Impact of Corporate Climate Change Performance on Information Asymmetry: International Evidence

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Impact of Corporate Climate Change Performance on Information Asymmetry: International Evidence

ABSTRACT

In this study, we examine the association between climate change performance and information asymmetry using 6,367 firm-year observations from 2011–2020 across 26 countries. We find that climate change performance is negatively associated with information asymmetry, suggesting that firms with higher climate change performance tend to have lower information asymmetry. We also find that the negative association between climate change performance and information asymmetry is stronger for firms with a higher level of institutional ownership and better corporate governance. Further analyses show a more pronounced negative association between climate change performance and information asymmetry for firms domiciled in countries with stakeholder-oriented business culture, a national emissions trading scheme (ETS) and a higher level of climate change performance. Our study's findings have significant implications for capital market participants, managers, policymakers, researchers, and practitioners worldwide in understanding the role of corporate climate change performance in the capital market.

Keywords: Climate change performance; information asymmetry; institutional investors; corporate governance; cross-country

JEL Classifications: G14; M14; M41; Q51; Q54

Data: All data used in this paper are publicly available from sources stated in the paper.

Climate change is the single greatest threat to a sustainable future but, at the same time, addressing the climate challenge presents a golden opportunity to promote prosperity, security, and a brighter future for all.

Ban Ki-Moon, Secretary-General, United Nations (2007–2016)

I. INTRODUCTION

Over the past two decades, global warming and unprecedented natural disasters have heightened public concerns about the adverse effects of climate change (Intergovernmental Panel on Climate Change [IPCC] 2018). Carbon emissions are widely recognized as a key driver of global warming and climate change, impacting both asset values and returns on assets (United Nations Environment Programme [UNEP] and World Resources Institute [WRI] 2015; Economic Intelligence Unit [EIU] 2015). For example, the EIU (2015) estimates that the potential loss of manageable assets due to climate change could range from US$4.20 trillion to US$43 trillion. Consequently, there is a growing demand for firms to reduce their carbon emissions and improve their overall climate change performance (Reid and Toffel 2009; Bose, Minnick, and Shams 2021).

The extant literature consistently demonstrates that external capital providers incorporate firms' carbon emissions and abatement initiatives into their valuations (Matsumura, Prakash, and Vera-Muñoz 2014; Clarkson, Li, Pinnuck, and Richardson 2015; Griffin, Lont, and Sun 2017; Choi and Luo, 2021; Bose et al., 2021; He, Luo, Shamsuddin and Tang 2022a). However, limited research has examined the capital market effects of climate change performance, specifically its impact on information asymmetry. Information asymmetry, a critical aspect of financial markets, affects a firm's information environment. Poor information environments lead to adverse selection, lower liquidity, market performance, and higher equity risk and cost of capital volatility, impacting firms' long-term survival and sustainability (Shroff, Sun, White and Zhang 2013). Although Schiemann and Sakhel (2018) examine the impact of the disclosure of physical climate risk on information asymmetry, and Matsumura, Prakash, and Vera-Muñoz (2024) explore the materiality of climate risk disclosures on firm risk, we focus specifically on climate change performance that drives sustainable economic transitions rather than disclosure.[2] Actual carbon management practices (performance) differ from their presentation or reporting (disclosure). Specifically, climate change performance measures the effectiveness of a firm's efforts in managing and controlling carbon emissions, reflecting tangible environmental actions and outcomes (He, Luo, Shamsuddin and Tang 2022b). In contrast, climate change disclosure involves how companies communicate their carbon management efforts, covering emissions data, strategic initiatives, targets, investments, and engagement activities. Voluntary disclosures can lead to discrepancies due to managerial discretion, and practices like greenwashing or window dressing are not uncommon. Given the asynchronous nature of climate change performance and disclosure, findings from disclosure studies cannot be directly applied to performance. This necessitates a dedicated investigation into climate change performance. Our study thus addresses this research gap by systematically examining the relationship between climate change performance and information asymmetry, providing insights into how firms' actions in addressing climate change impact information availability and quality in the capital market. This understanding is crucial for addressing climate change challenges and promoting sustainable development through capital market mechanisms.

In this study, we rely on two theoretical perspectives, namely, transparency and signaling, to predict the association between climate change performance and information asymmetry. The transparency (ethical) perspective highlights the importance of firms' climate change performance as an indicator of genuine accountability to stakeholders. Firms with superior climate change performance are expected to engage in responsible corporate actions, uphold high ethical standards, and improve overall transparency. This transparency fosters trust and positive relationships with stakeholders, including investors, thereby reducing information asymmetry. The signaling perspective, on the other hand, focuses on how climate change performance serves as a signal to investors. Firms demonstrating strong climate change performance signal proactive climate

[2] Schiemann and Sakhel (2018) examine the impact of physical risk disclosure on information asymmetry using data from 717 European firms during the period 2011–2013. Matsumura et al. (2024) investigate the materiality of climate risk disclosure in Form 10-K on firm risk, focusing on S&P 500 firms for the period 2008-2016.

strategies, superior risk management, and long-term financial viability (CDP 2020). These signals reduce information asymmetry by providing valuable insights into a firm's climate stewardship and its ability to manage associated risks and opportunities (Task Force on Climate-related Financial Disclosure [TCFD], 2017). As investors increasingly consider climate factors in their decisions, firms with superior performance may attract more favorable investor attention, further reducing information asymmetry.

To test these perspectives, we use an international sample of 6,367 firm-year observations from 2011–2020 covering 26 countries. We measure information asymmetry using the bid–ask spread and climate change performance with CDP's climate change performance ratings.[3] These ratings cover firm-level climate governance; climate change-related risk and opportunities; business strategy; climate change-related targets and performance; firms' initiatives for the reduction of carbon emissions; verification of carbon emissions; carbon pricing; and firm-level engagement with value chain partners in relation to climate change-related activities. The regression models are estimated using the ordinary least squares (OLS) regression method. Our findings show that climate change performance is negatively associated with information asymmetry, supporting both transparency and signaling perspectives. As our findings may be affected by unobservable and observable selection bias, we employ Heckman's (1979) two-stage analysis and entropy balancing analysis. To address endogeneity in our findings, we undertake quasi-experimental analysis using the 2015 Paris Agreement. We also employ firm fixed effects and country fixed effects to address omitted variable bias.

Our study next examines the moderating role of institutional investor ownership and corporate governance in the relationship between climate change performance and information asymmetry. Institutional investors play an active role in corporate governance through their external monitoring of management performance (Jensen and Meckling 1976). Prior empirical research also shows that

[3] The terms 'climate change performance ratings' and 'climate change performance scores' are used interchangeably in this paper.

good corporate governance reduces information asymmetry between firms and market participants (Kanagaretnam, Lobo, and Whalen 2007) and improves the levels of climate change disclosure (Peters and Romi 2014; Liao, Luo, and Tang 2015; Bui, Houqe, and Zaman 2020; Daradkeh, Shams, Bose, and Gunasekarage 2023). Consistent with these expectations, we find that the negative association between climate change performance and information asymmetry is more pronounced for firms with a higher level of institutional ownership and better corporate governance.

Furthermore, prior studies demonstrate that country-level factors play a crucial role in shaping the institutional context in which firms operate. These factors can incentivize firms to engage in climate change performance and to transparently disclose their actions and performance (Luo 2019; Luo and Wu 2019). Therefore, we examine how these country-level factors interact with corporate climate change performance to have an impact on information asymmetry. We specifically focus on three key country-level factors: country-level business culture, a national emissions trading scheme (ETS), and overall climate change performance. The results reveal that the negative association between climate change performance and information asymmetry is more pronounced for firms in countries with a stakeholder-oriented business culture, a national emissions trading scheme (ETS) and a higher level of climate change performance.

The findings of this study contribute to the literature in several ways. Firstly, our study adds to the literature on the capital market consequences of corporate climate change practices. Unlike previous studies that focus on the value relevance of carbon emissions in specific contexts such as the United States (US), Canada, Australia and European Union (EU) countries (e.g., Matsumura et al. 2014; Clarkson et al. 2015; Griffin et al. 2017; Choi and Luo 2021), we systematically explore the impact of climate change performance on information asymmetry. While Schiemann and Sakhel (2018) focus on information asymmetry related to climate change-related physical risk disclosure, we shift the focus to corporate climate change performance. By linking firms' comprehensive climate change performance to information asymmetry, our research provides a unique contribution to understanding the impact of environmental practices on market transparency in the context of evolving regulatory standards. Our study also addresses calls from the TCFD and accounting regulators for a deeper understanding of corporate climate change responses (e.g., Australian Accounting Standards Board [AASB] and Auditing and Assurance Standards Board [AUASB] 2019; International Accounting Standards Board [IASB] 2020). By examining the broader implications of climate change performance, our findings have important implications for standard-setters, regulators, policymakers, financial analysts, investors, and firms worldwide. Our findings are especially relevant in light of the United States Securities and Exchange Commission's (SEC) recent mandate for the disclosure of climate-related information by public companies in their SEC filings. The SEC's enhanced regulatory oversight highlights the importance of not only disclosing climate risks but also demonstrating concrete actions and performance. Our study contributes to this regulatory landscape by highlighting the role of comprehensive climate change performance in reducing information asymmetry, thereby supporting more transparent and accountable corporate practices.

Secondly, our study provides nuanced evidence by documenting the importance of considering both an internal governance mechanism (i.e., corporate governance performance) and an external monitoring mechanism (i.e., institutional investor ownership) in the nexus between corporate climate change performance and information asymmetry. We reveal that these mechanisms play a crucial role in shaping firms' behavior, disclosure practices and overall market transparency. Through the study's findings, we build an enhanced understanding of their impact on the relationship between climate change performance and information asymmetry. The study's findings also provide valuable insights into the effectiveness of corporate governance structures and the influence of institutional investors in promoting transparency and reducing information asymmetry in the capital market.

Thirdly, our study expands the existing literature by considering the relationship between corporate climate change performance and information asymmetry within an international sample. Schiemann and Sakhel (2018) use a sample from countries in the European Union (EU), with these being developed countries that share a similar institutional framework. By using an international sample and cross-country analyses, our findings provide important insights on how the institutional context interacts with corporate climate change performance to influence information asymmetry. Through this analysis, the study identifies the specific mechanisms through which country-level factors (i.e., stakeholder-orientated business culture, the presence of a national ETS, and the country-level climate change performance) shape the relationship between corporate actions and information disclosure in the capital market. This provides insights into the effectiveness of different institutional contexts in promoting corporate transparency and accountability.

The remainder of the paper is structured as follows. Section II presents the literature review and the hypotheses development, while Section III discusses the study's research design. Section IV reports the empirical results, while Section V provides the additional analyses' results. Section VI concludes the paper.

II. LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

Literature Review

Over the past two decades, external capital providers, institutional investors and financial analysts worldwide have increasingly considered corporate climate change performance and the associated financial risks in their decision-making processes (Reid and Toffel 2009; Eccles, Serafeim, and Krzus 2011; Matsumura et al. 2014).[4] Corporate climate change performance reveals a firm's commitment to, and actions and outcomes in, capturing opportunities and mitigating risks related to climate change through four key mechanisms, namely, governance, strategy, risk management, and metrics and targets (CDP 2018; Task Force on Climate-Related Financial Disclosures [TCFD] 2020; Bose and Hossain 2022). Stakeholder groups have heightened global interest in improving corporate climate change performance. The imperative to reduce carbon emissions and enhance corporate climate change performance has led to various contemporary initiatives worldwide, such as CDP,

[4] For example, CDP was founded by a group of institutional investors in 2000 and currently manages US$130 trillion in assets on behalf of over 680 institutional investors.

Climate Disclosure Standards Board (CDSB), the TCFD, the Global Reporting Initiative (GRI), the Investor Network on Climate Risks (INCR), the Coalition for Environmentally Responsible Economies (CERES) and the International Integrated Reporting Committee (IIRC), aiming to improve transparency (Matsumura et al. 2014; Bose and Hossain 2022). For example, the TCFD, established by the Financial Stability Board (FSB), has developed a set of recommendations for climate-related financial disclosure (Financial Stability Board [FSB] 2019; Bose and Hossain 2022). This initiative pressures firms to disclose their carbon governance, strategy, risk management, and performance metrics aligned with the TCFD's recommendations (TCFD 2020). Additionally, the CDSB has established a framework to assist firms in providing climate change-related information in mainstream financial reports. This framework delivers material information to external capital providers and financial markets, thus increasing transparency and assessing the capability of managing climate change's risks and opportunities (CDSB 2019). The heightened interest of investors, coupled with that of the financial market and the initiation of contemporary global initiatives, highlights the institutional significance of corporate climate change performance. Failure to deliver satisfactory climate change performance creates significant financial risks, as well as regulatory, litigation and reputational risks (TCFD, 2020). Therefore, corporate climate change performance is expected to have substantial impacts on the financial market.

Although some studies demonstrate that climate change performance affects corporate financial performance (Liesen, Figge, Hoepner, and Patten 2017; Luo and Wu 2019), most prior studies show the value relevance of corporate carbon emissions (Kim and Lyon 2011; Chapple, Clarkson and Gold 2013; Matsumura et al. 2014; Griffin et al. 2017; Cooper, Raman, and Yin 2018; Griffin, Lont, and Pomare 2020). These studies report that the capital market imposes a penalty for firms with higher levels of carbon emissions, coupled with a further penalty for firms that do not disclose their carbon emissions (Griffin et al. 2017). Liesen et al. (2017) also report that the behavior of external capital providers based on a firm's climate change response is reflected at the time of investment in a stock. Moreover, Schiemann and Sakhel (2018) argue that the reporting of climate change-related physical risk is negatively associated with information asymmetry. However, both studies are unable to validate the direct association between corporate climate change performance and information asymmetry, as they consider information asymmetry to be an intervening channel. By contributing to the extant literature on climate change performance and its influence on the capital market, we directly investigate whether corporate climate change performance is associated with information asymmetry.

Hypotheses Development

Our study, drawing on two theoretical perspectives—transparency and signaling—expects that firms with greater climate change performance tend to exhibit lower levels of information asymmetry. The transparency perspective, also known as ethical perspective, highlights that firms with superior climate change performance are often characterized by their adherence to higher ethical standards and their substantive commitment to promoting transparency (Wang and Qian 2011; Ioannou and Serafeim 2015; Husted, Jamali, and Saffar 2016). These firms genuinely commit to addressing climate change issues, rather than engaging in greenwashing or symbolic initiatives (Dahlmann, Branicki, and Brammer 2019). Recognizing the growing interest of a broader range of stakeholders in climate change practices, firms are striving to satisfy the needs and expectations of various stakeholders and to establish a transparent information environment (Freeman 1984; Clarkson 1995). This involves firms not only showcasing their improved climate change performance but also enhancing their accountability, both in terms of financial and non-financial transparency (Hong and Andersen 2011; Kim, Park, and Wier 2012; Gao and Zhang 2015; Gregory, Whittaker, and Yan 2016; Luo and Wu 2019). As a result, these firms foster trust and establish their positive reputation with their investors (Lai, Chiu, Yang, and Pai 2010; Minor and Morgan 2011; Lourenço, Callen, Branco, and Curto 2014; Axjonow, Ernstberger, and Pott 2018). As a result of their ethical and transparent behavior, these firms effectively reduce information asymmetry between themselves and investors (Kulkarni 2000).

The signaling perspective argues that firms with better climate change performance tend to signal and differentiate themselves through increased disclosure of their substantive carbon reduction actions and credible performance (Al-Tuwaijri, Christensen, and Hughes 2004; Clarkson, Li, Richardson, and Vasvari 2008; Luo and Tang 2014). For example, a firm's voluntary disclosure of substantive actions such as initiating carbon reduction projects, establishing climate change committees, reducing energy use in production processes or designing low-carbon products may serve as strong signals of a firm's superior carbon management capabilities, enabling it to gain competitive advantages and achieve financial performance (Lys, Naughton, and Wang 2015). Signaling by firms through increased disclosure enables investors to access relevant information more easily, eliminating the need for extensive information-gathering efforts (Cormier, Magnan, and Van Velthoven 2005; Barth, Cahan, Chen, and Venter 2017). Consequently, it reduces the level of private information and enhances investors' confidence and reassurance in relation to firms' operations and performance, leading to reduced information asymmetry (Cho, Lee, and Pfeiffer 2013; Cui, Jo, and Na 2018; Schiemann and Sakhel 2019). Therefore, we establish the following first hypothesis:

H1: Climate change performance is negatively associated with information asymmetry.

Institutional investors are considered to be the main suppliers of capital to a firm. These investors play an active role in corporate governance through their external monitoring of management performance (Jensen and Meckling 1976). Institutional investors are important to the capital market due to the magnitude of their investment as well as their role as informed traders (O'Neill and Swisher 2003). They consider both risks and returns when making their investment decisions. In recent times, institutional investors are becoming significantly concerned about the potential impact of climate change-related financial risks on their investment decisions. Krueger, Sautner, and Stark (2020) argue that institutional investors consider climate change-related risks in relation to higher returns (possibly through mitigating the costs of climate change) or lower risks (lower portfolio and tail risk) (Hoepner, Oikonomou, Sautner, Starks, and Zhou 2018; Gibson, Krueger and Mitali 2020). Institutional investors can obtain similar returns from their investments with less risk by choosing a socially responsible firm over its counterparts. Prior research shows that institutional investors are willing to accept a lower market return on investments (a 'sustainability premium') in firms that show a greater commitment to sustainability (Dhaliwal, Li, Tsang, and Yang 2011). Graves and Waddock (1994) argue that institutional investors consider investment in socially irresponsible firms to be riskier due to the threat of pressure from adverse legislative or regulatory actions, judicial decisions or consumer retaliation.

Furthermore, prior studies report that firms with higher institutional ownership have a lower level of information asymmetry (O'Neill and Swisher 2003). Institutional investors are considered a vibrant factor in stabilizing the stock market as their trading itself can provide a signal within the stock market and disseminate more comprehensive information (Healy and Palepu 2001). Their trading leads other retail investors to simulate the performance of institutional investors in the stock market, resulting in increased stock market liquidity and reduced information asymmetry (Merton 1987). Thus, participation by institutional investors in the market generates an 'information efficiency effect'. We apply this 'information efficiency' argument in the climate change performance context and expect that firms with a higher level of institutional investors will improve stock market liquidity by their trading after considering a firm's climate change response coupled with its climate change performance. Several studies document that institutional investors are positively associated with firm-level voluntary financial and non-financial performance. For example, El-Gazzar (1998) shows that firms with higher institutional investor ownership disclose more voluntary financial information to obtain investors' confidence. Dyck, Lins, Roth and Wagner (2019) show that institutional investors worldwide are pushing for stronger firm-level environmental and social performance. Similarly, Cotter and Najah (2012) find that climate change performance is greatly influenced by institutional investors. Therefore, it can be argued that firms with a higher level of institutional investors' ownership maintain better corporate climate change performance that ultimately reduces information asymmetry. Based on the above discussion, we predict the impact of climate change performance on information asymmetry to be strengthened for firms with higher institutional investor ownership. We formally state this prediction in the following hypothesis:

H2: The negative association between climate change performance and information asymmetry is stronger for firms with a higher level of institutional investors' ownership.

Corporate governance is considered one of the significant internal governance mechanisms that may play an important role in both corporate financial and non-financial disclosure and performance (e.g., Leuz and Verrecchia 2000; Verrecchia 2001; Ajinkya, Bhojraj, and Sengupta 2005; Kanagaretnam et al. 2007; Lei, Lin, and Wei 2013; Liao et al. 2015; Haque 2017; Bui et al. 2020; Ali, Bose, and Miah, 2022). Specifically, Daradkeh et al. (2022) find that firms with more capable managers disclose a greater level of climate change information, with this association negatively moderated by weak corporate governance. In their study, Choi and Luo (2021) report that the negative relationship between carbon emissions and firm value is weaker in firms with good corporate governance. Therefore, we anticipate that the influence of corporate climate change performance on information asymmetry is contingent upon the quality of corporate governance.

Firms with better corporate governance tend to have stronger internal carbon management controls, risk management practices and board oversight (Elsayih, Datt, Tang, Hamid, and Varua 2023). These firms are more likely to integrate climate change considerations into their business strategies and operations (Luo and Tang 2021). This enables them to effectively manage and mitigate climate change-related risks, resulting in improved climate change performance (Bui et al. 2020; Luo and Tang 2021). In addition, these firms are also more likely to have comprehensive reporting frameworks and mechanisms in place to ensure transparency, accountability and effective communication with stakeholders (Peters and Romi 2014; Liao et al. 2015). Overall, the combination of a stronger carbon management system and a more transparent information environment creates a favorable environment for a higher level of climate change performance, disclosure and transparency, leading to further reduction in information asymmetry, ultimately benefiting both the firm and its stakeholders. Therefore, we predict the impact of corporate climate change performance on information asymmetry to be stronger for firms with better corporate governance. We establish our third hypothesis as follows:

H3: The negative association between climate change performance and information asymmetry is more pronounced for firms with better-quality corporate governance.

III. RESEARCH DESIGN

Sample and Data

This study's sample consists of all firms that responded to the CDP questionnaire from 2011–2020. We start our sample period in 2011 as climate change performance rating data are only available from that year, while 2020 is the latest year of data collection. Climate change performance rating data are collected from the CDP database. Financial and non-financial data are collected from the Worldscope database and Refinitiv ESG database, respectively, while stock market data are collected from the DataStream database. We collect analysts' forecast data from the Institutional Brokers' Exchange System (I/B/E/S) database. We also collect country-level ETS data from the International Carbon Action Partnership (ICAP) and climate change risk index data from Germanwatch and Climate Action Network (2020). Other country-level data are collected from the World Bank database. After merging all databases and excluding all incomplete observations, we obtain an initial sample of 6,367 firm-year observations from 26 countries. Table 1, Panel A shows the sample selection procedure.

[INSERT TABLE 1 ABOUT HERE]

Table 1, Panel B and C show the distribution of firms in our sample by industry and year, respectively. Following prior studies (Dhaliwal, Radhakrishnan, Tsang, and Yang 2012), we retain all industries in our sample, including utilities and the financial industry. In our sample, the financial industry has the largest proportion of firms (14.69%), followed by transportation (8.47%) and computers (6.97%), while firms from 'other industries' (0.31%) have the lowest proportion. Moreover, no single industry covers more than 15% of the total observations. Table 1, Panel C presents the yearly distribution of firms in our sample. The highest proportion of observations is

14.56% in 2017, followed by 2018 (13.82%) and 2019 (13.37%), while 2011 has the lowest proportion of observations.

Measurement of Climate Change Performance

We obtain climate change performance rating data from the CDP database. An independent global not-for-profit organization, CDP runs global environmental disclosure systems for investors through which firms disclose their climate change-related information (Bui et al., 2020; Bose et al. 2021; Daradkeh et al., 2023; Bose, Lim, Minnick, and Shams 2023b). Every year, CDP collects firms' responses regarding their activities to address climate change through questionnaires and translates these responses into scores. The CDP scoring system is widely regarded as one of the most credible ratings in the world (The SustainAbility Institute 2023).[5] This score is also included in Google Finance's Key Stats and Ratio section.[6] The CDP climate change performance ratings score covers firm-level climate governance; climate change-related risks and opportunities; business strategy; climate change-related targets and performance; firms' initiatives for the reduction of carbon emissions; verification of carbon emissions; carbon pricing; and firm-level engagement with value chain partners regarding climate change-related activities (CDP 2018; Bui et al. 2020; Bose, Burns, Minnick, and Shams 2023a; Bose et al. 2023b; Daradkeh et al. 2023). Firms' climate change performance is rated by CDP, based on their response to the CDP questionnaire in accordance with well-designed scoring methodologies. From 2011–2015, CDP provided six performance bands. From 2016, CDP has provided eight performance bands (i.e., A, A-, B, B-, C, C-, D and D-) based on firms' CDP responses in relation to their climate change information. Our study assigns 8 for performance band A; 7 for A-; 6 for B; 5 for B-; 4 for C; 3 for C-; 2 for D; and 1 for D-, respectively (Bose et al., 2023a; Bose et al., 2023b; Daradkeh et al., 2023). The climate change ratings provided by CDP have evolved in scope over the years. For example, in 2017, CDP began incorporating climate change-

[5] The SustainAbility Institute (2023) report that the CDP ratings are the most credible environmental disclosure rating system in the world based on a survey using 1400 corporate sustainability professionals across 29 countries. See https://www.sustainability.com/globalassets/sustainability.com/thinking/pdfs/2023/rate-the-raters-report-april-2023.pdf (accessed on 25 May 2024).
[6] For example, see: https://www.google.com/finance/quote/BHP:ASX (accessed on 20 May 2024).

related financial disclosures, following the TCFD framework, into its rating system. Due to variability in the performance bands across different years, they are not directly comparable. However, this comparison is essential for our study as we delve into both the time series and cross-sectional dimensions of climate change performance. Therefore, we create a weighted measure for the climate change performance score (*CCPS*) that compares *CCPS* across countries, years and industries with the value ranging between 0 and 1. More specifically, we compute *CCPS* as the ratio of the difference between the original value of *CCPS* and the sample's minimum value of *CCPS* over the difference between the sample's maximum value of *CCPS* and the sample's minimum value of *CCPS* for firms within the same country and industry for each year.[7] The scores for climate change performance range from 0 for the lowest-ranked firm to 1 for the highest-ranked firm.

Measurement of Information Asymmetry

We employ bid–ask spreads as a proxy for information asymmetry following prior studies (e.g., Leuz and Verrecchia 2000; Cho et al. 2013; Schiemann and Sakhel 2018). Although information asymmetry cannot be measured directly, prior studies frequently use bid–ask spreads for measuring information asymmetry (Leuz and Verrecchia 2000; Cho et al. 2013; Shroff et al. 2013; Schiemann and Sakhel 2018). Theoretically, the bid-ask spread reflects the adverse selection component of the cost of capital. This component is reduced when there is less asymmetry in information among market participants, which, in turn, leads to a reduction in the bid-ask spread (Leuz and Verrecchia 2000; Schiemann and Sakhel 2018). Following this approach, we measure information asymmetry as the average of daily bid–ask spreads as a percentage of the daily closing price from October–December of year *t*. We use the three-month daily average of the spread as the CDP releases the climate change

[7] Prior studies (e.g., Kim, Li, and Li 2014; Ben-Nasr and Ghouma 2018; Bose et al., 2023b) use this scoring system. As our study focuses on cross-country context, we also include the country when we compute our climate change performance score measure.

score data to the market in September of each year. Therefore, October is the first full month after the publication of the information on related risks.[8]

Empirical Models and Variables

We estimate the following model to test the association between climate change performance *(CCPS)* and information asymmetry, as proposed in our first hypothesis (H1):

$$\begin{aligned} SPREAD_{i,t+\tau} = \beta_0 &+ \beta_1 CCPS_{i,t} + \beta_2 SIZE_{i,t} + \beta_3 ROA_{i,t} + \beta_4 LEV_{i,t} + \beta_5 FAGE_{i,t} + \beta_6 RISK_{i,t} \\ &+ \beta_7 ANALYST_{i,t} + \beta_8 LNPRICE_{i,t} + \beta_9 ENVPERF_{i,t} + \beta_{10} CSRDISC_{i,t} \\ &+ \beta_{11} CSPREAD_{i,t} + \beta_{12} LNGDP_{i,t} + \beta_{13} CRI_{i,t} + \beta_{14} STAKE_{i,t} + \beta_{15} LEGAL_{i,t} \\ &+ \sum Year_{i,t} + \sum Industry_{i,t} + \varepsilon_{i,t} \qquad (1) \end{aligned}$$

To test our second hypothesis (H2), we add the interaction between the climate change performance score *(CCPS)* and institutional investor ownership *(HIGH_INSTOWN)* to Equation (1). The model is as follows:

$$\begin{aligned} SPREAD_{i,t+\tau} = \beta_0 &+ \beta_1 CCPS_{i,t} + \beta_2 CCPS_{i,t} \times HIGH\_INSTOWN + \beta_3 HIGH\_INSTOWN_{i,t} + \beta_4 SIZE_{i,t} \\ &+ \beta_5 ROA_{i,t} + \beta_6 LEV_{i,t} + \beta_7 FAGE_{i,t} + \beta_8 RISK_{i,t} + \beta_9 ANALYST_{i,t} + \beta_{10} LNPRICE_{i,t} \\ &+ \beta_{11} ENVPERF_{i,t} + \beta_{12} ENVPERF_{i,t} + \beta_{13} CSPREAD_{i,t} + \beta_{14} LNGDP_{i,t} + \beta_{15} CRI_{i,t} \\ &+ \beta_{16} STAKE_{i,t} + \beta_{17} LEGAL_{i,t} + \sum Year_{i,t} + \sum Industry_{i,t} + \varepsilon_{i,t} \qquad (2) \end{aligned}$$

To test our third hypothesis (H3), we add an interaction between the climate change performance score *(CCPS)* and corporate governance performance *(HIGH_CGOV)* to Equation (1). The model is as follows:

$$\begin{aligned} SPREAD_{i,t+\tau} = \beta_0 &+ \beta_1 CCPS_{i,t} + \beta_2 CCPS_{i,t} \times HIGH\_CGOV + \beta_3 HIGH\_CGOV_{i,} + \beta_4 SIZE_{i,t} \\ &+ \beta_5 ROA_{i,t} + \beta_6 LEV_{i,t} + \beta_7 FAGE_{i,t} + \beta_8 RISK_{i,t} + \beta_9 ANALYST_{i,t} + \beta_{10} LNPRICE_{i,t} \\ &+ \beta_{11} ENVPERF_{i,t} + \beta_{12} CSRDISC_{i,t} + \beta_{13} CSPREAD_{i,t} + \beta_{14} LNGDP_{i,t} + \beta_{15} CRI_{i,t} \\ &+ \beta_{16} STAKE_{i,t} + \beta_{17} LEGAL_{i,t} + \sum Year_{i,t} + \sum Industry_{i,t} + \varepsilon_{i,t} \qquad (3) \end{aligned}$$

where the dependent variable *SPREAD* is a proxy for information asymmetry, measured as the average of the daily closing bid–ask spreads as a percentage of daily closing price from October–December of year *t*. The variable *CCPS* is the climate change performance rating/score. We measure

[8] For example, if the firm closes its financial year in December 2015, CDP disseminates the climate change performance score data to the market in September 2016, and we measure spread from October–December of year 2016.

HIGH_INSTOWN as a dummy variable of 1 if a firm's institutional investor ownership is greater than the sample's yearly median institutional investor ownership, and 0 otherwise. Similarly, we measure *HIGH_CGOV* as a dummy variable of 1 if the firm's corporate governance performance is higher than the sample's yearly median corporate governance performance, and 0 otherwise. We expect negative coefficients of *CCPS* in Equation (1); *CCPS×HIGH_INSTOWN* in Equation (2); and *CCPS×HIGH_CGOV* in Equation (3), indicating support for our hypotheses. Appendix A provides the definitions of all variables.

Our study controls for several variables following prior research (e.g., Cho et al. 2013; Schiemann and Sakhel 2018). We control for firm size as larger firms are more likely to have a higher level of climate change performance that would reduce information asymmetry (Schiemann and Sakhel 2018). Firm size (*SIZE*) is measured as the natural logarithm of market capitalisation. Firms with better financial performance have a positive effect on stock market liquidity that would reduce information asymmetry (Dhaliwal et al. 2011; Schiemann and Sakhel 2018). Therefore, we control for profitability (*ROA*), measured as net income divided by total assets. We also control for leverage (*LEV*), as the demand for information tends to increase with higher debt levels (Ott, Schiemann, and Günther, 2017). Firms exhibiting higher levels of climate change performance provide more extensive climate-related information to satisfy their debt holders, thereby reducing information asymmetry. Leverage *(LEV)* is measured as total debt divided by total assets. Firms of long standing in the market have more competitive advantages that influence them to provide more information to reduce information asymmetry (Bose et al. 2023b). Hence, we control for the firm's age *(FAGE)*, measured as the natural logarithm of the total number of years since the firm first appeared in the Worldscope database.

Moreover, information asymmetry can be more severe for firms with higher risk. Market makers bear a higher level of adverse selection risk when stock returns are more volatile (Bhattacharya, Desai, and Venkataraman 2013). Therefore, we control for stock return volatility *(RISK)*, measured as the standard deviation of daily stock returns over the fiscal year (Cho et al. 2013; Goh, Lee, Ng, and Ow

Yong 2016; Schiemann and Sakhel 2018). Furthermore, firms with a greater analyst following have a good information environment for investors, thereby reducing adverse selection problems (Brennan and Subrahmanyam 1995; Dhaliwal et al. 2012). Thus, we control for analysts' coverage, measured as the natural logarithm of the total number of analysts following a firm over the fiscal year (Chung, McInish, Wood, and Wyhowski 1995; Roulstone 2003). We control for share prices as a higher level of information asymmetry is more likely to occur at a lower level of stock prices due to discreteness in prices (Bhattacharya et al., 2013). Share price *(LNPRICE)* is measured as the annual average of closing stock prices. Firms with a higher environmental performance score and firms that disclose corporate social responsibility (CSR) information are more likely to have lower information asymmetry. Thus, we control for relative environmental performance *(ENVPERF)*, measured as the environmental performance score from the Refinitiv ESG database and the issuance of CSR reports *(CSRDISC)*.

We also control for country-level bid–ask spread *(CSPREAD)* following Schiemann and Sakhel (2019) and country-level gross domestic product (GDP) *(LNGDP)*, measured as the natural logarithm of GDP per capita to minimize the likelihood of model misspecification due to differences between countries. Furthermore, we control for the firm-level global climate risk index score *(CRI)* that indicates a firm's level of exposure and vulnerability to extreme events, through countries' understanding of warnings about preparedness for more frequent and/or more severe events in the future. We also control for a country's business culture, following Simnett, Vanstraelen and Chua (2009). A stakeholder-oriented culture possesses a legitimate interest in a firm's business operations. Therefore, stakeholder groups in these countries influence a firms' corporate functions (Simnett et al. 2009). Conversely, in shareholder-oriented countries, stakeholder groups have less legitimacy in, and influence on, a firm's corporate functions. We measure stakeholder-oriented business culture *(STAKE)* as an indicator variable that takes the value of 1 if a firm domiciled in code law countries, and 0 otherwise. In addition, a country's legal environment also has a significant influence on capital market development, corporate ownership structures, corporate policies and the properties of accounting information (Choi and Wong 2007). Therefore, we control for a country's legal environment. Following Bjornsen, Do, and Omer (2018), we measure legal environment *(LEGAL)* as the principal component factor of rule of law, regulatory quality and control of corruption index score rated by the World bank (2022).

Estimation Method

Our study estimates all our regression models using ordinary least squares (OLS) regression techniques. In these models, we use robust standard errors clustered by the firm to address heteroscedasticity and serial correlation issues. Furthermore, we use variance inflation factor (VIF) values to assess potential multicollinearity. We also apply year and industry fixed effects in all our regression models. We winsorise all firm-level continuous variables at the 1st and 99th percentiles to reduce the influence of extreme values.

IV. EMPIRICAL RESULTS

Descriptive Statistics and Correlation Analysis

Table 2, Panel A presents the descriptive statistics for the variables used in Equations (1)-(3). The mean (median) value of information asymmetry *(SPREAD)* is 0.137 (0.089), indicating that an average information asymmetry of 13.70 percent to the daily closing price across firms in our sample. The average (median) value of climate change performance (*CCPS)* is 0.471 (0.500), suggesting a moderate and consistent level of performance in climate change actions within their respective industries and countries. The mean value of the firm size *(SIZE)* in our sample is 9.128, closely aligning with the value of 9.122 reported by Bose et al. (2023a). The average return on assets *(ROA)* is 0.048, denoting a typical profitability rate of 4.80% among the sampled firms. The mean (median) value of leverage *(LEV)* is 0.254 (0.238), which is closer to the value of 0.250 reported by Bose et al. (2023a). The firms in our sample have an average age *(FAGE)* of 13.292 years, indicating a higher maturity level compared to the firms in Bose et al. (2023a).[9] The mean value of the firms risks *(RISK),*

[9] We convert firm age as the natural logarithm of total firm age before estimating the regression model.

measured by the standard deviation of annul stock returns, is 0.018, which is close to the value of 0.020 reported by Bose et al. (2023a). The mean value of analysts' coverage *(ANALYST)* is 5.181, while the average value of the natural logarithm of share price is 3.293. About 41.20% of the sample observations issue CSR reports, while the average value of environmental performance *(ENVPERF)* is 0.791. The country-level bid–ask spread *(CSPREAD)* and institutional investors' ownership *(INSTOWN)* have average values of 0.089 and 60%, respectively, while the average value of corporate governance performance (*CGOV)* is 0.605.

At the country-level, the natural logarithm of the gross domestic product (*LNGDP)* and global climate risk *(CRISK)* average is 10.651 and 4.154, respectively. About 79.80% of firms in our sample are based in countries with stakeholder-oriented business culture, and the average value of the country-level legal environment (*LEGAL)* is 2.501.

[INSERT TABLE 2 ABOUT HERE]

Table 2, Panel B reports the mean and median test results comparing firms with higher and lower climate change performance *(CCPS)*.[10] The results indicate that firms with higher *CCPS*, compared to firms with lower *CCPS*, exhibit a lower level of information asymmetry. Additionally, firms with higher *CCPS* tend to be larger in size, more profitable, and have a longer presence in the market. They are characterized by lower market risk and are followed by a greater number of analysts. These firms also have higher share prices and demonstrate superior environmental performance. They are more likely to issue CSR reports and experience lower country-level information asymmetry. Moreover, they exhibit higher institutional ownership and lower corporate governance performance and operate in countries with lower GDP and less stringent legal environments.

Table 3 presents a summary of the statistics of our study's key variables by country. Regarding country-level information asymmetry, Australia *(SPREAD*=0.701*)* has the highest level, followed by Germany (*SPREAD*=0.449*)*, whereas the United States (US) has the lowest level. Furthermore, firms

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[10] The indicator variable *HIGH_CCPS* takes a value of 1 if the firm's *CCPS* is higher than the country–industry–year-adjusted median of the climate change performance score, and 0 otherwise.

in the Netherlands have the highest climate change performance score *(CCPS*=0.582*)*, followed by firms in India *(CCPS*=0.578*)*. Singapore has the highest level of legal environment *(LEGAL*=3.550*)*, followed by Finland *(LEGAL*=3.512*)*, while Brazil *(LEGAL*=–0.336*)* has the lowest. Furthermore, India has the highest level of climate risk *(CRI*=20.455*)*, followed by the US *(CRI*=26.402*)*, while Singapore has the lowest level of climate risk *(CRI*=121.188*)*.

[INSERT TABLE 3 ABOUT HERE]

Table 4 reports Pearson's correlation matrix for the variables included in Equations (1)-(3). The results show that climate change performance (*CCPS)* is negatively correlated to information asymmetry (*SPREAD)*. Furthermore, they show that the correlation coefficients of all variables do not exceed 0.80, with Gujarati and Porter (2009) suggesting that bivariate correlations with values less than 0.80 do not create any multicollinearity problems. The mean variance inflation factor (VIF) value of the variables is 2.24, with VIF values ranging from 1.02–6.69. A VIF value higher than 10 is viewed as leading to potential multicollinearity concerns (Gujarati and Porter 2009), thus indicating that our results are unlikely to suffer from these concerns.

[INSERT TABLE 4 ABOUT HERE]

Regression Analysis

Our first hypothesis (H1) predicts that climate change performance is negatively associated with information asymmetry, while our second and third hypotheses (H2 and H3) predict that a negative association between climate change performance and information asymmetry is stronger for firms with a higher level of institutional investors and corporate governance, respectively. We report the regression results in Table 5. The coefficient of *CCPS* is negative and statistically significant (β=–0.042, p<0.01) in Model (1), suggesting that climate change performance is negatively associated with information asymmetry. This finding suggests that firms with a higher level of climate change performance have lower information asymmetry, thus supporting our first hypothesis (H1). In terms of economic significance, the estimated coefficient suggests that firms with higher climate change performance, on average, decrease their information asymmetry by 14.44% [(0.471×–0.042)/0.137×100] relative to the sample's mean.

[INSERT TABLE 5 ABOUT HERE]

Table 5, Model (2) shows the regression results of the moderating role of institutional investor ownership in the association between climate change performance and information asymmetry. To test the moderation hypothesis, the key variable of interest is the interaction term between climate change performance score and institutional investor ownership *(CCPS×HIGH_INSTOWN).* The interaction term captures the difference in the effects of climate change performance on information asymmetry between those with higher levels of institutional ownership and those with lower levels. Equally important, the coefficient on *CCPS* captures the effects of climate change performance for firms with lower level of institutional investors. The negative coefficient of *CCPS×HIGH_INSTOWN* (β=–0.029, p<0.01) indicates that, after controlling for other factors, the negative association between climate change performance and information asymmetry is stronger for firms with a higher level of institutional investors. Hence, our second hypothesis (H2) is supported. In terms of economic significance terms, the estimated coefficient suggests that firms with higher *CCPS*, on average, leads to a 17.53% [(0.471×–0.051)/0.137×100] decrease in the value of information asymmetry for firms with lower level of institutional investors' ownership, and a 27.50% [((0.471×-0.051)+(0.471×-0.029))/0.137×100] decrease in the value of information asymmetry for firms with higher level of institutional investors' ownership.

Furthermore, as shown in Table 5, Model (3), we examine the role of corporate governance performance in the association between climate change performance score and information asymmetry. To test the moderation hypothesis, the key variable of interest is the interaction term *(CCPS×HIGH_CGOV)*. This captures the difference in the effects of climate change performance on information asymmetry between those with high levels and those with low levels of corporate governance performance. Equally important, the coefficient of climate change performance captures the effect of climate change performance for firms with a lower level of corporate governance. The negative coefficient of *CCPS×HIGH_CGOV* (β=–0.029, p<0.01) indicates that, after controlling for other factors, the negative association between the climate change performance score and information asymmetry is noticeable for firms with a higher level of corporate governance. Thus, our third hypothesis (H3) is supported. In terms of economic significance terms, the estimated coefficient suggests that firms with higher CCPS, on average, leads to a 8.25% [(0.471×–0.024)/0.137×100] decrease in the value of information asymmetry for firms with lower corporate governance performance, and a 18.20% [((0.471×-0.024)+(0.471×-0.029))/0.137×100] decrease in the value of information asymmetry for firms with higher corporate governance performance.

Regarding the control variables, as shown in Table 5, Models (1)–(3), we find that the coefficients of *SIZE*, *LEV, LNPRICE* and *LNGDP* are negative and statistically significant. These findings suggest that larger firms, firms that are highly leveraged, have a higher stock price and a higher GDP have lower information asymmetry. These findings are closely aligned with prior studies (e.g., Cho et al. 2013; Ott et al. 2017; Schiemann and Sakhel, 2019). On the other hand, the coefficient of *CSPREAD* is positive and statistically significant, suggesting that firms with a higher country-level spread have higher information asymmetry, which is consistent with Schiemann and Sakhel (2019). Furthermore, the coefficients of *STAKE* and *LEGAL* are positive and statistically significant, indicating that firms in countries with stakeholder-oriented business culture and stronger legal environment have higher information asymmetry.

Endogeneity analysis

A potential endogenous relationship between CCPS and information asymmetry could be a concern in our regression models. Specifically, the association between CCPS and information asymmetry might be influenced by unobservable heterogeneity, observable heterogeneity, and omitted variable bias. To address these endogeneity issues, we employ several techniques, including: (a) Heckman (1979) two-stage analysis; (b) entropy balancing analysis; (c) the use of a quasi-experimental setting; and (d) the inclusion of firm fixed effects and country fixed effects.

Heckman's (1979) Two-Stage Analysis

The empirical association between information asymmetry and climate change performance could reflect self-selection bias as our sample includes only those firms that voluntarily provide climate change performance information to the CDP via the CDP questionnaire. To address potential self-selection bias, we adopt Heckman's (1979) two-stage procedure. In the first-stage model of Heckman's (1979) two-stage analysis, we develop a model including the firm's decision to respond to the CDP questionnaire by augmenting our sample with firms that did not respond to the CDP questionnaire over our sample period. More specifically, we develop the following probit regression model:

$$CDP_{i,t} = \beta_0 + \beta_1 PIDEC_{i,t} + \beta_2 SIZE_{i,t} + \beta_3 ROA_{i,t} + \beta_4 MB_{i,t} + \beta_5 LEV_{i,t} + \beta_6 FAGE_{i,t} + \beta_7 FOREIGN_{i,t} + \beta_8 CAPIN_{i,t} + \beta_9 RISK_{i,t} + \beta_{10} ANALYST_{i,t} + \beta_{11} ENVPERF_{i,t} + \beta_{12} CSRDISC_{i,t} + \beta_{13} LNGDP_{i,t} + \beta_{14} CRI_{i,t} + \beta_{15} STAKE_{i,t} + \beta_{16} LEGAL_{i,t} + \sum Year_{i,t} + \sum Industry_{i,t} + \varepsilon_{i,t} \quad (4)$$

In Equation (4), the dependent variable, *CDP*, is an indicator variable that is coded 1 if the firm voluntarily responded to the CDP questionnaire, and 0 otherwise. We select the independent variables following prior studies (e.g., Matsumura et al., 2014; Bose et al., 2023a, 2023b). In Equation (4), we include country-level government ideology *(PIDEC)* to satisfy the 'exclusion restrictions' criteria. The rationale for including country-level government ideology *(PIDEC)* is based on the argument that left-wing governments are more inclined to adopt environmentally friendly policies (Chang, Wen, Dong, and Hao 2018; Al Rabab'a, Rashid, Shams, and Bose, 2024). Consequently, we expect that firms in countries with left-wing governments are more likely to respond to the CDP questionnaire. This assumption justifies the relevance of *PIDEC* for the first-stage model. While the *PIDEC* might influence a firm's decision to CDP reporting, it does not inherently alter the level of information asymmetry within individual firms in the capital markets. This is due to the universal effort by countries to minimize information asymmetry among firms irrespective of the political ideology of their government parties. Therefore, we argue that *PIDEC* can be justifiably excluded from the second-stage model. We expect a positive coefficient for *PIDEC* in Equation (4). We obtain *PIDEC* data from the Database of Political Institutions by the World bank.[11] The definitions of the other variables are provided in Appendix A.

[INSERT TABLE 6 ABOUT HERE]

The first-stage regression results are reported in Table 6, Panel A. Consistent with our expectation, we find that the coefficient of *PIDEC* is positive and statistically significant (β=0.079, p<0.05). The model has a pseudo-R^2 value of 22.30% and the areas under the ROC curve[12] is 81%, while the partial R^2 values for *PIDEC* of 0.70%, which are significantly greater than 0, suggesting that the *PIDEC* is reasonable exogenous variables. Table 6, Panel B reports the second-stage regression results. These show that the coefficient of *CCPS* is negative and statistically significant (β=–0.055, p<0.01) in Model (1), while the coefficients of *CCPS×HIGH_INSTOWN* and *CCPS×HIGH_CGOV* are negative and statistically significant (β=–0.051, p<0.01; β=–0.055, p<0.01) as stated in Table 6. Furthermore, the coefficient of the inverse Mills ratio (*IMR)* is statistically insignificant across Models (1)–(3), suggesting that sample selection bias is not a significant concern in our study.[13]

Entropy Balancing Analysis

While Heckman's (1979) two-stage model addresses endogeneity arising from unobservable selection bias, our findings may be affected by observable heterogeneity bias (Tucker 2010; Lennox, Francis, and Wang 2012) and functional misspecification bias (Shipman, Swanquist, and Whited

[11] This database categorizes the three largest parties in a government based on their ideological orientations: left-wing, centrist, or right-wing. Adopting the methodology used by Bjørnskov (2008), we assign numerical values to these orientations: -1 for right-wing, 0 for centrist, and 1 for left-wing. Additionally, we proportionally weight the ideologies of single parties based on their parliamentary seat share. Thus, the "ideology" variable effectively reflects the self-declared relative ideology of governments (Bjørnskov, 2008). For example, a government that is consistently left-wing throughout a given period is assumed to represent a population in which the majority holds left-wing sympathies and ideologies, and this majority defines the policy set (Bjørnskov, 2008).

[12] To measure the accuracy of our model in distinguishing between firms that do and do not respond to the CDP questionnaire, we employ the receiver operating characteristics (ROC) curve analysis methodology, as introduced by Zweig and Campbell (1993). The area under the ROC is 96.10%, suggesting a high level of accuracy in identifying firms that do and do not respond the CDP questionnaire.

[13] An alternative explanation for the insignificant *IMR* result could be that our selection model is misspecified. However, we calculate the VIF value for *IMR* to ensure that the insignificant coefficient of *IMR* is not caused by multicollinearity. The unreported VIF value for *IMR* is 1.14 in each of Models (1)–(3), suggesting that multicollinearity is not an issue.

2017) which are additional sources of endogeneity. To address this concern, we employ the entropy balancing technique. This technique mitigates the effects of imbalances in firm characteristics, thereby reducing the likelihood that our results would relate to these imbalances rather than to climate change performance ratings. Table 7 provides the entropy balancing results, assigning weights to adjust for the sample's distributions of control observations (Hainmueller 2012; Hainmueller and Xu 2013). This adjustment balances the covariates on all three moments (mean, variance and skewness) of the distributions. The procedure assigned more weight to underrepresented observations and less weight to overrepresented observations, creating a 'pseudo' control group that mitigated the differences in covariates between treatment samples *(HIGH_CCPS=1)* and control samples *(HIGH_CCPS=0)*. The treatment group comprised observations with higher climate change performance scores *(HIGH_CCPS=1)*, while the control group comprised observations with lower climate change performance scores *(HIGH_CCPS=0)*. The definition of *HIGH_CCPS* is provided earlier in Section IV.

Table 7, Panels A and B show the descriptive statistics of the entropy balanced samples when balancing *HIGH_CCPI=1* versus *HIGH_CCPI=0* for the treatment and control groups, respectively. As shown in Table 7, Panel B, the results show that no differences are found between the treatment and control observations in terms of mean, variance and skewness. Table 7, Panel C shows the multivariate analysis of the entropy balanced sample. The coefficient of *CCPS* is negative and statistically significant for information asymmetry (β=-0.030, p<0.01) in Model (1), while the coefficients of *CCPS×HIGH_INSTOWN* and *CCPS×HIGH_CGOV* are negative and statistically significant (β=-0.026, p<0.01; β=-0.030, p<0.01) in Models (2) and (3), respectively. These results suggest that our findings are not affected by observable selection bias and functional misspecification bias.

[INSERT TABLE 7 ABOUT HERE]

Quasi-Experimental Analysis

We employ a quasi-natural experimental framework to address endogeneity concerns in our findings. More specifically, we utilize the 2015 Paris Agreement as an exogenous policy shock to run quasi-natural experimental analysis. The Paris Agreement is a legally binding international treaty on climate change with the main objective of limiting global warming well below 2° Celsius under the pre-industrial level. The 193 signatories of the Paris Agreement committed to reduce greenhouse gas (GHG) emissions. These countries also agreed to review their commitment every five years and to provide support to developing nations for climate change mitigation efforts and adoption of these measures. Therefore, the 2015 Paris Agreement is widely considered as a watershed moment in global climate regulation, with this expected to enhance a firm's climate change performance.

The Paris Agreement serves as an ideal shock with which to explore the causal relationship between climate change performance and information asymmetry. To comply with the Agreement, participating countries are expected to develop stricter environmental regulations that could require firms to maintain a higher level of climate change performance. Therefore, the Paris Agreement represents a shift in environmental regulation that could enhance firms' climate change performance, consequently reducing information asymmetry. Prior studies (Delis, de Greiff, and Ongena 2019; Capasso, Gianfrate and Spinelli 2020; Seltzer, Starks, and Zhu 2022) frequently use the Paris Agreement as an ideal shock for exploring causal relationships. If climate change performance reduces information asymmetry, our expectation is that firms with a higher level of climate change performance will have a lower level of information asymmetry after the Paris Agreement. Therefore, we use the Paris Agreement as an exogenous policy shock to conduct our quasi-natural experimental analysis.

We run two regression models to test the impact of the 2015 Paris Agreement. In the first regression model, we create an indicator variable of *POST* that takes a value of 1 for the period 2016–2018, and 0 for the pre-period 2012–2014. In the second regression model, we add the Paris

Agreement year to the pre-period. We then interact *POST* with *CCPS (CCPS×POST)* to test our prediction. A statistically significant coefficient for *CCPS×POST* will support our prediction.

Table 8 reports the regression results. These show that the coefficients of *CCPS×POST* are negative and statistically significant across both models, suggesting that firms with a higher level of climate change performance score have lower information asymmetry after the strengthening of climate policies in the 2015 Paris Agreement. These results corroborate our study's findings that information about firm-level climate change performance reduces information asymmetry.

[INSERT TABLE 8 ABOUT HERE]

Firm and Country Fixed Effects

Any omitted variables that are correlated with climate change performance scores may create an endogeneity problem in our research models. Even though our study incorporates several firm-level variables and country-level variables that could potentially affect both climate change performance and information asymmetry, as well as including industry and year fixed effects in all regression models, our research models could suffer from omitted variable bias. To address this concern, we perform firm fixed effects and country fixed effects regressions. The benefit of using firm and country fixed effects is the removal of the omitted time-invariant firm/country characteristics that could potentially cause a spurious correlation between climate change performance and information asymmetry. Table 9, Panels A and B present the firm and country fixed effects regression results, respectively. The coefficient of *CCPS*, *CCPS×HIGH_INSTOWN,* and *CCPS×HIGH_CGOV* retain the same negative sign across all models in Panel A and B, which is consistent, as stated in Table 5. Therefore, these results confirm that our findings do not suffer from omitted variable bias.

[INSERT TABLE 9 ABOUT HERE]

V. ROBUSTNESS CHECKS

United States (US) Effect and Country Analysis

As shown in Table 3, firms in the US comprise the largest proportion of observations (32.10%) in our sample. Prior studies argue that voluntary disclosure may be more effective in the US than in other countries, as the US has an efficient capital market and a strong legal system (e.g., Francis, Khurana, and Pereira 2005). Moreover, prior studies using cross-country perspectives have raised concerns that the findings of studies may be driven by US firms. Therefore, we re-run all our regression analyses separating US firms and non-US firms. We do not report the regression results in this study for reasons of brevity, but the unreported results show that the findings are qualitatively similar. Furthermore, for the country sensitivity tests, we re-run our regression models after excluding each of the following groups, one at a time: (1) Japanese firms; (2) UK firms; and (3) firms in countries with less than 10, 20, 30, 50 and 100 observations. We find that the unreported results of each analysis remain qualitatively similar to our main findings.

Other Analyses

Our sample is dominated by firms operating in the financial industry (14.69%), as shown in Table 1. To gauge the robustness of our findings, we re-run all regression models excluding these firms. The unreported results demonstrate that our findings remain qualitatively similar after excluding firms operating in the financial industry. Finally, we employ additional measures of CCPS from CDP reports that offer a more direct measurement of CCPS. These include actual carbon emission reduction achievements, verification of climate-related statements, and the integration of climate incentives with executives' compensation. We calculate GHG emissions reductions *(Emission_Reduction)* as an indicator variable that equals 1 if the firm reduces its actual carbon emissions, reported in CO_2-e metric tonnes, compared to the previous year, and 0 otherwise. Furthermore, we measure *Carbon_Assurance* as an indicator variable that takes a value of 1 if a firm obtains third-party verification for its climate-related statements, and 0 otherwise. Similarly, we measure *Carbon_Incentive* as an indicator variable that takes a value of 1 if the firm incorporates climate-related targets into its executives' compensation schemes, and 0 otherwise. We report the regression results in Table 10. The results suggest that our findings hold for using all of these measures of climate-change performance.

[INSERT TABLE 10 ABOUT HERE]

VI. ADDITIONAL ANALYSES

Do Country-Level Variants Affect the Association Between Climate Change Disclosure and Information Asymmetry?

Prior studies document that non-financial disclosure by a firm is affected by country-level contextual factors (Simnett et al. 2009; Dhaliwal et al. 2012). Therefore, we investigate whether our findings are affected by stakeholder-oriented business culture, a national emissions trading scheme (ETS) and climate change performance at the country level.

Firstly, stakeholder-oriented business culture at the country level plays a crucial role in shaping firms' priorities and responsibilities in relation to addressing climate change (Liang and Renneboog 2017; Luo, Wu, and Zhang 2021). Countries with a strong stakeholder-oriented business culture tend to emphasize the importance of considering the interests of various stakeholders, including non-financial stakeholders (Simnett et al. 2009; Zhou, Simnett, and Green 2016). Exploring the moderating effect of country-level stakeholder-oriented business culture can help us to understand how the alignment between firms' climate change performance and stakeholder expectations affects information asymmetry. Secondly, the presence of a national ETS signifies a market-based carbon pricing policy that incentivizes firms to reduce their GHG emissions. Firms operating in countries with an ETS thus face regulatory and economic pressures and incentives to improve their climate change performance (Schiemann and Sakhel 2018; Bose et al. 2023a). Therefore, investigating the moderating effect of an ETS can provide insights into how the regulatory environment affects the relationship between corporate climate change performance and information asymmetry. Thirdly, examining the moderating role of overall climate change performance at the country level can provide insights into the broader environmental context within which firms operate. Countries with a higher level of overall climate change performance may not only tend to have more robust frameworks, policies and practices in place but may also exhibit a higher level of social norm for seeking to address climate-related issues (Datt, Luo, Tang, and Mallik 2018; Luo et al. 2021). An investigation of this moderating effect increases our understanding of how a country's overall climate change performance interacts with corporate climate change performance to influence information asymmetry.

We measure the stakeholder-oriented business culture of a country (stakeholder-oriented vs. shareholder-oriented) based on a country's nature of the legal system (Simnett et al. 2009). Specifically, we define firms domiciled in code law countries as having a stakeholder-oriented business culture *(STAKE)*, while those located in common law countries are defined as having a shareholder-oriented business culture, following Ball, Kothari and Robin (2000). In addition, *ETS* is an indicator variable, which takes a value of 1 if the firm operates in a country that has a national emissions trading scheme (ETS), and 0 otherwise. Finally, we measure a country's climate change performance using the climate change performance index (*CCPI*) introduced by Germanwatch and Climate Action Network (2020). We create an indicator variable that takes a value of 1 if a country's climate change performance index score is greater than or equal to the sample's median *(HIGH_CCPI)*, and otherwise 0 *(LOW_CCPI)*.

To test the moderating effects of these country-level variables, we adopt sub-sample analysis where we run the baseline regressions on both high and low subsamples. Table 11, Panel A shows the sub-sample analysis based on the country-level stakeholder-oriented business culture. The coefficient of *CCPS* is negative and statistically significant in Model (1), while the interaction coefficients of *CCPS×HIGH_INSTOWN* and *CCPS×HIGH_CGOV* are negative and statistically significant in Models (3) and (5), respectively. Furthermore, the equality of coefficient test of *CCPS*, *CCPS×HIGH_INSTOWN* and *CCPS×HIGH_CGOV* between two groups support our findings. Overall, the results suggest that our findings are more pronounced for firms domiciled in countries with stakeholder-oriented business culture.

[INSERT TABLE 11 ABOUT HERE]

Table 11, Panel B reports the sub-sample analysis based on the country-level adoption of ETS. The coefficient of *CCPS* is negative and statistically significant in Model (1), the interaction coefficient of *CCPS×HIGH_INSTOWN* is negative and statistically significant in Model (3), while the coefficient of *CCPS×HIGH_CGOV* is negative and statistically significant in Model (5). Furthermore, we test the equality of coefficient of *CCPS*, *CCPS×HIGH_INSTOWN* and *CCPS×HIGH_CGOV* between two groups, however, they are statistically insignificant. Although the difference of coefficient is statistically insignificant, the coefficients on *CCPS*, *CCPS×HIGH_INSTOWN* and *CCPS×HIGH_CGOV* are only statistically significant for firms in countries with ETS. Based on these, we argue that the impact of climate change performance on information asymmetry and the moderating role of institutional investor ownership and corporate governance performance in this relationship are more pronounced for firms in countries with a national emissions trading scheme (ETS).

Table 11, Panel C reports the sub-sample analysis based on country-level climate change performance. The coefficients of *CCPS* are negative and statistically significant in both Models (1) and (2). Although we find that the impact of *CCPS* is more pronounced for firms in countries with higher and lower climate change performance, the magnitude of the coefficient is stronger for firms in countries with higher climate change performance scores. Furthermore, the interaction coefficient of *CCPS×HIGH_INSTOWN* is negative and statistically significant in Model (3), while the coefficient of *CCPS×HIGH_CGOV* is negative and statistically significant in Model (5). Furthermore, the equality of coefficient test of *CCPS*, *CCPS×HIGH_INSTOWN* and *CCPS×HIGH_CGOV* between two groups support our findings. Overall, we find that the impact of climate change performance on information asymmetry and the moderating role of institutional investor ownership and corporate governance performance are more pronounced for firms in countries with a higher level of climate change performance.

VII. CONCLUSION

In this study, we examine the association between climate change performance and information asymmetry, and the moderating role of institutional investors and corporate governance in this association. Based on 6,367 firm-year observations across 26 countries from 2011–2020, by addressing transparency and signaling perspectives, we find that climate change performance is negatively associated with information asymmetry. We also find that the negative association between climate change performance and information asymmetry is stronger for firms with a higher level of institutional investors and better-quality corporate governance performance. Our results are robust using Heckman's (1979) two-stage analysis and entropy balancing analysis. Furthermore, we utilize the 2015 Paris Agreement as an external shock to climate change performance for firms within our sample period and run a quasi-experimental analysis. Our findings are found to be robust using this form of analysis. In addition, we analyze the moderating role of country-level contextual factors in the association between climate change performance and information asymmetry. The results indicate that our findings are more pronounced for firms in countries with a stakeholder-oriented business culture, the presence of a national ETS and a higher level of climate change performance.

Our study contributes to the growing literature on climate change performance and its impact on the capital market. We also contribute to the literature by showing that monitoring by institutional investors and internal corporate governance mechanisms accentuate the negative impact of climate change performance on information asymmetry. This study's findings have important implications given that climate change performance is attracting the attention of various stakeholders, including regulators and policy makers, worldwide. Overall, our study contributes to the debate on the costs and benefits of climate change performance, emphasizing its significance for enhancing market transparency and efficiency.

While our study provides valuable insights into the relationship between climate change performance and information asymmetry, it has certain limitations that should be acknowledged. Firstly, our study's sample excludes firms that did not respond to the CDP questionnaires. Although we adopt Heckman's (1979) two-stage approach to address self-selection bias, future studies could validate our findings using data on CDP non-disclosure from other sources. Secondly, although we employ firm and country fixed effects, as well as a quasi-experimental analysis to address endogeneity, our findings may be affected by some omitted variable bias. Despite these limitations, the findings are robust to alternative model specifications and may offer valuable insights to decision-makers about the relationship between climate change performance and information asymmetry, and the moderating roles of institutional investors' ownership and better corporate governance in this association. Future research could focus on more detailed discussion and analysis in one country and compare the findings of this study with findings in other countries and regions. Thirdly, we also acknowledge the inherent limitations of self-reported measures of climate change performance ratings such as climate governance, strategic initiatives, emission reductions and risk management practices. These measures may not fully capture the concrete actions firms take to manage climate risks and can introduce biases, such as over-reporting or greenwashing. Future research should incorporate more objective and standardized measures of climate change performance, such as specific climate risk management actions. This would provide a more accurate assessment of how firms manage climate risks and their impact on market transparency. Moreover, examining the influence of recent regulatory changes, like the SEC's climate risk disclosure mandate, could provide deeper insights into their effects on firms' climate change performance and market transparency.

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Table 1: Sample selection and distribution

Panel A: Sample selection	
CDP data coverage from 2011–2020	17,543
Less: Firm-year observations not matched with other databases	1,796
Firm-year observations available with climate change performance ratings	15,747
Less: Firms not responding to CDP questionnaire	(7,363)
Less: Firm-year observations dropped due to insufficient control variables	(2,017)
Final test sample from 2011–2020	**6,367**

Panel B: Industry-wise distribution of firms in sample

Name of Industry	**Number of firms**	**% of sample**
Mining/Construction	370	5.81
Food	344	5.40
Textiles/Print/Publishing	261	4.10
Chemicals	326	5.12
Pharmaceuticals	204	3.20
Extractive	249	3.91
Manufacturing: Rubber/glass/etc.	116	1.82
Manufacturing: Metal	121	1.90
Manufacturing: Machinery	273	4.29
Manufacturing: Electrical Equipment	167	2.62
Manufacturing: Transport Equipment	286	4.49
Manufacturing: Instruments	220	3.46
Manufacturing: Miscellaneous	38	0.60
Computers	444	6.97
Transportation	539	8.47
Utilities	370	5.81
Retail: Wholesale	104	1.63
Retail: Miscellaneous	348	5.47
Retail: Restaurant	44	0.69
Financial	935	14.69
Insurance/Real Estate	185	2.91
Services	403	6.33
Others	20	0.31
Total Sample	**6,367**	**100**

Panel C: Year-wise distribution of firms in sample

Year	**Number of firms**	**% of sample**
2011	32	0.50
2012	363	5.70
2013	473	7.43
2014	632	9.93
2015	652	10.24
2016	714	11.21
2017	927	14.56
2018	880	13.82
2019	851	13.37
2020	843	13.24
Total	**6,367**	**100**

Table 2: Descriptive statistics

Panel A: Descriptive statistics

	Observations	Mean	Std. Dev.	Median	1st Quartile	3rd Quartile
SPREAD	6,367	0.137	0.190	0.089	0.034	0.159
CCPS	6,367	0.471	0.370	0.500	0.000	0.800
SIZE	6,367	9.128	1.274	9.105	8.192	9.997
ROA	6,367	0.048	0.057	0.042	0.015	0.077
LEV	6,367	0.254	0.165	0.238	0.130	0.360
FAGE	6,367	2.347	0.905	2.565	1.792	3.045
RISK	6,367	0.018	0.007	0.017	0.014	0.022
ANALYST	6,367	5.181	0.545	5.273	4.905	5.545
LNPRICE	6,367	3.293	1.150	3.353	2.483	4.118
ENVPERF	6,367	0.791	0.407	1.000	1.000	1.000
CSRDISC	6,367	0.412	0.332	0.472	0.000	0.714
CSPREAD	6,367	0.089	0.130	0.007	0.005	0.277
INSTOWN	6,367	0.600	0.280	0.614	0.398	0.848
CGOV	6,367	0.605	0.206	0.631	0.452	0.774
LNGDP	6,367	10.651	0.560	10.767	10.579	10.947
CRI	6,367	4.154	0.351	4.177	3.836	4.477
STAKE	6,367	0.798	0.402	1.000	1.000	1.000
LEGAL	6,367	2.501	0.827	2.534	2.464	3.032

Panel B: Mean and median test results

	HIGH_CCPS **(N=3,899)**		***LOW_CCPS*** **(N=2,468)**		**Mean test (*p*-value)**	**Median test (*p*-value)**
	Mean	**Median**	**Mean**	**Median**		
SPREAD	0.112	0.083	0.176	0.106	0.000	0.000
SIZE	9.347	9.309	8.782	8.734	0.000	0.000
ROA	0.049	0.043	0.047	0.041	0.098	0.392
LEV	0.255	0.238	0.253	0.239	0.552	0.526
FAGE	2.373	2.565	2.306	2.565	0.004	0.012
RISK	0.018	0.017	0.019	0.017	0.002	0.005
ANALYST	5.235	5.323	5.095	5.187	0.000	0.000
LNPRICE	3.322	3.388	3.247	3.316	0.011	0.015
ENVPERF	0.441	0.531	0.366	0.388	0.000	0.000
CSRDISC	0.831	1.000	0.728	1.000	0.000	0.000
CSPREAD	0.592	0.601	0.612	0.638	0.012	0.000
INSTOWN	0.619	0.650	0.583	0.611	0.007	0.000
CGOV	0.086	0.006	0.095	0.009	0.000	0.000
LNGDP	10.637	10.716	10.673	10.789	0.013	0.000
CRI	4.154	4.190	4.154	4.162	0.970	0.536
STAKE	0.482	0.000	0.495	0.000	0.313	0.313
LEGAL	2.479	2.524	2.535	2.574	0.008	0.000

Note: Definitions of variables are provided in Appendix A.

Table 3: Country descriptive statistics

	Observations	% of sample	*SPREAD* (%)	*CCPS*	*STAKE*	*LEGAL*	*CRI*
Australia	98	1.54	0.701	0.385	0	3.195	49.635
Austria	22	0.35	0.249	0.318	1	2.807	63.599
Belgium	14	0.22	0.138	0.500	1	2.473	71.009
Brazil	113	1.77	0.273	0.487	1	-0.336	67.999
Canada	282	4.43	0.308	0.411	0	3.171	52.635
Denmark	70	1.10	0.118	0.486	1	3.432	84.324
Finland	70	1.10	0.133	0.544	1	3.512	111.122
France	390	6.13	0.109	0.507	1	2.290	51.109
Germany	95	1.49	0.449	0.230	1	3.020	47.172
Hong Kong	6	0.09	0.314	0.500	0	3.073	112.473
India	58	0.91	0.092	0.578	0	-0.329	20.455
Ireland	29	0.46	0.223	0.499	0	2.797	77.818
Italy	70	1.10	0.166	0.461	1	0.661	45.609
Japan	958	15.05	0.161	0.507	1	2.500	38.669
Netherlands	78	1.23	0.091	0.582	1	3.332	79.579
Norway	102	1.60	0.170	0.463	1	3.399	82.837
Portugal	7	0.11	0.216	0.000	1	1.649	50.360
Singapore	16	0.25	0.195	0.535	0	3.550	121.188
South Africa	184	2.89	0.238	0.465	0	0.205	44.591
South Korea	150	2.36	0.182	0.491	1	1.506	77.235
Spain	127	1.99	0.147	0.475	1	1.528	57.194
Sweden	164	2.58	0.116	0.520	1	3.477	87.946
Switzerland	207	3.25	0.095	0.506	1	3.322	69.523
Turkey	53	0.83	0.191	0.490	1	-0.096	85.020
United Kingdom	960	15.08	0.127	0.451	0	3.037	64.087
United States	2,044	32.10	0.052	0.462	0	2.529	26.402
Total/Average	**6,367**	**100**	**0.137**	**0.471**		**2.501**	**47.911**

Table 4: Correlation matrix

		[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]
SPREAD	**[1]**	1.000																	
CCPS	**[2]**	-0.158***	1.000																
SIZE	**[3]**	-0.357***	0.247***	1.000															
ROA	**[4]**	-0.090***	0.010	0.164***	1.000														
LEV	**[5]**	-0.076***	-0.002	-0.016	-0.148***	1.000													
FAGE	**[6]**	-0.061***	0.041***	0.066***	-0.019*	-0.021*	1.000												
RISK	**[7]**	0.158***	-0.045***	-0.269***	-0.250***	-0.014	-0.076***	1.000											
ANALYST	**[8]**	-0.191***	0.140***	0.551***	0.095***	-0.037***	-0.006	-0.068***	1.000										
LNPRICE	**[9]**	-0.271***	0.039***	0.416***	0.258***	-0.056***	0.063***	-0.327***	0.199***	1.000									
ENVPERF	**[10]**	-0.081***	0.118***	0.213***	-0.011	0.074***	0.014	-0.060***	0.146***	0.066***	1.000								
CSRDISC	**[11]**	-0.024*	0.148***	0.167***	0.019	0.005	0.036***	-0.079***	0.059***	0.031**	0.194***	1.000							
CSPREAD	**[12]**	-0.260***	-0.019	0.323***	0.146***	0.077***	0.082***	-0.111***	0.119***	0.357***	0.025**	-0.149***	1.000						
HIGH_INSTOWN	**[13]**	-0.259***	-0.078***	0.147***	0.149***	0.063***	0.008	-0.135***	0.120***	0.146***	-0.013	0.058***	0.497***	1.000					
HIGH_CGOV	**[14]**	-0.120***	0.051***	0.228***	0.002	0.041***	0.025**	-0.057***	0.164***	0.075***	0.084***	0.076***	0.124***	0.150***	1.000				
LNGDP	**[15]**	-0.097***	-0.023*	0.147***	0.005	-0.003	0.077***	-0.157***	0.105***	0.342***	0.010	-0.082***	0.283***	0.160***	0.100***	1.000			
CRI	**[16]**	0.161***	0.026**	-0.282***	-0.081***	-0.071***	-0.053***	0.077***	-0.222***	-0.329***	-0.067***	0.102***	-0.561***	-0.307***	-0.074***	-0.075***	1.000		
STAKE	**[17]**	0.205***	-0.005	0.003	-0.034***	-0.001	0.003	-0.105***	-0.011	0.209***	0.057***	0.117***	-0.237***	-0.327***	-0.062***	0.089***	0.195***	1.000	
LEGAL	**[18]**	0.060***	-0.016	-0.130***	-0.036***	-0.100***	0.026**	-0.050***	-0.005	-0.108***	-0.045***	-0.015	-0.306***	-0.022***	0.028**	0.561***	0.337***	-0.136***	1.000

Notes: Superscript ***, ** and * represent statistical significance at the 1%, 5% and 10% levels, respectively; definitions of variables are provided in Appendix A.

Table 5: Regression results of association between information asymmetry and climate change performance

	Dependent variable=*SPREAD*		
	Model (1)	**Model (2)**	**Model (3)**
CCPS	-0.042***	-0.051***	-0.024**
	(-3.735)	(-3.904)	(-2.532)
CCPS×HIGH_INSTOWN	—	-0.029***	—
		(-4.873)	
HIGH_INSTOWN	—	-0.015	—
		(-1.107)	
CCPS×HIGH_CGOV	—	—	-0.029***
			(-2.977)
HIGH_CGOV	—	—	0.005
			(0.529)
SIZE	-0.026***	-0.024***	-0.025***
	(-3.031)	(-2.977)	(-2.929)
ROA	0.119	0.149	0.120
	(0.927)	(1.161)	(0.925)
LEV	-0.072*	-0.067*	-0.070*
	(-1.821)	(-1.791)	(-1.778)
FAGE	-0.004	-0.004	-0.004
	(-1.692)	(-1.674)	(-1.680)
RISK	0.819	0.705	0.836
	(1.047)	(0.865)	(1.063)
ANALYST	-0.002	0.004	-0.001
	(-0.142)	(0.382)	(-0.053)
LNPRICE	-0.032*	-0.031*	-0.032*
	(-1.985)	(-2.012)	(-1.987)
ENVPERF	-0.011	-0.013	-0.011
	(-1.197)	(-1.621)	(-1.282)
CSRDISC	-0.002	-0.002	-0.002
	(-0.227)	(-0.255)	(-0.157)
CSPREAD	0.453***	0.521***	0.459***
	(2.826)	(3.317)	(2.882)
LNGDP	-0.141**	-0.139**	-0.141**
	(-2.446)	(-2.471)	(-2.461)
CRI	-0.076	-0.086	-0.076
	(-1.024)	(-1.205)	(-1.027)
STAKE	0.220***	0.202***	0.219***
	(3.952)	(3.898)	(3.929)
LEGAL	0.099**	0.100**	0.100**
	(2.192)	(2.284)	(2.220)
Intercept	1.977***	1.982***	1.958***
	(3.160)	(3.226)	(3.137)
Year Fixed Effects	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes
Observations	6367	6367	6367
R^2	0.339	0.357	0.340

Notes: Superscript ***, ** and * represent statistical significance at the 1%, 5% and 10% levels, respectively; coefficient values (robust *t*-statistics) are shown with standard errors clustered at the firm level; definitions of variables are provided in Appendix A.

Table 6: Heckman's (1979) two-stage model analysis

Panel A: Heckman's (1979) first-stage probit regression results

	Coefficient	*z*-stat	*p*-value
PIDEC	0.079	2.011	0.044**
SIZE	-1.179	-3.655	0.000***
ROA	-0.014	-2.393	0.017**
MB	0.012	0.086	0.932
LEV	0.080	3.522	0.000***
FAGE	0.384	7.002	0.000***
FOREIGN	-1.321	-2.627	0.009***
CAPIN	-0.118	-3.845	0.000***
RISK	0.220	5.448	0.000***
ANALYST	0.980	12.669	0.000***
ENVPERF	0.610	12.929	0.000***
CSR_DISC	0.059	0.806	0.420
LNGDP	0.560	7.163	0.000***
CRI	-0.111	-2.049	0.040**
STAKE	-0.027	-0.465	0.642
LEGAL	-5.017	-5.838	0.000***
Intercept	0.079	2.011	0.044**
Year Fixed Effects		Yes	
Industry Fixed Effects		Yes	
Observations		14,359	
Pseudo R^2		0.223	
Log likelihood		-6962.87	
ROC curve		0.810	

Panel B: Heckman's (1979) second-stage regression results for association between information asymmetry and climate change performance.

	Dependent variable=*SPREAD*		
	Model (1)	Model (2)	Model (3)
CCPS	-0.055***	-0.079***	-0.022*
	(-2.929)	(-3.411)	(-1.839)
CCPS×HIGH_INSTOWN	—	-0.051***	—
		(-4.629)	
HIGH_INSTOWN	—	-0.058***	—
		(-2.922)	
CCPS×HIGH_CGOV	—	—	-0.055***
			(-3.755)
HIGH_CGOV	—	—	0.012
			(1.032)
SIZE	-0.022***	-0.021**	-0.021**
	(-3.004)	(-2.656)	(-2.774)
ROA	-0.070	0.050	-0.064
	(-0.735)	(0.539)	(-0.668)
LEV	-0.091**	-0.075*	-0.087**
	(-2.180)	(-2.006)	(-2.087)
FAGE	-0.000	-0.002	-0.000
	(-0.003)	(-0.530)	(-0.075)
RISK	0.999	0.779	1.057*
	(1.608)	(1.201)	(1.758)
ANALYST	0.005	0.015	0.006
	(0.266)	(0.844)	(0.355)
LNPRICE	-0.024	-0.028*	-0.024
	(-1.346)	(-1.732)	(-1.372)

ENVPERF	0.050	0.027	0.047
	(1.421)	(0.886)	(1.375)
CSRDISC	0.041	0.036	0.041
	(1.640)	(1.357)	(1.646)
CSPREAD	-0.166	0.136	-0.147
	(-1.405)	(1.285)	(-1.231)
LNGDP	-0.020	-0.061	-0.023
	(-0.373)	(-1.211)	(-0.445)
CRI	-0.002	-0.047	-0.005
	(-0.042)	(-0.823)	(-0.084)
STAKE	0.080**	0.108***	0.082**
	(2.178)	(3.105)	(2.230)
LEGAL	0.017	0.052	0.020
	(0.391)	(1.279)	(0.475)
IMR	0.141	0.101	0.137
	(1.431)	(1.123)	(1.408)
Intercept	0.505	1.060**	0.515
	(0.913)	(2.062)	(0.944)
Year Fixed Effects	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes
Observations	5,925	5,925	5,925
R^2	0.233	0.304	0.237

Notes: Superscript ***, ** and * represent statistical significance at the 1%, 5% and 10% levels, respectively; coefficient values (robust t-statistics) are shown with standard errors clustered at the firm level; definitions of variables are provided in Appendix A.

Table 7: Entropy balancing analysis

Panel A: Descriptive statistics of variables before entropy balancing

	Treatment (HIGH_CCPS)			**Control (LOW_CCPS)**		
	Mean	**Variance**	**Skewness**	**Mean**	**Variance**	**Skewness**
SIZE	9.407	1.619	0.056	8.821	1.517	0.193
ROA	0.050	0.003	0.163	0.048	0.004	-0.101
LEV	0.255	0.027	0.540	0.251	0.028	0.495
FAGE	2.350	0.792	-0.923	2.296	0.815	-0.885
RISK	0.019	0.000	1.570	0.020	0.000	1.453
ANALYST	5.248	0.277	-1.178	5.110	0.290	-0.954
LNPRICE	3.305	1.259	-0.103	3.219	1.236	-0.073
ENVPERF	0.434	0.116	-0.166	0.343	0.091	0.250
CSRDISC	0.798	0.162	-1.480	0.646	0.229	-0.610
CSPREAD	0.090	0.017	0.667	0.101	0.018	0.528
LNGDP	10.630	0.329	-3.111	10.660	0.305	-3.554
CRI	4.122	0.142	0.465	4.102	0.137	0.414
STAKE	0.466	0.249	0.137	0.477	0.250	0.093
LEGAL	2.500	0.662	-1.955	2.540	0.628	-2.309

Panel B: Descriptive statistics of variables after entropy balancing

	Treatment (HIGH_CCPS)			**Control (LOW_CCPS)**		
	Mean	**Variance**	**Skewness**	**Mean**	**Variance**	**Skewness**
SIZE	9.407	1.619	0.056	9.407	1.619	0.056
ROA	0.050	0.003	0.163	0.050	0.003	0.163
LEV	0.255	0.027	0.540	0.255	0.027	0.540
FAGE	2.350	0.792	-0.923	2.350	0.792	-0.923
RISK	0.019	0.000	1.570	0.019	0.000	1.570
ANALYST	5.248	0.277	-1.178	5.248	0.277	-1.178
LNPRICE	3.305	1.259	-0.103	3.305	1.259	-0.103
ENVPERF	0.434	0.116	-0.166	0.434	0.116	-0.166
CSRDISC	0.798	0.162	-1.480	0.798	0.162	-1.481
CSPREAD	0.090	0.017	0.667	0.090	0.017	0.667
LNGDP	10.630	0.329	-3.111	10.640	0.329	-3.111
CRI	4.122	0.142	0.465	4.122	0.142	0.465
STAKE	0.466	0.249	0.137	0.466	0.249	0.137
LEGAL	2.500	0.662	-1.955	2.500	0.662	-1.955

Panel C: Regression results of association between information asymmetry and climate change performance using entropy balanced sample

	Dependent variable=*SPREAD*		
	Model (1)	**Model (2)**	**Model (3)**
CCPS	-0.030^{***}	-0.042^{***}	-0.011^{**}
	(-6.706)	(-9.107)	(-2.037)
CCPS×HIGH_INSTOWN	—	-0.026^{***}	—
		(-16.554)	
HIGH_INSTOWN	—	-0.020^{***}	—
		(-3.428)	
CCPS×HIGH_CGOV	—	—	-0.030^{***}
			(-4.874)
HIGH_CGOV	—	—	0.007
			(1.360)
SIZE	-0.020^{***}	-0.017^{***}	-0.019^{***}
	(-9.747)	(-8.322)	(-9.481)

ROA	0.039	0.066*	0.042
	(1.134)	(1.919)	(1.224)
LEV	-0.053***	-0.047***	-0.050***
	(-4.151)	(-3.725)	(-3.952)
FAGE	-0.002	-0.002	-0.002
	(-1.017)	(-1.133)	(-1.071)
RISK	0.199	0.059	0.219
	(0.573)	(0.171)	(0.632)
ANALYST	-0.015***	-0.009**	-0.014***
	(-3.788)	(-2.127)	(-3.509)
LNPRICE	-0.018***	-0.019***	-0.018***
	(-6.892)	(-7.312)	(-6.864)
ENVPERF	-0.004	-0.007	-0.005
	(-0.682)	(-1.400)	(-0.856)
CSRDISC	0.001	0.003	0.001
	(0.135)	(0.575)	(0.251)
CSPREAD	0.331***	0.410***	0.338***
	(7.511)	(9.450)	(7.659)
LNGDP	-0.123***	-0.122***	-0.122***
	(-8.953)	(-9.124)	(-8.957)
CRI	-0.029***	-0.042***	-0.029***
	(-3.240)	(-4.723)	(-3.256)
STAKE	0.167***	0.148***	0.166***
	(15.613)	(13.412)	(15.458)
LEGAL	0.075***	0.078***	0.076***
	(7.749)	(8.203)	(7.801)
Intercept	1.547***	1.571***	1.530***
	(11.452)	(11.996)	(11.355)
Year Fixed Effects	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes
Observations	6,367	6,367	6,367
R^2	0.291	0.315	0.292

Notes: Superscript ***, ** and * represent statistical significance at the 1%, 5% and 10% levels, respectively; coefficient values (robust *t*-statistics) are shown with standard errors clustered at the firm level; definitions of variables are provided in Appendix A.

Table 8: Quasi-experimental analysis

	Dependent variable=*SPREAD*	
	Model (1)	**Model (2)**
CCPS	-0.027**	-0.030***
	(-2.458)	(-2.800)
CCPS×POST	-0.033**	-0.030**
	(-2.161)	(-2.097)
POST	-0.033	-0.032
	(-0.920)	(-0.884)
SIZE	-0.033***	-0.031***
	(-4.836)	(-4.955)
ROA	0.009	0.038
	(0.071)	(0.279)
LEV	-0.081**	-0.091**
	(-2.094)	(-2.200)
FAGE	-0.006*	-0.006*
	(-1.980)	(-1.814)
RISK	1.265*	1.969**
	(2.015)	(2.424)
ANALYST	-0.002	-0.003
	(-0.156)	(-0.246)
LNPRICE	-0.028	-0.029
	(-1.683)	(-1.627)
ENVPERF	-0.011	-0.009
	(-1.415)	(-1.218)
CSRDISC	-0.004	-0.003
	(-0.346)	(-0.323)
CSPREAD	-0.015	-0.032
	(-0.161)	(-0.319)
LNGDP	-0.083	-0.075
	(-1.648)	(-1.498)
CRI	-0.037	-0.044
	(-0.586)	(-0.654)
STAKE	0.114***	0.113**
	(2.815)	(2.674)
LEGAL	0.056	0.055
	(1.399)	(1.380)
Intercept	1.481**	1.321**
	(2.461)	(2.317)
Year Fixed Effects	Yes	Yes
Industry Fixed Effects	Yes	Yes
Country Fixed Effects	Yes	Yes
Observations	4,572	5,499
R^2	0.267	0.275

Notes: Superscript ***, ** and * represent statistical significance at the 1%, 5% and 10% levels, respectively; coefficient values (robust *t*-statistics) are shown with standard errors clustered at the firm level; definitions of variables are provided in Appendix A.

Table 9: Regression results of association between information asymmetry and climate change performance: Firm and country fixed effects

Panel A: Firm fixed effects			
	Dependent variable=*SPREAD*		
	Model (1)	**Model (2)**	**Model (3)**
CCPS	-0.017**	-0.025***	0.004
	(-2.594)	(-4.694)	(0.548)
CCPS×HIGH_INSTOWN	—	-0.018***	—
		(-9.017)	
HIGH_INSTOWN	—	-0.031***	—
		(-4.817)	
CCPS×HIGH_CGOV	—	—	-0.035***
			(-4.126)
HIGH_CGOV	—	—	0.001
			(0.124)
Intercept	0.321	0.374	0.265
	(0.396)	(1.547)	(0.331)
Control Variables	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Industry Fixed Effects	No	No	No
Firm Fixed Effects	Yes	Yes	Yes
Observations	6,367	6,367	6,367
R^2	0.797	0.801	0.798
Panel B: Country fixed effects			
	Dependent variable=*SPREAD*		
	Model (1)	**Model (2)**	**Model (3)**
CCPS	-0.021***	-0.028***	-0.003
	(-4.555)	(-5.517)	(-0.540)
CCPS×HIGH_INSTOWN	—	-0.021***	—
		(-8.114)	
HIGH_INSTOWN	—	0.001	—
		(0.124)	
CCPS×HIGH_CGOV	—	—	-0.029***
			(-4.049)
HIGH_CGOV	—	—	-0.003
			(-0.655)
Intercept	0.992	1.042	0.935
	(1.429)	(1.531)	(1.366)
Control Variables	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes
Observations	6,367	6,367	6,367
R^2	0.604	0.614	0.607

Notes: Superscript ***, ** and * represent statistical significance at the 1%, 5% and 10% levels, respectively; coefficient values (robust *t*-statistics) are shown with standard errors clustered at the firm level; definitions of variables are provided in Appendix A.

Table 10: Regression results of association between information asymmetry and climate change performance: Some components of CCPS

	Dependent variable=*SPREAD*		
	Emission_Reduction	**Carbon_Assurance**	**Carbon_Incentive**
	Model (1)	**Model (2)**	**Model (3)**
CCPS	-0.011**	-0.012***	-0.027***
	(-2.060)	(-2.661)	(-4.797)
SIZE	-0.033***	-0.034***	-0.033***
	(-10.161)	(-12.886)	(-12.865)
ROA	0.069	0.021	0.016
	(1.325)	(0.469)	(0.345)
LEV	-0.071***	-0.086***	-0.086***
	(-3.373)	(-5.215)	(-5.255)
FAGE	-0.007*	-0.005**	-0.005*
	(-1.938)	(-2.016)	(-1.878)
RISK	1.120**	1.620***	1.566***
	(2.214)	(3.856)	(3.742)
ANALYST	-0.010*	-0.008*	-0.008*
	(-1.850)	(-1.780)	(-1.864)
LNPRICE	-0.023***	-0.023***	-0.023***
	(-5.644)	(-7.339)	(-7.389)
ENVPERF	-0.004	-0.004	-0.002
	(-0.538)	(-0.703)	(-0.293)
CSRDISC	0.009	0.003	0.004
	(1.229)	(0.480)	(0.657)
CSPREAD	-0.132***	-0.164***	-0.158***
	(-5.910)	(-7.900)	(-7.588)
LNGDP	-0.022**	-0.025**	-0.025***
	(-2.173)	(-2.570)	(-2.622)
CRI	-0.025**	-0.026***	-0.026**
	(-2.112)	(-2.613)	(-2.571)
STAKE	0.066***	0.077***	0.077***
	(9.678)	(13.484)	(13.488)
LEGAL	0.019**	0.021***	0.021***
	(2.484)	(2.892)	(2.916)
Intercept	0.741***	0.862***	0.873***
	(6.613)	(7.861)	(7.970)
Year Fixed Effects	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes
Observations	4,120	6,367	6,367
R^2	0.224	0.226	0.228

Notes: Superscript ***, ** and * represent statistical significance at the 1%, 5% and 10% levels, respectively; coefficient values (robust t-statistics) are shown with standard errors clustered at the firm level; definitions of variables are provided in Appendix A.

Table 11: Regression results of association between information asymmetry and climate change performance: Country-level factors

Panel A: Regression results of association between information asymmetry and climate change performance using country-level stakeholder orientation

	Dependent variable=*SPREAD*					
	STAKE=1	*STAKE=0*	*STAKE=1*	*STAKE=0*	*STAKE=1*	*STAKE=0*
	Model (1)	**Model (2)**	**Model (3)**	**Model (4)**	**Model (5)**	**Model (6)**
CCPS	-0.046***	-0.004	0.033*	-0.009	-0.004	-0.010
	(-3.800)	(-0.919)	(1.746)	(-1.440)	(-0.425)	(-1.636)
CCPS×HIGH_INSTOWN	—	—	-0.159***	0.007	—	—
			(-3.240)	(1.286)		
HIGH_INSTOWN	—	—	0.137***	-0.006	—	—
			(3.384)	(-0.803)		
CCPS×HIGH_CGOV	—	—	—	—	-0.073***	0.009
					(-3.450)	(1.197)
HIGH_CGOV	—	—	—	—	0.016	-0.011**
					(1.157)	(-3.272)
Intercept	2.441***	0.220	1.909***	0.223	2.396***	0.222
	(3.609)	(1.365)	(3.132)	(1.378)	(3.609)	(1.402)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,100	3,267	3,100	3,267	3,100	3,267
R^2	0.304	0.483	0.340	0.483	0.310	0.486
Test of equality of coefficient (Chi^2)	25.23***		184.79***		20.25***	

Panel B: Regression results of association between information asymmetry and climate change performance using country-level adoption of national emissions trading scheme (ETS)

	Dependent variable=*SPREAD*					
	ETS=1	**ETS=0**	**ETS=1**	**ETS=0**	**ETS=1**	**ETS=0**
	Model (1)	**Model (2)**	**Model (3)**	**Model (4)**	**Model (5)**	**Model (6)**
CCPS	-0.040***	-0.026	-0.058***	-0.009	0.001	0.005
	(-3.219)	(-1.134)	(-3.141)	(-0.367)	(0.118)	(0.184)
CCPS×HIGH_INSTOWN	—	—	-0.034***	-0.048	—	—
			(-6.437)	(-1.234)		
HIGH_INSTOWN	—	—	-0.048**	-0.025	—	—
			(-2.647)	(-0.877)		
CCPS×HIGH_CGOV	—	—	—	—	-0.064***	-0.056
					(-4.227)	(-1.097)
HIGH_CGOV	—	—	—	—	0.010	0.014
					(1.118)	(0.620)
Intercept	1.731**	1.702***	1.844**	1.802***	1.719**	1.683***
	(2.177)	(4.193)	(2.565)	(4.259)	(2.206)	(4.124)

Control Variables	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5,716	651	5,716	651	5,716	651
R^2	0.257	0.653	0.307	0.661	0.265	0.655
Test of equality of coefficient (Chi^2)	0.71		0.59		0.29	

Panel C: Regression results of association between information asymmetry and climate change performance using a country-level climate change performance index (CCPI) score

	Dependent variable=*SPREAD*					
	HIGH_CCPI	*LOW_CCPI*	*HIGH_CCPI*	*LOW_CCPI*	*HIGH_CCPI*	*LOW_CCPI*
	Model (1)	**Model (2)**	**Model (3)**	**Model (4)**	**Model (5)**	**Model (6)**
CCPS	-0.062***	-0.009**	-0.093***	-0.009**	-0.022	-0.002
	(-2.789)	(-2.665)	(-3.649)	(-2.602)	(-1.662)	(-0.249)
CCPS×HIGH_INSTOWN	—	—	-0.060***	-0.007	—	—
			(-4.579)	(-1.397)		
HIGH_INSTOWN	—	—	-0.081***	-0.012	—	—
			(-4.344)	(-1.623)		
CCPS×HIGH_CGOV	—	—	—	—	-0.066***	-0.010
					(-3.703)	(-1.329)
HIGH_CGOV	—	—	—	—	0.012	-0.007
					(0.904)	(-1.564)
Intercept	0.777	0.389*	1.285**	0.466**	0.774	0.369*
	(1.258)	(1.904)	(2.304)	(2.656)	(1.276)	(1.873)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,605	1,762	4,605	1,762	4,605	1,762
R^2	0.308	0.461	0.335	0.463	0.317	0.470
Test of equality of coefficient (Chi^2)	31.35***		151.91***		12.08***	

Notes: Superscript ***, ** and * represent statistical significance at the 1%, 5% and 10% levels, respectively; coefficient values (robust *t*-statistics) are shown with standard errors clustered at the firm level; definitions of variables are provided in Appendix A.

Appendix A: Definitions of variables

Notation	Variable Name	Explanation
Panel A: Dependent variable		
SPREAD	Information asymmetry	The average of the daily closing bid–ask spreads as a percentage of the daily closing price from October to December of year *t*.
Panel B: Research variable		
CCPS	Climate change performance score	CDP score from collection of firms' responses in CDP questionnaires on their activities to address climate change.
Panel C: Firm-level control variables		
SIZE	Firm size	Natural logarithm of market capitalization at the beginning of the year.
ROA	Profitability	Measured as net income before extraordinary items divided by total assets.
LEV	Leverage	Measured as total debt divided by total assets.
FAGE	Firm age	Natural logarithm of the number of years since the firm's inception.
RISK	Stock return volatility	Measured as the standard deviation of daily stock returns over the fiscal year.
ANALYST	Analyst coverage	Natural logarithm of the total number of analysts following a firm over a fiscal year.
LNPRICE	Share price	Measured as the natural logarithm of the annual average of closing stock prices.
ENVPERF	Environmental performance score	Measured as the environmental performance score from the Refinitiv ESG database
CSRDISC	CSR disclosure	An indicator variable that takes a value of 1 if a firm issues a CSR or sustainability report or publishes a section in its annual report on CSR/sustainability, and 0 otherwise.
CDP	Firm's response to CDP	Measured as an indicator variable coded 1 if the firm responds to the CDP questionnaire, and 0 otherwise.
PIDEC	Political ideology	An indicator variable of 1 if a country has a left-wing government, 0 if a country has a centrist government; and -1 if a country has a right-wing government.
MB	Market-to-book value	The ratio of market value of equity to book value of equity
CAPIN	Capital intensity	Measured as the firm's capital expenditure scaled by its sales revenue
FOREIGN	Foreign operations	An indicator variable that takes a value of 1 if the firm has foreign operations, and 0 otherwise.
Panel D: Country-level control variables		
CSPREAD	Country-level spread	The average of the bid–ask spreads of all firms from the country for the month of the analysis.
LNGDP	Gross domestic product	Natural logarithm of gross domestic product (GDP) per capita.
CRI	Climate risk index	Global climate risk index data collected from Germanwatch and Climate Action Network. A higher score indicates lower country-level global climate risk.
LEGAL	Legal environment	Measured as the principal component factor of rule of law, regulatory quality and control of corruption index score rated by the World bank (2022).
Panel E: Moderating variables		
HIGH_CGOV	Corporate governance performance	An indicator variable that takes a value of 1 if the firm's corporate governance performance score is higher than yearly median of corporate governance performance score and 0 otherwise.
HIGH_INSTOWN	Institutional investor ownership	An indicator variable that takes a value of 1 if the firm's institutional investors' ownership is higher than yearly median of institutional investors' ownership, and 0 otherwise.
STAKE	Business culture	An indicator variable that takes the value of 1 if a firm domiciled in a country with stakeholder orientation, and 0 otherwise.
ETS	Emissions trading scheme	An indicator variable that takes a value of 1 if the firm operates in a country that has a national emissions trading scheme (ETS), and 0 otherwise.
CCPI	Climate change performance index score	Climate change performance index score from Germanwatch and Climate Action Network. Higher score indicates higher country-level climate change performance.