may ask about managers' perceptions of potential challenges, opportunities, and uncertainties, as well as their plans for responding to them. While debtholders/lenders may not be able to attend all borrowers' quarterly earnings conference calls, they can review the publicly available transcripts to learn about firms' exposure to climate risks and thereby gain greater confidence in determining risk premiums in debt financing. Firms' climate reports are self-published and potentially manipulated, and their environmental practices can be superficial (e.g., publishing ecological reports and responding to NGOs' calls for heightened climate awareness). As such, they do not necessarily convey useful information. In contrast, conference call transcripts are more likely to convey valuable soft and hard information regarding a company's climate vulnerability. Such information can allow lenders to make more informed decisions regarding the terms and conditions of their debt contracts with borrowers.

financing (e.g., issuing shares) (e.g., Yang et al., 2022; Ge and Qiu, 2007; Fisman and Love, 2003; Rajan and Zingales, 1998). Despite these insights, a considerable gap persists in our understanding of financial development's role in the relationship between climate exposure and debt costs. We address this by highlighting financial development as a critical factor that influences savings, investment decisions, and the efficiency of fund allocation. Financial development helps mitigate problems related to information asymmetries and financial constraints, thereby improving the functionality of financial systems.[5] We define financial development as a multidimensional process involving globalised financial sectors and contemporary financial systems (see Svirydzenka, 2016). We hypothesise that firms in countries with advanced financial markets and institutions generally enjoy easier, more affordable access to external finance and face lower information barriers and transaction costs (Yang et al., 2022; Beck et al., 2008). This advantage could offset the increased debt costs faced by firms exposed to climate risks.

Moreover, the evolution of financial markets and institutions likely reduces the costs of formal external financing (e.g., bank credits), promoting firm growth (Rajan and Zingales, 1998). Conversely, firms in countries with underdeveloped financial systems might struggle to access bank loans, especially when they face greater climate exposure. As a result, they may have to resort to costlier alternative financing methods like trade credit (Yang et al., 2022). Our findings confirm that the observed positive relationship between climate exposure and corporate debt costs occurs predominantly in countries with low levels of financial development and credit availability. This result underscores the significant impact of financial development on the relationship between climate risks and corporate lending activities.

Furthermore, we build on previous studies of carbon emissions (e.g., Zhu and Hou, 2022; Nguyen and Phan, 2020; Jung et al., 2018) by examining how carbon intensity influences the relationship between firms' climate exposure and debt costs. Our results generally show that firms with greater climate exposure and higher carbon intensity face increased debt costs. Firms with extremely high carbon intensity experience the most significant increases in financing costs. Conversely, we observe negligible effects of climate exposure on debt costs among firms with low or extremely low carbon intensity. These findings highlight the crucial role of carbon intensity in the relationship between a firm's climate exposure and its cost of debt. Our research underscores

[5] The improved functionality of financial systems can include the increasingly significant roles of banks, investment banks, insurance companies, mutual funds, pension funds, venture capital firms, and many other types of nonbank financial institutions.

the effectiveness of government regulations and climate policies aimed at encouraging carbon-intensive firms and sectors to adopt greener practices. Without such measures, these firms might face larger economic burdens due to their cost of debt financing.

Moreover, we expand upon the current understanding of CSR and climate finance by investigating how environmental and social (ES) ratings influence the effect of climate exposure on corporate debt costs. Our findings suggest that debtholders tend to penalise firms with higher ES disclosure that are more exposed to climate change, possibly perceiving their disclosures as "greenwashing" (Cao et al., 2022). Debtholders may focus more on potential negatives, such as bankruptcy and reputational risks, in which case they may adopt a more conservative stance and have less trust in debtors' positive reports. We also find that the adverse impact of climate exposure on the cost of debt is more pronounced among financially constrained firms than among their less constrained counterparts. This suggests that financial constraints, which limit access to affordable financing, compel firms to accept higher borrowing costs. Therefore, when financially constrained firms have significant climate exposure, they struggle to negotiate favourable terms with debtholders, who are inclined to penalise increased exposure. Finally, we also investigate how climate change sentiment and risk affect the corporate cost of debt. We examine climate change sentiment—specifically, the frequency of climate change bigrams that follow the use of positive (+) and negative (-) tone words. We also examine the risks, defined as the relative frequency of bigrams that appear in sentences with terms like "risk", "uncertainty", and their synonyms. Our findings suggest that debtholders are more inclined to base their lending decisions on assessments of climate change exposure and risk than on general sentiment.

The paper is organised as follows. In Section 2, we discuss prior research on the influence of climate change on corporate activities and build our hypothesis on the relation between firm-level climate risk exposure and corporate cost of financing through external debts. In Sections 3 and 4, we explain our data sample, present our empirical models, and perform a preliminary statistical analysis of our empirical data. Sections 5, 6, and 7 present our regression analysis results, channel analysis, and robustness tests, respectively. Section 8 concludes the study.

2. Relevant Literature and Hypothesis Development

An early study by Chava (2014) reveals the adverse impact of a firm's environmental externalities (e.g., excessive toxic chemicals emission and other hazardous waste discharge,

accusations of illegal waste management, and substantial revenue from fossil fuels) on its cost of financing activities. The study shows that debtholders such as banking lenders steadily increase interest rates and exit debt contracting with firms that fail to address their harmful environmental impacts because such firms might become more exposed to climate change risks. Huang et al. (2018) focus primarily on the cost of capital and financial decisions for companies operating in regions susceptible to environmental disasters. Since firms in these locations are more likely to be negatively affected by extreme weather events (e.g., storms, flooding, and heat waves), they are more likely to suffer from lower and more volatile earnings and cash flows. Therefore, such firms tend to hold more cash, have more long-term debts, and make fewer dividend payouts to retain financial slack and organisational resilience to environmental risks associated with worsening climate change. Indeed, Jung et al. (2018) show that firms that have higher awareness of environmental risk, adopt a reasonable decarbonising strategy, and disclose sustainability-focused information are more likely to obtain desirable contracts from the debt market. Furthermore, Kling et al. (2021) find that a country's vulnerability to climate change has an adverse influence on its sovereign borrowings, and firms in these countries suffer from higher costs of debt and appear more financially constrained.

More recently, a growing literature has documented empirical evidence on the impact of climate-related regulatory, physical, and transitional risks on corporate financing, investment, and operating behaviours (Dang et al., 2022; Karydas and Xepapadeas, 2022; Rao et al., 2022; Krueger et al., 2020). For example, Dang et al. (2022) demonstrate the regulatory risk of environmental policy. They find that manufacturing firms were compelled to alter their capital structure by increasing financial leverage after the NOx Budget Trading Program was enacted in 11 U.S. states, which caused an electricity price shock to polluting companies. Rao et al. (2022) focus on Indian companies operating in regions with frequent extreme weather conditions. They find that firms adjust their investment strategies in response to both excess and deficient rainfall. Market participants are also concerned about how firms react to extreme weather that may trigger severe natural disasters such as flooding or drought, and their caution imposes more adverse impacts on firms' operational performance and future cash flows. Nguyen et al. (2022) provide evidence that mortgage lenders demand higher interest rates on houses in regions more likely to be affected by rising sea levels.

Other studies (e.g., Herbohn et al., 2019; Jung et al., 2018) show that lending institutions impose climate risk premiums on bank loans, including stricter collateral requirements and covenant terms in debt contracting. Such premiums are aligned with the borrower's carbon and greenhouse gas emissions, as well as other aspects of its environmental performance. Further, climate finance-related literature (e.g., Dang et al., 2022; Reboredo and Ugolini, 2022; Zhu and Hou, 2022; Bolton and Kacperczyk, 2021; Balachandran and Nguyen, 2018) demonstrates that both existing and anticipated climate change–related challenges increasingly pressure corporate managers to adapt their capital structure, financing costs, and investment strategies. The pressure is particularly severe for firms operating in regions more exposed to global warming and other natural catastrophes. However, due to the lack of valid and reliable datasets, we have only a limited understanding of how individual firms' vulnerability to climate issues affect their external debt financing costs.

In practice, firms' perceptions of the impact of climate change on their operations may vary. Even if the firms operate in the same sectors and locations, managers may perceive their exposure to climate risks differently. Indeed, managers' awareness and comprehension of the potential dangers of climate change can be influenced by various factors that are not limited to whether they operate in locations vulnerable to environmental disasters. Meanwhile, the managers have a thorough understanding of the state of their firms and the severity of their exposure to climate change threats. In addition, the literature shows that companies worldwide have increasingly reported information about their awareness of and strategies for addressing any future climate threats. Prior climate and sustainable finance research have also established a connection between the climate risk information reported by firms and other corporate actions.

However, most existing environmental and climate risk reporting remains voluntary, which makes it susceptible to managerial capture, discretion, and oversight (Eliwa et al., 2021; Javadi and Masum, 2021; Matsumura et al., 2014). While environmental sustainability has become a prominent topic in the corporate realm, managers may falsify climate-related disclosure to protect their personal interests and the firm's public reputation. In response to the increasing institutional demand to improve corporate environmental performance, a firm may use its climate reporting to highlight its substantive or symbolic ecological engagement. Firms' manipulation of their environmental reporting poses a challenge for researchers who aim to reach rigorous conclusions

about the association between firms' exposure to climate risks and their cost of external debt financing.

One way for researchers to avoid relying on potentially self-serving environmental disclosures is to acquire managers' direct discursive answers to questions about climate-related risks and environmental challenges. Following Sautner et al. (2023), we examine corporate earnings conference calls. These calls allow stakeholders to question top managers about the climate and environmental issues confronting their firms and ask how they have prepared for the potential opportunities, regulatory risks, and physical risks associated with climate change. Typically, these stakeholders include primary and minority shareholders as well as other groups concerned about the firm's operations, such as institutional investors, professional financial analysts, the mass media, and debtholders or creditors such as lending institutions (Larcker and Zakolyukina, 2012; Brown et al., 2004). Therefore, the transcripts of conference calls, which are available to the public immediately after the event, contain valuable information about the managers' spontaneous responses to climate issues (Bowen et al., 2002; Matsumoto et al., 2011). Such responses can be seen as more reliable indicators of the extent to which individual firms are exposed to climate issues. Therefore, the managerial discourse regarding climate risks can help debtholders evaluate the firms' capacity and intent to comply with debt contracting requirements. If creditors have more useful "hard" and "soft" information about a firm's climate risk exposure, they may become more confident in assessing the likelihood of default due to cash flow shortage induced by the adverse consequences of climate change–related risks (Fields et al., 2012).

According to Sautner et al. (2023), climate change may allow companies to innovate and gain a competitive edge as "the firstcomers". However, to capitalise on any opportunity, businesses must make long-term investments, such as installing environmentally friendly assets, promoting green innovation, and fostering a corporate culture that supports sustainable development. In addition, complying with climate and environmental regulation (e.g., mandatory CSR reporting) can increase operational costs and fixed expenses by compelling businesses to adopt more eco-friendly, sustainable manufacturing and production. Moreover, physical risks triggered by climate change can directly affect a firm's everyday operations and production activities or even abruptly destroy them. All three hazards associated with worsening climate change can affect a company's regular operations and production, reduce short-term cash flows, and increase the likelihood of financial trouble and default risk. These potential negative repercussions may influence the lenders'

evaluation of the borrowers' capacity and willingness to fulfil their debt obligations, resulting in a higher cost of debt. Accordingly, we propose the following hypothesis in alternative form:

H_1: A significant and positive association exists between firm-level climate change exposure and corporate cost of debt.

Next, we explore how regional financial development and credit availability (or credit supply) influence the relationship between a firm's exposure to climate change risks and its debt financing costs. The financial development index of the International Monetary Fund (IMF) uses criteria such as market size and liquidity, the accessibility of financial services for individuals and companies, and the efficiency of institutions in delivering these services affordably. A higher index suggests that financial institutions (like banks and insurance companies) and markets (including stock and bond markets) are more effective. This efficiency results from their improved access to crucial information about a firm's operations and prospects, as well as their enhanced capability to process this information. Essentially, greater financial development can help ease credit supply to companies by reducing information asymmetries between insiders and outsiders and by diminishing firms' financial constraints, as noted by Greenwood et al. (2010), Saci et al. (2009), and Beck et al. (2008).

Numerous studies have examined the effects of financial development and credit supply on corporate financing practices (Rajan and Zingales, 1998; Fisman and Love, 2003; Ge and Qiu, 2007; Yang et al., 2022), investments in capital expenditures (e.g., Cingano et al., 2016; Amiti and Weinstein, 2018), and firm productivity (e.g., Manaresi and Pierri, 2019). These studies typically find that firms in regions with well-developed financial markets, which have high financial development and credit supply, benefit from lower external financing costs. Thus, firms have an incentive to fund their operations through external means, such as bank loans or equity offerings (e.g., issuing shares) (Rajan and Zingales, 1998; Fisman and Love, 2003; Ge and Qiu, 2007). More recent research links financial development and credit supply with sustainability and ecological considerations. For instance, Accetturo et al. (2022) observe that increased credit availability boosts firms' likelihood of investing in green technologies, highlighting its potential role in fostering the green transition. Nonetheless, with escalating environmental challenges and global warming raising societal concerns, the impact of financial development and credit supply on the correlation between a firm's climate risk exposure and its debt financing costs remains uncertain.

We hypothesise that firms in countries with higher financial development typically enjoy more accessible and affordable access to external financing, as well as lower informational barriers and transaction costs (Beck et al., 2008; Yang et al., 2022). Countries with higher financial development have more sophisticated financial markets and institutions and higher credit supply. This environment likely diminishes the debt cost increases that firms highly exposed to climate change may face. Additionally, the development of financial markets and institutions tends to lower the costs of formal external financing (e.g., bank loans), which supports firm growth (Rajan and Zingales, 1998). In contrast, firms in countries with lower financial development and credit supply may struggle to access bank loans, particularly when they are more exposed to climate change risks. Consequently, these firms might be compelled to rely on alternative financing sources like trade credit (Yang et al., 2022), which are often more expensive.

H2: The observed positive association between firm-level climate change exposure and corporate debt cost is more pronounced in countries with less developed financial markets and institutions.

3. Data and Sample

We start our sample using a comprehensive list of 13,297 stocks provided by Sautner et al. (2023)[6] from 2001 to 2020. We avoid survivorship bias by including both active and dead equities in our sample (see Eliwa et al., 2021). After extracting the entire sample of selected stocks, we use ISIN codes to extract firm-level data from Thompson Reuters' DataStream (TRDS), which contains data on the firm cost of debt, accounting, and governance variables from World Scope. We extract CSR/ESG and corporate carbon emissions data from Refinitiv Eikon (formerly ASSET4). After obtaining a complete set of firm-level accounting data, we match it with firm-level climate change exposure data by Sautner et al. (2023).

Our initial sample includes 13,297 listed firms from 63 countries. We employ the GDP growth rate using a two-digit ISO country code for each nation to control for macroeconomic factors. The data on country-level GDP growth are from WDIs-WB.[7] The multidimensional financial development and sub-index data for credit supplies are from the Financial Development Database of the International Monetary Fund (FD-IMF).[8] Following the literature on corporate finance (e.g.,

[6] https://osf.io/fd6jq/
[7] We accessed World Development Indicators data by the World Bank (WDIs-WB) via https://datatopics.worldbank.org/world-development-indicators/
[8] IMF Data Home Page - At a Glance - IMF Data

Gillan et al., 2021; Trinh et al., 2021), we remove financial firms with SIC codes 6000-6999. We matched our sample with FD-IMF using the International Organization for Standardization ISO Alpha-3 digit[9] and filter for European countries only.[10] Our final firm-level sample for the European economies includes 10,322 firm-year observations for the descriptive statistics corresponding to our main regression models.[11]

4. Empirical Model

To examine the impacts of firm-level climate change exposure on corporate cost of debt, we employ the following baseline regression estimation:

$$Cost\ of\ Debt\ _{i,t} = \alpha + \beta_1 CCExposure_{i,t} + \beta_2 CGs_{i,t} + \beta_3 FCs_{i,t} + \beta_4 GDPg_{i,t} + \gamma + \tau + \varepsilon \quad (1)$$

where i, t indicate firm i at time t for firm-year panel data. $Cost\ of\ Debt\ _{i,t}$ represents a firm's cost of debt, which is measured by a firm's interest expense on debt, which captures the employment of the firm's capital for a service charge before its interest-reduced capitalisation. We include the firm's interest expense on short-term and long-term debt, capitalised lease obligations, and amortization expense associated with debt issuance by the firm. This measure has been widely used in previous studies related to corporate debt costs (e.g., Eliwa et al., 2021; Regenburg and Seitz, 2021). $CCExposure_{i,t}$ represents the firm-level climate risk exposure (Sautner et al., 2023), which includes a proxy for overall firm-level climate risk exposure (*CCExposure*) and its components, including firm-level climate risk exposure for opportunity ($CCExposure^{Op}$), regulatory ($CCExposure^{Reg}$), and physical ($CCExposure^{Phy}$) shocks. *CCExposure* measures the frequency of the specified climate change bigrams appearing in a given conference call transcript. $CCExposure^{Op}$ restricts the bigrams to the new (green) technologies such as "nuclear renewable", "pv panel", and "carbon free" and the word combinations linked to developments in "electric vehicles", including "charge infrastructure" and "battery electric". $CCExposure^{Reg}$ restricts the bigrams to the regulatory exposure such as "carbon tax", "air pollution", and "air quality", as well

[9] ISO - International Organization for Standardization

[10] We exclude Israel from the EU sample.

[11] The accounting data are unequally spaced for all the sample firms; for instance, the cost of debt variable has 117,341 observations, while the firm-level climate exposure risk variables have 88,818 observations. Major financial variables have 146,000 observations for firm size, leverage, market-to-book ratio, EBIT, and operating income. Our variables on corporate governance have 245,388 observations for the entire sample.

as "regulation" or its synonyms, such as "epa regulation" "control regulation" "energy regulatory" and "environmental standard". Likewise, $CCExposure^{Phy}$ restricts the bigrams to the physical aspects of climate change such as "natural hazard" or "sea level", and word pairs such as "island coastal" "hurricane ice" or "large desalination".

Regarding the control factors, we select variables that can potentially affect firm-level climate change exposure. $CGs_{i,t}$ represents corporate governance variables including *Chair-CEO Duality*, *Audit Committee*, and *Environmental Disclosure*. $FCs_{i,c,t}$ represents financial controls commonly used in the stream of finance literature, including *LnAssets*, *Debt/Equity*, *Market to Book*, *Cash/Assets*, *EBIT/Interest*, *PPE/Assets*, and *Operating Income Growth*. We further include *IFRS* and *EPSI* in our empirical models. *IFRS* is a dummy variable taking the value of one if the firm follows the international financial reporting standard, and zero otherwise. *EPSI* is the OECD Environmental Policy Stringency Index[12], which focuses on climate change and air pollution mitigation policies (Kruse et al., 2022; Botta and Kozluk, 2014). Finally, *GDP Growth* represented by $GDPg_{i,t}$ in model (1) is included to capture differences in economic development across countries. Appendix 1 presents detailed definitions and measurements of all variables. We also include year- and country-fixed effects as γ and τ in Eq. (1).

5. Results

5.1. Descriptive Statistics

Tables 1 and 2 present the sample descriptive statistics and correlation matrix. Table 1 shows that the mean (standard deviation) of corporate cost of debt is 0.065 (0.118). The mean (standard deviation) *CCExposure* is 1.381 (2.513), while those of the alternative measures $CCExposure^{Op}$, $CCExposure^{Reg}$, and $CCExposure^{Phy}$ are 0.564 (1.303), 0.082 (0.228), and 0.011 (0.050), respectively. Regarding control variables, we find that on average 18.5% of total firm-year observations have a CEO who is also the chair, 78.3% of total firm-year observations include an audit committee, and 96.6% of total firm-year observations disclose environmental information. Table 2 shows no serious multicollinearity problem, evidenced by low coefficients between pairs of independent variables (<0.8), and low unreported variance inflation factors (VIFs).

[Insert Table 1 & 2]

[12] For more details, see the OECD website: https://www.oecd-ilibrary.org/economics/measuring-environmental-policy-stringency-in-oecd-countries_90ab82e8-en

5.2. Firm-Level Climate Change Exposure and Corporate Cost of Debt

Table 3 (columns 1-4) reports the regression results on the association between four alternative measures of firm-level climate change exposure (i.e., *CCExposure*, $CCExposure^{Op}$, $CCExposure^{Reg}$, and $CCExposure^{Phy}$) and corporate cost of debt (*Cost of Debt*). We find a positive association, which implies that firms with higher exposure to climate change have higher cost of debt.[13] Economically, a 1% increase in *CCExposure* leads to a 0.975% increase in the corporate cost of debt presented in Eq. (1) for the overall firm-level climate risk exposure. The findings are robust and suggest even more extreme impacts: the predicted coefficients are 1.532% and 6.853% for climate risk exposure related to opportunities and regulatory shocks, respectively. However, we find insignificant results for $CCExposure^{Phy}$. Our baseline results show that firm-level climate risk exposure measures that consider cross-section and time-series variations are aligned with increases in the corporate cost of debt. These results reflect the economic costs of climate risks incurred by the sample firms. The signs of the control variables align with those of previous studies.

[Insert Table 3]

5.3. The Role of Financial Development and Credit Supplies

In this section, we extend the literature on climate change exposure by investigating the role of financial development and credit supply in the association between climate exposure and corporate debt costs. We use the subsample tests to examine hypothesis 2. Our goal is to overcome the problem in the past literature of attempting to capture complex financial development with a single proxy (e.g., Bena & Ondko, 2012; Liberti and Mian, 2010; Lei et al., 2018). To that end, we employ a new broad-based multidimensional financial development index (Svirydzenka, 2016[14]; Čihák et al., 2012): (1) the overall financial development pyramid (*Fin_dev*) and (2) the financial institutions depth index specifically designed to capture credit supplies (*Cre_supplies*). First, the overall measure of *the financial development index* (*Fin_dev*) is multidimensionally constructed by (1) the financial institutions (FI) sub-index [including *FI Depth (FID), FI Access (FIA),* and *FI Efficiency (FIE)*] and (2) financial markets (FM) sub-index [including *FM Depth (FMD), FM*

[13] The F test statistic with our p-value = 0.000 shows that our overall results are significant. In other words, our linear regression model better fits the data than a model that contains no independent variables.

[14] For more details, see this IMF Working Paper: https://www.imf.org/en/Publications/WP/Issues/2016/12/31/Introducing-a-New-Broad-based-Index-of-Financial-Development-43621

Access (FMA), and *FM Efficiency (FME)*]. This measure assesses how developed financial markets are overall. Second, the financial institutions depth focuses only on the financial institution development index (proxied by *Cre_supplies*[15] because it better reflects the financial institution's depth, such as the ratios of private sector credit to GDP, pension fund assets to GDP, mutual fund assets to GDP, and insurance premiums to GDP).

Table 4 reports the results of the association between climate change exposure and corporate cost of debt conditioning on the levels of financial development and credit supplies. In Panels A and B, firms located in countries with low and high levels of financial development are those with *Fin_dev* below and above the median values, respectively. In Panels C and D, firms located in countries with low and high levels of credit supplies are those with *Cre_supplies* below and above the median values, respectively. We find that our main findings reported in Table 3 are more pronounced in the subsamples of countries with lower financial development and credit supply levels. This result implies that although firms with greater exposure to climate change have higher debt costs, their debt costs could be lower in countries with higher financial development and credit supply levels. Our results suggest the important effect of financial development on the association between climate risks and corporate lending activities.

[Insert Table 4]

6. Channel Analysis

6.1. Carbon Intensity, Climate Change Exposure and Corporate Cost of Debt

We begin our channel analysis by testing the impact of carbon intensity (risk) on the association between firm-level climate change exposure and corporate cost of debt. To do so, we use the median values of carbon intensity as the cut-off to classify high (median value or greater) and low (less than the median value) carbon-intensity firms. In addition, we use quantile analysis to rank extremely high carbon-intensity firms (Quantile 4) and extremely low carbon-intensity firms (Quantile 1). We use three alternative measures of carbon intensity risk for the sensitivity check: *Carbon Risk 1* (i.e., the natural logarithm of CO_2 emissions), *Carbon Risk 2* (i.e., CO_2 emissions scaled by income), and *Carbon Risk 3* (i.e., CO_2 emissions scaled by total assets).

Panels A-D of Table 5 present the levels of carbon intensity for high, low, extremely high, and

[15] In unreported tests, we examine all other subindices and find consistent results.

extremely low carbon-intensity firms, respectively. This channel analysis by carbon intensity further contributes to our baseline results in Table 3, showing that the higher the carbon intensity level, the greater the debt cost that firms with climate change exposure must pay. Indeed, extremely high carbon-intensity firms incur the most significant increases in the cost of debt financing, with the estimated coefficients ranging from 1.368% to 1.52% for the extremely high carbon-intensity firms in Panel C. For the higher carbon-intensity level, firms with higher climate change exposure must pay a higher cost of debt of 1.037%-1.572% across our carbon intensity measures. Interestingly, we generally find insignificant impacts of climate change exposure on a firm's cost of debt in the samples of low carbon-intensity firms (except the model of *Carbon Risk 2*, with weak significance level) and extremely low carbon-intensity firms. This suggests the critical role of carbon intensity in the positive link between firm-level climate change exposure and the cost of debt. The findings imply that climate policies and regulations should encourage firms with higher carbon-intensity level to become greener; otherwise, the firms' cost of debt financing will be higher.

[Insert Table 5]

6.2. The Effects of ES Disclosure

Table 6 reports the results on the moderating effect of environmental and social (ES) disclosure on the association between climate change exposure and corporate cost of debt. The moderating variable is measured by ES disclosure (see Li et al., 2023). Firms with high ES disclosure (*HighES_Disc*) are those whose ES ratings[16] are equal to or above the mean value. We then interact *HighES_Disc* with each measure of climate change exposure. The results are presented in Table 6. We find a positive and significant association between the interaction terms (Models 1-3) and corporate debt cost. This implies that our main results are more pronounced in firms with high ES disclosure, perhaps because debtholders are influenced by the ES activities disclosed by firms exposed to increased climate change.

Economically, debtholders are more sensitive to firms with high ES disclosure and climate exposure, with a predicted 1.569% (Model 1) increase in the cost of debt. The results are economically meaningful, with statistically significant coefficients for the interaction terms (except in Model 4). These findings highlight that given a minor change in climate-related shocks,

[16] This variable is sourced from the Refinitiv ESG database. We exclude the 'G' (governance) component because governance is generally considered irrelevant to firms' CSR activities (Li et al., 2023; Lins et al., 2017).

firms with high ES disclosure may moderate their cost of debt financing more actively because they are more sensitive to climate-driven factors than firms with low ES disclosure.

[Insert Table 6]

6.3. The Effects of Financial Constraints

We further investigate the possible impacts of financial constraints on the relationship between climate change exposure and a firm's cost of debt. We measure financial constraints using the size-age (*SA* Index) and the Whited-Wu index (*WW* Index). The results are reported in Table 7 (Panels A and B, respectively). The positive association between *CCExposure* and *Cost of Debt* is more pronounced in financially constrained (above median) firms than in their financially unconstrained (below median) peers. This outcome suggests that financial constraints or the difficulties businesses face in accessing affordable financing sources negatively impact lenders' assessments of climate change exposure. In other words, under existing financial constraints, lenders may penalise firms more severely if they experience a high level of exposure to climate change. Economically, given a 1% increase in *CCExposure*, firms with higher financial constraints tend to increase their cost of debt by 1.132% and 0.875%, as measured by the *SA* and *WW* indexes, respectively.

[Insert Table 7]

7. Endogeneity Treatments and Robustness Checks

7.1. Using One-Year Lagged Values of Firm-Level Climate Change Exposure

The relationship between climate change exposure and the cost of debt can be causal, and the two variables may influence each other at the same time. For example, firms with a higher cost of debt may also exhibit higher climate change exposure. Thus, we first address such simultaneity issues by retesting our main model (Eq. 1) while using one-year lagged values of firm-level climate change exposure and control variables. The results are reported in Table 8. The impacts of climate change exposure on the cost of debt are likely to last longer (at least one year) across the three alternative measures of exposure (i.e., broad exposure and its components, including exposure

related to regulatory and opportunity shocks). In other words, our main findings remain the same after we address the simultaneity issue.

[Insert Table 8]

7.2. Difference-in-Difference Regression Using PSM Sample

Using lagged values cannot fully address the endogeneity that may exist in the empirical models. Therefore, following Nguyen and Phan (2020), we employ a quasi-experimental design involving difference-in-differences (DiD) regressions using a PSM (propensity score matching) sample intended to tackle endogeneity issues. Our DiD estimation is as follows:

$$\text{Cost of debt}_{i,t} = \alpha + \beta_1 Treated^{High\ CCExp} * Post2015 + \beta_2 Treated^{High\ CCExp} + \beta_3 Post2015 + \beta_k \sum_{i=0}^{n} Controls_{i,t} + \varepsilon \quad (2)$$

Following the stream of recent literature on empirical finance, corporate sustainability, and climate finance (Phung et al., 2022; Trinh et al., 2021; Nguyen and Phan, 2020), we present our standard DiD estimation model with PSM in Eq. (2). $Treated^{High\ CCExp}$ represents firms with a higher level of climate change exposure (the treated group) and is set equal to 1 if a firm belongs to the treated group and 0 otherwise. We use the Paris Agreement in 2015, also known as COP21, as the exogenous event to firms' climate exposure intensity. COP21 is one of the most prominent global events highlighting the negative impact of irresponsible corporate economic activities on the natural environment and human society. COP21 is an exogenous event used in the recent corporate finance literature on ESG/CSR practices and climate issues (e.g., Gillan et al., 2021; Phung et al., 2022). After COP21, we expect that investors, market participants, shareholders, debtholders, and firm managers across the globe have become more concerned with the current operating models of companies that contribute to climate change and global warming. Thus, treated firms, which have higher levels of climate change exposure, may be associated with greater debtholder concerns following the exogenous shock in 2015. $Post2015$ is a dummy that is set equal to 1 if the firm-year observation belongs to the post-2015 period and 0 otherwise. We present *Treated* and *Post2015* dummies with their interactions as $Treated^{High\ CCExp} * Post2015$. Controlling for the same set of control variables as in Eq. (1), we apply four matching procedures with 1:1 matching without replacement, 1:1 matching with replacement, nearest neighbour (n=2)

matching, and nearest neighbour (n=3) matching. The results of these procedures are presented in Panels A-D of Table 9, respectively. The results on the interaction terms across most models confirm the positive relationship between climate change exposure and the corporate cost of debt following COP21.

[Insert Table 9]

7.3. Alternative Measures of Corporate Cost of Debt

We further test the findings for robustness by employing an alternative measure of the cost of debt: *Interest*. The results are reported in Table 10. We find that the positive relationship between climate change exposure and the cost of debt remains about the same. This finding implies that debtholders tend to punish the companies with higher levels of climate change exposure, as they are concerned about the effects of such significant environmental risks. Interestingly, we also observe a positive link between climate change exposure and the cost of debt when we use the firm-level climate risk exposure for regulatory shock ($CCExposure^{Reg}$). $CCExposure^{Reg}$ restricts the bigrams to regulatory exposure such as "carbon tax", "air pollution", and "air quality", as well as "regulation" or its synonyms, such as "epa regulation", "control regulation", "energy regulatory", and "environmental standard". Thus, the results suggest that debtholders are more concerned about the risks related to regulatory changes that firms are exposed to.

[Insert Table 10]

7.4. The Effects of Firm-Level Climate Change Sentiment and Climate Change Risk

In additional tests, we use climate change sentiment and climate change risk as alternative proxies for a firm-level climate change exposure (see Sautner et al., 2023). *CCSentiment* refers to the frequency of bigrams after we condition on the presence of the positive (+) and negative (-) tone words in Loughran and McDonald (2011). *CCRisk* refers to the relative frequency of bigrams that appear in the sentences with words such as "risk", "uncertainty", and their synonyms.

We report these results in Tables 11 and 12. Table 11 shows regression results for models using *CCSentiment*, $CCSentiment^{Op}$, $CCSentiment^{Reg}$, and $CCSentiment^{Phy}$ as the independent variables. We find an insignificant and positive association between climate change sentiment and a firm's cost of debt. However, we generally find positive and negative results when we classify sentiment into positive and negative tone words used in the conference calls. In Table 12, we test how firm-

level climate change risk affects the corporate cost of debt. We find significant and positive links for all types of exposure except for opportunity-related exposure ($CCRisk^{Op}$). This outcome implies that debtholders are more likely to make their lending decisions by considering climate change exposure and risk than by considering general sentiment. However, this finding does not mean they ignore the climate change sentiment; in our sample, such risk may simply be more difficult to evaluate.

[Insert Table 11]

[Insert Table 12]

8. Concluding remarks

Using a European sample of 10,322 firm-year observations, we find a positive relationship between firm-level climate change exposure and the cost of debt financing for corporations. This result suggests that firms exposed to greater climate change are more likely to be charged more by their creditors. We find this result only for the subsample of countries with low financial development and low credit supply levels, which underscores the importance of financial development on the association between climate risks and corporate lending activities.

We next investigate the channels by which corporate debt costs are associated with a firm's exposure to climate risks. The findings reveal that firms with higher carbon intensity have a higher debt financing cost, indicating that carbon intensity plays a significant role in the observed relationship between firm-level climate risk exposure and debt cost. The findings also show that debtholders penalise companies with higher ES disclosure that are exposed to greater levels of climate change exposure. This outcome may indicate that lenders suspect "greenwashing" by the managers of firms exposed to climate risk. Prudent creditors are more cautious (exhibit less trust) about good news coming from debtors.

In addition, we test the moderation effects of financial constraints to confirm that the positive linkage between climate risk exposure and corporate debt cost is more pronounced in financially constrained firms than in their financially unconstrained peers. With such financial constraints, a company with a high level of climate risk exposure cannot negotiate better borrowing terms with its debtholders, as debtholders tend to penalise firms with a high level of exposure to climate risk. Our primary findings are consistent across various model specifications and sensitivity tests.

Finally, we find that the debtholders are more likely to make their lending decisions by considering climate change exposure and risk than general sentiment.

Our study offers several important policy implications for regulators, corporate managers, and lending institutions in the era of decarbonisation. Government and regulators must continue constructing favourable institutions and policies to encourage firms to pursue environmental innovations for sustainable development. In the absence of such policies, firm managers may find that maintaining costly long-term environmental investment is too challenging because it causes short-term cash flow shortages and restricted access to financing. In addition, the debt market appears to be concerned about firms' exposure to climate change, which may lead to a shortage of revenue and working capital. Lenders appear to incorporate this risk factor into their lending decisions (i.e., by charging higher interest rates) to protect themselves should liquidity and default risks occur. Last but not least, although environmental sustainability reporting remains largely voluntary, firm executives should improve their firms' transparency and accountability for mitigating climate change.

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Table 1:

Descriptive Statistics					
Variable	Obs	Mean	Std. dev.	Min	Max
Cost of Debt	10,322	0.065	0.118	0.001	1.201
CCExposure	10,322	1.381	2.513	0.000	13.984
$CCExposure^{Op}$	10,322	0.564	1.303	0.000	7.433
$CCExposure^{Reg}$	10,322	0.082	0.228	0.000	1.392
$CCExposure^{Phy}$	10,322	0.011	0.050	0.000	0.351
Chair-CEO Duality	10,322	0.185	0.388	0.000	1.000
Audit Committee	10,322	0.783	0.412	0.000	1.000
Environmental disclosure	10,322	0.966	0.181	0.000	1.000
LnAssets	10,322	15.293	1.693	9.083	18.714
Debt/Equity	10,322	1.031	1.402	0.000	10.827
Market to Book	10,322	0.030	0.033	0.000	0.246
Cash/Assets	10,322	0.046	0.046	0.000	0.274
EBIT/Interest	10,322	19.777	101.957	-729.000	856.959
PPE/Assets	10,322	0.277	0.219	0.002	0.883
Operating Income Growth	10,322	0.029	1.591	-9.474	10.123
IFRS	10,322	0.902	0.298	0.000	1.000
EPSI	10,322	3.275	0.615	0.472	4.556
GDP Growth	10,322	0.873	2.964	-9.270	6.102

This table reports the descriptive statistics of all variables. Appendix A presents all detailed description of variables.

Table 2:
Correlation Matrix

		[1]	[2]	[3]	4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]
1.	*CCExposure*	1																
2.	$CCExposure^{Op}$	0.90***	1															
3.	$CCExposure^{Reg}$	0.53***	0.38***	1														
4.	$CCExposure^{Phy}$	0.14***	0.07***	0.09***	1													
5.	Chair-CEO Duality	0.02*	0.02*	0.01	0.02***	1												
6.	Audit Committee	0.08***	0.06***	0.09***	0.02**	0.39***	1											
7.	Environmental disclosure	0.08***	0.07***	0.05***	0.02*	-0.08***	-0.18***	1										
8.	LnAssets	0.17***	0.1**	0.14***	0.06***	0.26***	0.55***	-0.00	1									
9.	Debt/Equity	0.05***	0.05***	0.02**	0.01	0.01**	0.02***	-0.00	0.17***	1								

10.	Market to Book	-0.10***	-0.09***	-0.07***	-0.04***	-0.01*	0	-0.04***	-0.22***	1							
11.	Cash/ Assets	0.05***	0.06***	0.02**	0.02**	0	-0.11***	0	1	-0.07***	-0.04***	1					
12.	EBIT/Interest	-0.02**	-0.02**	-0.02**	0	0.02***	0.06***	1	0.06***	-0.09***	-0.06***	-0.07***	1				
13.	PPE/Assets	0.22***	0.17***	0.17***	0***	1	0.18***	0.02***	0.17***	-0.14***	-0.19***	0.01*	0	1			
14.	Operating Income Growth	-0.02**	-0.02**	-0.02*	0	-0.02	0.01	0.02***	0.01	-0.03***	1	-0.01*	0.02	-0.01	1		
		0.07***	0.06***	0.06***	0.01	0.08***	0.27***	0.07***	0.12***	0.01	-0.01*	-0.08***	0.03***	-0.07***	0.01*	1	
15.	IFRS	0.03***	0.04***	0.04***	-0.00	0.02***	0.23***	0.04***	0.02***	-0.00	-0.01*	-0.18***	0.01*	-0.17***	0.03***	0.53***	1
16.	EPSI				0					0.02***	0.01*	0.01***	-0.01*	0.18***	0.01*		
17.	GDP Growth	-0.08***	-0.07***	-0.02***	-0.01	-0.06***	0.13***	-0.02***	-0.07***	-0.06***	0.08***	-0.03***	0.03***	-0.01	0.05***	-0.18***	-0.25***

This table reports the correlation matrix among all independent variables. Appendix A presents all detailed description of variables. P-values are reported in square brackets. * denotes 5% significance level.* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3:
Firm-level ***Climate Change Exposure*** and Corporate Cost of Debt

VARIABLES	[1] Cost of Debt	[2] Cost of Debt	[3] Cost of Debt	[4] Cost of Debt
CCExposure	0.975**			
	[0.023]			
CCExposure^{Op}		1.532*		
		[0.066]		
CCExposure^{Reg}			6.853***	
			[0.006]	
CCExposure^{Phy}				10.520
				[0.615]
Chair-CEO Duality	0.002	0.002	0.002	0.002
	[0.488]	[0.505]	[0.527]	[0.558]
Audit Committee	-0.003	-0.003	-0.003	-0.003
	[0.217]	[0.224]	[0.222]	[0.227]
Environmental disclosure	0.007	0.007	0.007	0.008
	[0.314]	[0.305]	[0.306]	[0.293]
LnAssets	-0.012***	-0.012***	-0.012***	-0.012***
	[0.000]	[0.000]	[0.000]	[0.000]
Debt/Equity	-0.003***	-0.003***	-0.003***	-0.003***
	[0.000]	[0.000]	[0.000]	[0.000]
Market to Book	-0.028	-0.028	-0.029	-0.029
	[0.481]	[0.475]	[0.467]	[0.462]
Cash/Assets	-0.370***	-0.369***	-0.368***	-0.367***
	[0.000]	[0.000]	[0.000]	[0.000]
EBIT/Interest	0.000***	0.000***	0.000***	0.000***
	[0.001]	[0.001]	[0.001]	[0.001]
PPE/Assets	-0.040***	-0.039***	-0.038***	-0.038***

	[0.000]	[0.000]	[0.000]	[0.000]
Operating Income Growth	0.000	0.000	0.000	0.000
	[0.950]	[0.957]	[0.959]	[0.965]
IFRS	-0.022***	-0.022***	-0.022***	-0.022***
	[0.004]	[0.004]	[0.004]	[0.004]
EPSI	0.015***	0.015***	0.015***	0.015***
	[0.002]	[0.002]	[0.002]	[0.002]
GDP Growth	-0.001	-0.001	-0.001	-0.001
	[0.211]	[0.209]	[0.211]	[0.202]
Year FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Constant	0.278***	0.277***	0.278***	0.276***
	[0.000]	[0.000]	[0.000]	[0.000]
Observations	10,322	10,322	10,322	10,322
R-squared	0.092	0.092	0.092	0.092
F-test (p-value)	0.000***	0.000***	0.000***	0.000***

This table reports the results of the association between climage change exposure and corporate cost of debt. Dependent variable is the firm *Cost of Debt*, measured by the interest expense on debt. Independent variables include alternative measures of firm-level climate risk exposure by Sautner et al. (2023). Control variables include corporate governance, firm characteristics and country characteristics. All regression models also control for year and country fixed effects. Appendix A presents all detailed description of variables. P-values are reported in square brackets. ***, ** and * denotes 1%, 5% and 10% significance levels.

Table 4:
Climate Change Exposure and Corporate Cost of Debt: The Effect of Financial Development and Credit Supplies

	Panel A: Low level of financial development				Panel B: High level of financial development			
VARIABLES	[1] Cost of Debt	[2] Cost of Debt	[3] Cost of Debt	[4] Cost of Debt	[5] Cost of Debt	[6] Cost of Debt	[7] Cost of Debt	[8] Cost of Debt
CCExposure	1.303**				0.244			
	[0.031]				[0.766]			
CCExposure^{Op}		2.510**				-0.489		
		[0.040]				[0.588]		
CCExposure^{Reg}			10.307***				0.835	
			[0.001]				[0.844]	
CCExposure^{Phy}				17.872				-3.272
				[0.491]				[0.933]
Year/Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.258***	0.257***	0.259***	0.255***	0.351***	0.349***	0.350***	0.350***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.006]	[0.000]	[0.000]	[0.006]
Observations	6,441	6,441	6,441	6,441	3,881	3,881	3,881	3,881
R-squared	0.106	0.106	0.106	0.106	0.082	0.082	0.082	0.082
F-test (p-value)	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
	Panel C: Low level of credit supplies				Panel D: High level of credit supplies			
VARIABLES	[1] Cost of Debt	[2] Cost of Debt	[3] Cost of Debt	[4] Cost of Debt	[5] Cost of Debt	[6] Cost of Debt	[7] Cost of Debt	[8] Cost of Debt
CCExposure	1.855***				0.047			
	[0.008]				[0.917]			
CCExposure^{Op}		3.006**				-0.174		
		[0.018]				[0.829]		
CCExposure^{Reg}			15.915***				0.417	
			[0.000]				[0.903]	
CCExposure^{Phy}				23.084				-3.433

				[0.506]				[0.890]
Year/Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.304***	0.301***	0.304***	0.295***	0.291***	0.291***	0.291***	0.291***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Observations	4,833	4,833	4,833	4,833	5,489	5,489	5,489	5,489
R-squared	0.124	0.124	0.123	0.123	0.074	0.074	0.074	0.074
F-test (p-value)	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***

This table reports the results of the association between climage change exposure and corporate cost of debt conditioning on the levels of financial development and credit supplies. In Panel A and B, firms located in low and high level of financial development are those with Fin_dev below and above the median values, respectively. In Panel C and D, firms located in low and high level of credit supplies are those with Cre_supplies below and above the median values, respectively. Control variables include corporate governance, firm characteristics and country characteristics. All regression models also control for year and country fixed effects. Appendix A presents all detailed description of variables. P-values are reported in square brackets. ***, ** and * denotes 1%, 5% and 10% significance levels.

Table 5:
Carbon Intensity, Climate Change Exposure and Corporate Cost of Debt

	Panel A: High Carbon Intensity Firms			Panel A: Low Carbon Intensity Firms		
	Carbon Risk 1 >= Median	*Carbon Risk 2 >= Median*	*Carbon Risk 3 >= Median*	*Carbon Risk 1 < Median*	*Carbon Risk 2 < Median*	*Carbon Risk 3 < Median*
	[1]	[2]	[3]	[4]	[5]	[6]
VARIABLES	*Cost of Debt*	*Cost of Debt*	*Cost of Debt*	*Cost of Debt*	*Cost of Debt*	*Cost of Debt*
CCExposure	1.037**	1.492***	1.572***	-0.344	-0.353	-0.839
	[0.033]	[0.004]	[0.004]	[0.781]	[0.737]	[0.395]
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.257***	0.252***	0.263***	0.296***	0.243***	0.124*
	[0.000]	[0.000]	[0.000]	[0.001]	[0.001]	[0.073]
Observations	6,701	6,323	6,173	3,621	3,999	4,149
R-squared	0.118	0.116	0.110	0.077	0.079	0.082
F-test (p-value)	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
	Panel C: Extremely High Carbon Intensity Firms			Panel D: Extremely Low Carbon Intensity Firms		
	Carbon Risk 1 (Quantile 4)	*Carbon Risk 2 (Quantile 4)*	*Carbon Risk 3 (Quantile 4)*	*Carbon Risk 1 (Quantile 1)*	*Carbon Risk 2 (Quantile 1)*	*Carbon Risk 3 (Quantile 1)*
	[1]	[2]	[3]	[4]	[5]	[6]
VARIABLES	*Cost of Debt*	*Cost of Debt*	*Cost of Debt*	*Cost of Debt*	*Cost of Debt*	*Cost of Debt*
CCExposure	1.368**	1.520**	1.395**	-0.343	-0.037	-0.183
	[0.021]	[0.021]	[0.032]	[0.551]	[0.958]	[0.795]
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.301***	0.295***	0.294***	0.218***	0.203***	0.198***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Observations	4,589	4,373	4,345	5,733	5,949	5,977
R-squared	0.131	0.123	0.122	0.073	0.073	0.075
F-test (p-value)	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***

This table reports the results of the association between climage change exposure and corporate cost of debt conditioning on the degree of carbon intensity. In Panel A and B, high and low carbon intensity firms are those with *Carbon risk 1 (or Carbon risk 2 or Carbon risk 3)* above and below the median values, respectively. In Panel C and D, extremely high and extremely low carbon intensity firms are those with *Carbon risk 1 (or Carbon risk 2 or Carbon risk 3)* above 75th percentile (Q4) value and below 25th percentile (Q1) value, respectively. Control variables include corporate governance, firm characteristics and country characteristics. All regression models also control for year and

country fixed effects. Appendix A presents all detailed description of variables. P-values are reported in square brackets. ***, ** and * denotes 1%, 5% and 10% significance levels.

Table 6:
The Moderating Effects of Environmental and Social (ES) Disclosure

VARIABLES	[1] Cost of Debt	[2] Cost of Debt	[3] Cost of Debt	[4] Cost of Debt
CCExposure x HighES_Disc	1.569*			
	[0.095]			
CCExposure	-0.296			
	[0.716]			
CCExposure^{Op} x HighES_Disc		3.639**		
		[0.050]		
CCExposure^{Op}		-1.456		
		[0.367]		
CCExposure^{Reg} x HighES_Disc			11.499*	
			[0.053]	
CCExposure^{Reg}			-1.920	
			[0.714]	
CCExposure^{Phy} x HighES_Disc				-0.749
				[0.989]
CCExposure^{Phy}				11.066
				[0.818]
HighES_Disc	-0.002	-0.002	-0.001	0.000
	[0.553]	[0.604]	[0.770]	[0.995]
Control variables	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Constant	0.278***	0.277***	0.278***	0.276***
	[0.000]	[0.000]	[0.000]	[0.000]
Observations	10,322	10,322	10,322	10,322
R-squared	0.092	0.092	0.092	0.092
F-test (p-value)	0.000***	0.000***	0.000***	0.000***

This table reports the results of the moderating effect of Environmental and Social (ES) Disclosure on the association between climage change exposure and corporate cost of debt. Dependent variable is the firm *Cost of Debt*, measured by the interest expense on debt. Independent variables include alternative measures of firm-level climate risk exposure by Sautner et al. (2023). The moderating variable is measured by the level of Environmental and Social (ES) Disclosure. Firms with high ES disclosure (*HighES_Disc*) are those whose ES ratings are equal to or above the mean value. Control variables include corporate governance, firm characteristics and country characteristics. All regression models also control for year and country fixed effects. Appendix A presents all detailed description of variables. P-values are reported in square brackets. ***, ** and * denotes 1%, 5% and 10% significance levels.

Table 7:
The Effects of Financial Constraint

	SA Index		**WW Index**	
	Financially constrained firms (>Median)	Financially unconstrained firms (<Median)	Financially constrained firms (>Median)	Financially unconstrained firms (<Median)
VARIABLES	[1] *Cost of Debt*	[2] *Cost of Debt*	[3] *Cost of Debt*	[4] *Cost of Debt*

CCExposure	1.132**	0.333	0.875*	0.159
	[0.019]	[0.734]	[0.071]	[0.492]
Control variables	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Constant	0.276***	0.319***	0.308***	0.215***
	[0.000]	[0.000]	[0.000]	[0.000]
Observations	7,108	3,214	9,559	763
R-squared	0.099	0.100	0.092	0.427
F-test (p-value)]	0.000***	0.000***	0.000***	0.000***

This table reports the regression results of the effect of climate change exposure and corporate cost of debt for subsamples of firms sorted on the level of financial constraints. Financially constrained frms are those that either size-age (*SA Index*) or Whited-Wu index (*WW Index*) is above the median value. Financially unconstrained (UC) firms are those that either size-age (*SA Index*) or Whited-Wu index (*WW Index*) is below the median value. Control variables are all included. All regression models also capture year and country fixed effects. Appendix A presents definitions and measurements of all variables. P-values are reported in square square brackets. ***, ** and * denotes 1%, 5% and 10% significance levels.

Table 8:
Using One-year Lagged Values of Firm-Level ***Climate Change Exposure***

VARIABLES	[1] Cost of Debt $_t$	[2] Cost of Debt $_t$	[3] Cost of Debt $_t$	[4] Cost of Debt $_t$
$CCExposure_{t-1}$	1.028**			
	[0.030]			
$CCExposure^{Op}_{t-1}$		1.345		
		[0.130]		
$CCExposure^{Reg}_{t-1}$			11.381***	
			[0.002]	
$CCExposure^{Phy}_{t-1}$				0.557
				[0.967]
Control variables $_{t-1}$	*Yes*	*Yes*	*Yes*	*Yes*
Year FE	*Yes*	*Yes*	*Yes*	*Yes*
Industry FE	*Yes*	*Yes*	*Yes*	*Yes*
Country FE	*Yes*	*Yes*	*Yes*	*Yes*
Constant	0.254***	0.253***	0.256***	0.251***
	[0.000]	[0.000]	[0.000]	[0.000]
Observations	9,145	9,145	9,145	9,145
R-squared	0.093	0.093	0.093	0.093
F-test (p-value)	0.000***	0.000***	0.000***	0.000***

This table reports the regression results of the effect of climate change exposure and corporate cost of debt using one-year lagged values. Control variables are all included. All regression models also capture year and country fixed effects. Appendix A presents definitions and measurements of all variables. P-values are reported in square square brackets. ***, ** and * denotes 1%, 5% and 10% significance levels.

Table 9:
Difference-in-difference Regression using PSM-matched Sample: The Paris Agreement COP 21 (2015)

	Panel A: 1:1 matching without replacement	Panel B: 1:1 matching with replacement	Panel C: Nearest neighbour (n=2)	Panel D: Nearest neighbour (n=3)
	[1]	[2]	[3]	[4]
VARIABLES	Cost of Debt	Cost of Debt	Cost of Debt	Cost of Debt
Treated $^{High\ CCExp}$ **** Post2015***	0.016**	0.017**	0.009	0.010*
	[0.019]	[0.013]	[0.175]	[0.093]
Treated $^{High\ CCExp}$	-0.014**	-0.012**	-0.007	-0.007
	[0.016]	[0.045]	[0.198]	[0.135]
Post2015	-0.028***	-0.032***	-0.023***	-0.025***
	[0.000]	[0.000]	[0.000]	[0.001]
Chair-CEO Duality	0.001	0.002	0.001	0.001
	[0.829]	[0.666]	[0.881]	[0.778]
Audit Committee	-0.006	-0.008**	-0.005	-0.005
	[0.149]	[0.047]	[0.165]	[0.314]
Environmental disclosure	0.006	0.003	0.004	0.007
	[0.687]	[0.866]	[0.812]	[0.536]
LnAssets	-0.010***	-0.010***	-0.010***	-0.010***
	[0.000]	[0.000]	[0.000]	[0.000]
Debt/Equity	-0.002**	-0.003**	-0.002**	-0.003
	[0.046]	[0.029]	[0.043]	[0.152]
Market to Book	0.147***	0.133**	0.102**	0.123
	[0.007]	[0.015]	[0.038]	[0.107]
Cash/Assets	-0.315***	-0.339***	-0.319***	-0.316***
	[0.000]	[0.000]	[0.000]	[0.000]
EBIT/Interest	-0.000	-0.000**	-0.000	-0.000
	[0.558]	[0.034]	[0.559]	[0.849]
PPE/Assets	-0.025***	-0.029***	-0.030***	-0.029***
	[0.000]	[0.000]	[0.000]	[0.002]
Operating Income Growth	0.001	0.000	-0.000	-0.001
	[0.457]	[0.946]	[0.592]	[0.320]
IFRS	-0.033***	-0.031***	-0.020**	-0.021*
	[0.000]	[0.002]	[0.022]	[0.091]
EPSI	-0.006*	-0.005	-0.008***	-0.008
	[0.050]	[0.145]	[0.006]	[0.142]
GDP Growth	0.000	0.000	0.001	0.001**
	[0.338]	[0.501]	[0.243]	[0.013]
Constant	0.291***	0.295***	0.289***	0.283***
	[0.000]	[0.000]	[0.000]	[0.000]
Observations	6,422	6,422	7,307	8,604
R-squared	0.066	0.070	0.065	0.065
F-test (p-value)	0.000***	0.000***	0.000***	0.000***

This table reports the robustness results of the difference-in-difference regression using PSM-matched sample. The exogenous shock is the Paris Agreement COP21 in 2015. Control variables are all included and lagged by one-year. Appendix A presents definitions and measurements of all variables. P-values are reported in square square brackets. ***, ** and * denotes 1%, 5% and 10% significance levels.

Table 10:
Alternative Measures of Corporate Cost of Debt

VARIABLES	[1] Interest	[2] Interest	[3] Interest	[4] Interest
CCExposure	0.348***			
	[0.010]			
CCExposure^{Op}		0.503**		
		[0.050]		
CCExposure^{Reg}			3.365**	
			[0.016]	
CCExposure^{Phy}				-5.675
				[0.300]
Control variables	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Constant	0.170***	0.170***	0.171***	0.169***
	[0.000]	[0.000]	[0.000]	[0.000]
Observations	10,129	10,129	10,129	10,129
R-squared	0.190	0.190	0.190	0.190
F-test (p-value)	0.000***	0.000***	0.000***	0.000***

This table reports the regression results of the effect of climate change exposure and corporate cost of debt using alternative measures of the latter. Control variables are all included. All regression models also capture year, industry and country fixed effects. Appendix A presents definitions and measurements of all variables. P-values are reported in square square brackets. ***, ** and * denotes 1%, 5% and 10% significance levels.

Table 11:
Firm-level ***Climate Change Sentiment*** and Corporate Cost of Debt

VARIABLES	[1] Cost of Debt	[2] Cost of Debt	[3] Cost of Debt	[4] Cost of Debt	[5] Cost of Debt	[6] Cost of Debt	[7] Cost of Debt	[8] Cost of Debt	[9] Cost of Debt	[10] Cost of Debt	[11] Cost of Debt	[12] Cost of Debt
CCSentiment	-0.416											
	[0.741]											
CCSentiment^{Op}		0.327										
		[0.907]										
CCSentiment^{Reg}			0.301									
			[0.966]									
CCSentiment^{Phy}				-5.566								
				[0.810]								
CCSentiment [+]					1.907*							
					[0.100]							
CCSentiment^{Op} [+]						2.457						
						[0.285]						
CCSentiment^{Reg} [+]							9.277					
							[0.138]					
CCSentiment^{Phy} [+]								-17.460				
								[0.437]				
CCSentiment									-			

[-]									5.425** [0.015]			
CCSentiment^{Op} [-]										-6.577* [0.097]		
CCSentiment^{Reg} [-]											-19.992** [0.020]	
CCSentiment^{Phy} [-]												21.295 [0.269]
Control variables	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Year FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Country FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Constant	0.275*** [0.000]	0.275*** [0.000]	0.275*** [0.000]	0.275*** [0.000]	0.277*** [0.000]	0.276*** [0.000]	0.276*** [0.000]	0.275*** [0.000]	0.278*** [0.000]	0.277*** [0.000]	0.277*** [0.000]	0.275*** [0.000]
Observations	10,322	10,322	10,322	10,322	10,322	10,322	10,322	10,322	10,322	10,322	10,322	10,322
R-squared	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092
F-test (p-value)	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***

This table reports the regression results of the effect of climate change sentiment and corporate cost of debt. Control variables are all included. All regression models also capture year and country fixed effects. Appendix A presents definitions and measurements of all variables. P-values are reported in square square brackets. ***, ** and * denotes 1%, 5% and 10% significance levels.

Table 12:
Firm-Level ***Climate Change Risk*** and Corporate Cost of Debt

VARIABLES	[1] Cost of Debt	[2] Cost of Debt	[3] Cost of Debt	[4] Cost of Debt
CCRisk	15.082* [0.060]			
CCRisk^{Op}		19.780 [0.127]		
CCRisk^{Reg}			69.968** [0.045]	
CCRiske^{Phy}				-
Control variables	*Yes*	*Yes*	*Yes*	*Yes*
Year FE	*Yes*	*Yes*	*Yes*	*Yes*
Country FE	*Yes*	*Yes*	*Yes*	*Yes*
Constant	0.278*** [0.000]	0.277*** [0.000]	0.276*** [0.000]	0.275*** [0.000]
Observations	10,322	10,322	10,322	10,322
R-squared	0.092	0.092	0.092	0.092
F-test (p-value)	0.000***	0.000***	0.000***	0.000***

This table reports the regression results of the effect of climate change risk and corporate cost of debt. Control variables are all included. All regression models also capture year and country fixed effects. Appendix A presents definitions and measurements of all variables. P-values are reported in square square brackets. ***, ** and * denotes 1%, 5% and 10% significance levels

Appendix A:
Variables, definitions, and sources

Variable	Definition	Source

Cost of Debt	A firm's interest expense on debt capturing the employment of the firm's capital for service charge before its interest reduced capitalization that considers the firm's interest expense on short-term, long-term debt, capitalized lease obligations and amortization expense associated with debt issuance by the firm	*World Scope - TRDS*
Interest	Estimated average interest rate, measured by Interest Expense on Debt / (Short-Term Debt & Current Portion of Long-Term Debt + Long-Term Debt) * 100.	*World Scope - TRDS*
Fin_dev	The mutidimensional financial development (FD) index capturing the development of financial institutions (FI) and markets (FM) with their depth, access, and efficiency (FID, FIA, FIE and FMD, FMA, FME).	*FD-IMF*
Cre_supplies	Financial Institutions Depth (FID) index for capturing the credit supplies to the economy including i) bank credit to the private sector in percent of GDP, ii) pension fund assets to GDP, iii) mutual fund assets to GDP, and iv) insurance premiums to GDP.	*FD-IMF*
CCExposure	Overall firm-level climate risk exposure by Sautner et al. (2023)	*Sautner et al. (2023)*
$CCExposure^{Op}$	Firm-level climate risk exposure for opportunity by Sautner et al. (2023)	*Sautner et al. (2023)*
$CCExposure^{Reg}$	Firm-level climate risk exposure for regulatory by Sautner et al. (2023)	*Sautner et al. (2023)*
$CCExposure^{Phy}$	Firm-level climate risk exposure for physical by Sautner et al. (2023)	*Sautner et al. (2023)*
Chair-CEO Duality	Dummy variable, taking the value of one if the CEO simultaneously chairs the board and zero otherwise	*World Scope - TRDS*
Audit Committee	Dummy variable, taking the value of one if the company has an audit board committee and zero otherwise	*World Scope - TRDS*
Environmental disclosure	Dummy variable, taking the value of one if the company discloses their environmental activities and zero otherwise	*World Scope - TRDS*
LnAssets	Firm size measured by log value of a firm's total assets.	*World Scope - TRDS*
Debt/Equity	Leverage measured by the ratio of the debt to equity with the following formula: Debt-to-Equity = (Long Term Debt + Short Term Debt & Current Portion of Long-Term Debt) / Common Equity * 100	*World Scope - TRDS*
Market to Book	Market value of the ordinary (common) equity divided by the balance sheet value of the ordinary (common) equity in the company	*World Scope - TRDS*
Cash/Assets	Cash over total assets	*World Scope - TRDS*
EBIT/Interest	Measured by Earnings Before Interest and Taxes / Interest Expense on Debt	*World Scope - TRDS*
PPE/Assets	Property, Plant, and Equipment over total assets	*World Scope - TRDS*
Operating Income Growth	Income ratio measured by the difference between sales and total operating expenses	*World Scope - TRDS*
IFRS	International Financial Reporting Standard	*World Scope - TRDS*
EPSI	The OECD Environmental Policy Stringency Index	*OECD*
GDP Growth	Country-level annual growth rate of a country's gross domestic product (GDP).	*WDIs-WB*

N*ote:* The World Scope - Thomson Reuters Datastream [TRDS] data is extracted using the licensed account [h.h.trinh@massey.ac.nz] offered by the School of Economics and Finance, Massey University, Private Bag 11, 222 Palmerston North, 4442, New Zealand. Financial Development: International Monetary Fund [FD-IMF] is publicly available at Financial Development IMF Data [version 2024]. Data on firm-level climate risk exposure is publicly available at https://doi.org/10.17605/OSF.IO/FD6JQ. The OECD Environmental Policy Stringency Index is extracted from OECD (2024), "Environmental Policy: Environmental Policy Stringency Index," OECD Environment Statistics (database), https://doi.org/10.1787/2bc0bb80-en. WDI-WB data is publicly available at WDI-HHome (worldbank.org).

Appendix B:
Sample Distribution by Countries and Years

	Austria	Belgium	Czech Republic	Denmark	Finland	France	Germany	Greece	Hungary	Iceland	Ireland	Italy	Luxembourg	Netherlands	Norway	Poland	Portugal	Spain	Sweden	Switzerland	United Kingdom	Freq	Percent
2001	0	1	0	0	1	2	2	0	0	0	1	1	0	0	1	0	0	0	1	1	0	11	0.11
2002	0	2	0	2	3	7	10	0	0	0	3	3	0	9	1	0	1	3	2	4	14	64	0.62
2003	6	8	1	12	9	35	45	5	1	0	7	12	3	20	1	3	3	12	23	29	59	304	2.95
2004	7	9	1	12	11	45	47	6	1	0	8	17	4	21	12	2	4	11	21	29	73	341	3.30
2005	6	9	1	12	20	47	52	4	1	1	10	19	3	23	16	2	4	12	26	35	98	401	3.88
2006	7	11	2	11	14	44	58	6	1	1	10	24	4	26	18	2	4	14	28	33	100	383	3.72
2007	7	12	1	13	27	65	59	5	1	0	11	26	4	27	20	3	5	15	29	34	119	483	4.68
2008	9	10	2	16	25	66	65	8	1	0	11	26	3	31	22	3	6	15	28	34	129	510	4.94
2009	8	8	2	17	27	63	58	9	1	0	10	26	3	28	20	3	5	16	30	32	121	497	4.81
2010	8	12	2	17	29	66	58	8	3	0	10	26	3	29	20	3	6	20	32	32	142	616	5.98

2																												5
0																											5	.
1		1		1	2	7	6				1	2		3	2			2	3	3	15	5	4
1	9	2	2	6	7	5	2	8	3	0	0	4	3	0	1	3	7	5	1	6	4	8	1
2																							5
0																						5	.
1	1	1		1	2	7	6					2		3	2			2	3	3	17	9	7
2	1	5	3	8	9	4	4	6	2	0	9	6	4	0	2	4	8	6	1	7	1	0	2
2																							4
0																						4	.
1				1	1	6	4					2		1	1			2	2	2	14	6	5
3	7	9	2	2	8	8	9	3	2	0	6	1	4	9	9	2	7	4	2	9	4	7	2
2																							4
0																						4	.
1	1			1	1	6	5					2		2	2			2	2	2	14	8	6
4	0	9	3	3	8	2	8	3	3	0	7	5	4	0	3	4	7	1	3	7	4	4	9
2																							4
0																						4	.
1		1		1	1	6	5					2		1	2			2	1	2	13	6	4
5	6	5	3	6	6	1	8	1	2	0	9	2	4	8	4	5	5	1	8	6	1	1	7
2																							4
0																						5	.
1		1		1	2	6	6				1	2		1	2			1	3	2	14	1	9
6	7	3	2	9	0	5	2	2	2	0	1	1	4	7	7	9	6	9	8	8	1	3	7
2																							7
0																						8	.
1	1	2		3	3	9	9				1	4		3	4	1		3	6	4	20	0	8
7	8	1	2	0	2	2	7	8	3	1	1	3	4	2	3	1	8	6	7	1	5	5	0
2																							8
0							1															9	.
1	2	2		3	3	9	0				1	4		3	6	1		3	9	5	21	0	8
8	0	1	4	6	5	1	9	7	3	1	2	3	5	4	3	7	8	8	2	3	6	8	0
2																							9
0							1												1			9	.
1	2	2		3	3	9	1				1	4		3	7	1		3	1	5	22	7	4
9	0	3	4	8	9	3	3	7	3	1	4	0	4	6	5	9	8	8	4	8	7	4	4
2																							9
0							1												1			9	.
2	1	2		3	3	9	2				1	4		3	7	1		3	1	5	23	8	5
0	7	6	3	9	8	1	0	6	3	1	4	0	4	8	5	6	8	6	9	9	4	7	6
																						10	
						1	1															**0**	
						,	,															**,**	
Freq	1	2		3	4	2	2	1			1	4		4	5	1	1	4	7	6		**3**	1
	8	4		4	4	2	4	0	3		8	8		8	3	1	1	0	7	5	2,6	**2**	0
	3	6	40	9	8	2	6	2	6	6	4	5	67	8	3	1	0	2	5	7	32	**2**	0

Percent	12.38	0.39	38.34	34.84	11.07	12.09	0.35	0.06	1.78	1.70	0.65	4.73	51.16	1.08	1.07	3.89	7.51	6.37	25.50		100

Appendix C:
Sample Distribution by Industries

Industry	Freq.	Percent
Basic Materials	958	9.28
Consumer Discretionary	2,092	20.27
Consumer Staples	870	8.43
Energy	595	5.76
Health Care	1,056	10.23
Industrials	2,501	24.23
Real Estate	38	0.37
Technology	733	7.10
Telecommunications	563	5.45
Utilities	474	4.59
Others	442	4.29
Total	10,322	100

Note: Regarding Refinitiv Datastream, the table reports the ICBIM - ICB Industry Mnemonic that shows the FTSE Russell Industry Classification Benchmark (ICB) Industry level classification mnemonic, the Industry classification is also available in the form of a code (ICBIC) or the name (ICBIN). Reference: https://www.lseg.com/en/ftse-russell/industry-classification-benchmark-icb?