Economic Uncertainty and Climate Change Exposure

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Abstract

This paper explores how economic uncertainty affects firms' climate change exposure. We use an extensive sample from 24 countries from 2002 to 2021. Employing a novel measure of firm-level climate change exposure developed by Sautner et al. (2023b), we empirically demonstrate that prior to the Paris Agreement in 2015, economic uncertainty leads to a decrease in climate change disclosures. However, after the Paris Agreement, our findings reveal a positive association between economic uncertainty and climate change exposure. The positive disclosure effect is primarily driven by higher climate-related opportunities and regulatory exposures. Our findings are robust when we employ alternative definitions for economic uncertainty, alternative samples, additional firm-level and country-level control variables, and alternative methodologies. Analyzing the moderating impact of firm-level ownership structures, we find that the positive impact of economic uncertainty on climate change disclosures (after the Paris Agreement) is stronger for firms with higher institutional and higher foreign ownership. Further analysis investigates the moderating impact of country-level environmental performance indicators. We present novel empirical evidence suggesting that firms operating in countries with less climate vulnerability, higher readiness, more stringent environmental policies, superior climate protection performance, and higher environmental litigation risk tend to have higher climate change exposure in uncertain times.

Keywords: Climate change, economic uncertainty, Paris Agreement, ownership

Jel Classification: G30, G32, G34

1. Introduction

Extreme weather events, decreasing biodiversity, droughts, sea-level rise, and high temperatures are among the consequences of climate change for the natural world. According to the World Economic Forum (2023), extreme weather events and climate-related disasters have led to substantial economic losses, totaling nearly $1.5 trillion from 2010 to 2019, representing a significant increase from $997.9billion from 2000 to 2009. Climate change and environmental degradation pose a threat to the entire world. In response to that, countries and international organizations develop action plans. For example, the UN has pledged to achieve net-zero emissions. Over 140 countries, including major polluters like China, the United States, India, and the European Union, accounting for approximately 88% of global emissions, have set their net-zero goals. Likewise, the EU's 2050 long-term strategy aims for climate neutrality by 2050, meaning the economy will achieve net-zero greenhouse emissions.[1] In this regard, the Paris Agreement, signed on December 12, 2015, at the UN Climate Change Conference (COP21) in Paris, represents a major global commitment to tackle climate change and promote a sustainable, low-carbon future.

The scarcity of resources and the impacts of climate change are increasingly reshaping financial decisions worldwide (Calvet al., 2022) as their consequences become more visible. Investors and corporations try to align their strategies with global sustainability goals and environmental regulations. Given the urgent nature of climate change consequences, companies need to provide high-quality, timely, and comparable information on sustainability-related risks and opportunities and how that could impact their operations. Accordingly, several global initiatives have been launched. For example, the International Financial Reporting Standards (IFRS) Foundation established the International Sustainability Standards Board in 2021 and issued IFRS S2 Climate-related Disclosures in 2023 that provide a global baseline for sustainability-related financial disclosures[2].

[1] https://climate.ec.europa.eu/eu-action/climate-strategies-targets/2050-long-term-strategy_en

[2] Moreover, the Financial Stability Board established the Task Force on Climate-related Financial Disclosures (TCFD) in 2015 to enhance and expand the reporting of climate-related financial information. The Corporate Sustainability Reporting Directive (CSRD) is a European Union legislation, effective from January 5, 2023, mandating EU businesses to disclose the social and environmental risks they face.

Meanwhile, economic uncertainty impacts firms in several ways, including a higher risk of debt default, lower stock prices, and reduced investments (Gulen and Ion, 2016; Huang et al., 2024; Jung and Song, 2023). In response, investors rely more on firm disclosures, mainly because as economic uncertainty rises, stock price informativeness reduces and the value of firm-specific information increases. Despite the amount of literature on its influence on the real economy, whether economic uncertainty affects firm disclosures is relatively less explored. In this paper, we explore how economic uncertainty affects firms' disclosures on their climate change exposures.

A growing stream of research focuses on how economic (policy) uncertainty influences firms' voluntary disclosures on their business, operations, earnings, and etc. For example, Nagar et al. (2019) demonstrate that managers can mitigate information asymmetry caused by economic policy uncertainty (EPU) through additional voluntary disclosures in the U.S. Likewise, Lu et al. (2024) find a positive relationship between EPU and Chinese firms' voluntary earnings forecast disclosures, suggesting that as external uncertainty rises, firms use these disclosures to reduce information asymmetry. Similarly, Boone et al. (2020) show that managers in the U.S. respond to local policy uncertainty by increasing their voluntary disclosure.

On the other hand, the 2015 Paris Agreement marked a significant global initiative to address climate change, establishing targets for reducing greenhouse gas emissions and strategies for mitigating its impacts. Firms that recognize the urgency of climate issues are more likely to take preemptive and precautionary measures in response to climate-related shocks (Feng et al., 2024). Consequently, there has been a growing emphasis in research on how economic uncertainty influences the green behavior of firms, presenting mixed findings. Hou et al. (2022) find that EPU negatively influences their Chinese firms' green behavior which is measured by an index derived from firms' corporate social responsibility (CSR) reports. On the contrary, Zhang et al. (2023) find that EPU positively affects green commitment, with this impact being more significant for non-state-owned enterprises, manufacturing companies, and firms that are not heavy polluters. This result aligns with Yuan et al. (2022), who argue that as EPU increases, firms are more likely to engage in corporate social responsibility (CSR) to send positive signals, reduce negative stakeholder perceptions, and gain long-term competitive advantages. Recently, Hoang

(2024) reports that, using ESG scores as a measure of disclosure, firms in the U.S. provide more environmental, social, and governance (ESG) information when climate policy uncertainty (CPU) increases, supporting the idea that firms use ESG reporting to protect themselves from climate risks. Meanwhile, Assaf et al. (2024) provide evidence that policy uncertainty is linked to an increase in firm level climate change-related news, using the Corporate Social Responsibility Newswire (CSRwire) as a source of climate change news in the media. Our study differs from this literature by exploring how firms experiencing economic uncertainty, disclose on their climate change-related exposures during their discussions in analysts calls.

In our study, we use a novel measure of firm-level climate change exposure developed by Sautner et al. (2023b), who utilize a machine-learning algorithm to pinpoint discussions about exposure to climate change in earnings conference calls. Earnings calls are important corporate events where financial analysts listen to company management and ask questions regarding current and future developments that are significant to the firm. While constructing the climate change exposure, Sautner et al. (2023b) consider the entire earnings call, including the management presentation and the Q&A session with analysts. The Q&A session, where managers and analysts interact, is considered the most informative part of the call, and investors can gather valuable information from those conversations (Rennekamp et al., 2022). The measure of Sautner et al. (2023b) is comprehensive and captures the level of attention that financial analysts and management pay to climate change topics. Furthermore, as the proxy for economic uncertainty, we use the World Economic Uncertainty Index (WUI) of Ahir et al. (2022), who constructed a metric that uses text mining of the Economist Intelligence Unit's national reports to track uncertainty worldwide. WUI serves as a standardized, forward-looking measure of economic uncertainty across countries, as it is based on a single source: EIU country reports (Bilgin et al., 2021). These EUI country reports assess both economic and political developments in each country, along with projections related to future policy and economic conditions.

There is burgeoning literature that use Sautner et al. (2023b)'s measure and reveal the impact of climate risk exposures on various firm-level outcomes, such as accounting conservatism (Ferdous et al., 2024), stock price crash risk (Jung and Song, 2023), cost of

equity (Cepni et al., 2024), risk premium (Sautner et al., 2023a), cash holdings (Ma et al., 2024), stock liquidity (Liu et al., 2024), tax avoidance (Song and Xian, 2024), and green transformation (Fang, 2024). Yet, research on the factors that drive firm-level disclosures on climate change exposures is very limited. For instance, studies document that climate policy uncertainty (Ongsakul et al., 2023), ex-ante litigation risk (Hossain et al., 2023), gender diversity on boards (Trinh et al., 2023), carbon disclosure (Trinh, 2023) are among the factors that drive firm-level climate change exposures.

The primary objective of this paper is to explore the impact of economic uncertainty on firm-level disclosures on climate change exposures and its sub-categories by considering the role of the Paris Agreement. Moreover, we consider the moderating impact of firm-level ownership structures such as institutional and foreign ownership. Finally, this paper also explores the moderating impact of country-level variables such as climate vulnerability and readiness, environmental policy stringency, climate protection performance, and environmental litigation risk in the association between economic uncertainty and climate change exposure.

With a sample of 34,795 firm-year observations coinciding to 3,583 unique firms from 24 countries examined from 2002 to 2021, we empirically analyze the association between economic uncertainty and climate change exposures. Our findings demonstrate that (1) economic uncertainty leads to a decline in climate change exposure before the Paris Agreement. This finding implies that firms may have other priorities in times of economic uncertainty before the Paris Agreement period, thus tend to be less inclined to prioritize climate change initiatives due to concerns about their costs. (2) In contrast, there is a positive association between economic uncertainty and climate change exposure after the Paris Agreement. This outcome implies that the Paris Agreement acts as an exogenous shock, and firms start prioritizing climate change and caring more about the environment, especially when facing economic uncertainty. (3) The positive disclosure effect between economic uncertainty and climate change is primarily driven by higher discussions of climate-related opportunities and regulatory exposures. Our findings are robust when we use different economic uncertainty definitions, alternative samples, additional firm-level and country-level control variables, and alternative methodologies. (4) The positive impact of economic uncertainty on climate change exposure after the

Paris Agreement is stronger for firms with higher institutional and foreign ownership. Thus, firms with higher institutional and foreign ownership disclose more about climate change exposures in uncertain times after the Paris Agreement, implying that institutional and foreign ownership positively affects governance, and these investors support sustainability-related activities, including climate change exposures. (5) Firms operating in countries with less climate vulnerability, higher readiness, more stringent environmental policies, superior climate protection performance, and higher environmental litigation risk tend to have higher climate change exposure in uncertain times.

Our paper has several contributions to the literature. The existing literature considers various factors that drive voluntary climate change disclosures, such as climate policy uncertainty (Ongsakul et al., 2023), ex-ante litigation risk (Hossain et al., 2023), gender diversity on boards (Trinh et al., 2023), and carbon disclosures (Trinh, 2023). To our knowledge, our study is the first study to examine whether and how economic uncertainty affects firms' disclosures on climate change exposures using firm-level disclosure data derived from analyst calls discussions. Moreover, another strand of literature focuses on how economic (policy) uncertainty influences the green behavior and performance of firms, presenting mixed findings (Hou et al., 2022; Yuan et al., 2022, Zhang et al. 2023). Hence, by exploring the impact of economic uncertainty on climate change disclosures, we also contribute to the literature on economic uncertainty. Employing an extensive sample (covering 24 countries worldwide) for an extended time frame (2002-2021), our study also contributes to the literature by investigating the moderating impact of firm-level ownership structures such as institutional and foreign ownership. We find evidence that the link between economic uncertainty and climate change exposure is stronger for firms with higher institutional and foreign ownership. Furthermore, our study reveals novel evidence that several country-level environmental performance indicators moderate this association. We document that, in uncertain times, firms operating in countries with less climate vulnerability, higher readiness, more stringent environmental policies, superior climate protection performance, and higher environmental litigation risk disclose more on their climate change exposures.

The rest of the paper is organized as follows. Section 2 provides the hypothesis development. Section 3 presents the data and methodology. Section 4 provides the findings, robustness, and additional analysis and discusses the findings. The last section concludes the paper.

2. Hypothesis Development

Firms are motivated to mitigate doubts about their stability and, accordingly, reassure the market by releasing new information during periods of uncertainty. (Assaf et al. 2024). Nagar et al. (2019) document that managers increase their voluntary disclosure in response to uncertainty. In line with that, Zhang et al. (2023) argue that, in times of increased external uncertainty, firms tend to enhance their legitimacy and social identity to boost organizational diversity and differentiate themselves from competitors. While it is not common to provide operational and financial information during uncertain periods when activity is likely to slow, non-financial information remains a viable alternative (Drobetz et al. 2018; Assaf et al. 2024). Bochkay and Joos (2021) demonstrate that analysts rely on qualitative information, particularly the tone of disclosures, nearly three times more when there is macroeconomic uncertainty. Therefore, companies are expected to release positive signals to the market and stakeholders by disclosing more environmental information and committing to green practices. Information asymmetry is more pronounced during uncertainty, and previous research indicates that disclosing non-financial information can increase value and help minimize information asymmetry (Cormier et al., 2009).

Our study blends several theoretical arguments to shed light on the association between economic uncertainty and climate change exposure. Primarily, the signaling theory can explain the positive relationship between economic uncertainty and climate risk exposure. Yuan et al. (2022) document that during periods of high uncertainty, social responsibility sends positive signals to stakeholders, reducing negative perceptions and fostering long-term competitive advantages. On the other hand, the risk management hypothesis proposes that firms with strong corporate social responsibility (CSR) practices tend to perform better during crises, suggesting that investing in CSR can provide resistance in times of uncertainty (Mbanyele and Muchenje, 2022). For example,

Albuquerque et al. (2019) show that CSR lowers systematic risk and enhances firm value. According to Poursoleyman et al. (2024), CSR activities function as insurance premiums for firms, protecting them not only from firm-specific issues but also from global challenges. Furthermore, Jin et al. (2023) find that during the COVID-19 pandemic, firms with higher ESG disclosures have higher returns and experience lower downside risk. Earnings call discussions can be a platform for sharing and discussing the positive signals about actions regarding climate change, alleviating information asymmetry between firms and investors, and creating a more competitive image. Decreasing information asymmetry can also lower the cost of capital (Balakrishnan et al. 2014).

As uncertainty grows, companies struggle to predict future economic conditions accurately, leading to greater business risks, a higher likelihood of debt default, and an increased perceived risk for lenders (Huang et al., 2024). To address this, managers may enhance their climate-related disclosures to improve lenders' perceptions of their ability to manage debt service risks. Moreover, due to rising concerns about climate change's potential consequences, the social pressure hypothesis argues that the external monitoring of analysts, nongovernmental organizations (NGOs), suppliers, customers, and regulators can force companies to provide more information regarding their environment and climate change. Environmental issues become a central concern for all stakeholders when economic uncertainty increases, prompting firms to communicate how they incorporate climate-related practices into their strategies (Assaf et al., 2024).

Economic uncertainty has various effects on firms, such as a higher probability of debt default (Huang et al., 2024), lower stock prices (Jung and Song, 2023), and reduced investments (Gulen and Ion, 2016). In response to these negative effects, investors tend to increasingly depend on analysts who put in additional effort (Loh and Stulz, 2018; El Ghoul et al., 2021). As economic uncertainty rises, the variance of future returns increases, leading to a decrease in the informativeness of stock prices (Drobetz et al. 2018). This makes firm-specific information more valuable, increasing the motivation to gather such detailed information (El Ghoul et al. 2021). Theoretical and empirical analysis of Andrei et al. (2019) demonstrates that increased economic uncertainty leads investors to focus more on firm-specific information. More specifically, investors tend to focus more on the earnings announcements of firms with higher beta, higher informative

announcements, higher idiosyncratic volatility, less informative prices, and lower information acquisition costs. There will be increased attention to firm-specific information, such as actions related to firm policies and actions about climate change investors. Hence, learning intensifies when there is high uncertainty in the market. There is a rising concern of investors engaging in environmental risk management, potential consequences of climate change, and responsible investing. The survey results of Krueger et al. (2020) reveal that institutional investors perceive climate risks as having significant financial implications for their portfolio firms and are already starting to materialize. Moreover, those investors consider climate risks because of nonfinancial (reputation, moral) and financial reasons (risk & return). Importantly, 63% of survey participants hold discussions with management about the financial effects of climate risks, while 32% recommend specific actions to management related to climate risks. Analysts play an important role in financial markets by gathering, analyzing, and sharing information about public companies with market participants. As key information intermediaries, they must consider the potential effects of global climate change on companies and share them with investors (Khiari et al., 2024). This behavior will be more pronounced during uncertain times when firm-specific information is more valuable. However, during uncertainty, investors face challenges in gathering and analyzing such information, and non-financial firm-specific information can provide insight into a company's internal management and strategies regarding climate change (Huang et al. 2024). Earnings call meetings can be an avenue for supplying the non-financial information investors need. Therefore, while managers will be willing to share more about the practices of firms regarding climate change and green activities, investors and financial analysts will also try to collect more information to make better-informed decisions and assess firm prospects in the earnings call.

Since the Paris Agreement, the debate on climate change has intensified. The stakeholders' awareness regarding climate change has increased substantially, leading to a higher pressure to transition to a low-carbon economy. In this context, firms aim to provide more information regarding their environmental policies and green practices, which the market and stakeholders will reward. This might result in differences between firms' disclosures before and after the Paris Agreement. Before the Agreement, firms might have been less inclined to provide additional information regarding climate change

during periods of uncertainty, since they would have other priorities. However, after the Agreement, they would be more willing to share such information due to heightened public and investor awareness of climate issues. Based on these arguments, we propose the following hypothesis:

H_1: Economic uncertainty is positively associated with firm-level disclosures on climate change exposures after the Paris Agreement.

While a positive relationship between economic uncertainty and climate change exposure is expected after the Paris Agreement, we anticipate this relationship might get reversed prior to the Paris Agreement. For example, Feng et al. (2024) show that a firm's bankruptcy risk increases with its exposure to climate change. However, the impact is muted after the 2015 Paris Agreement, which heightened public awareness of climate issues. Companies that become aware of climate change and choose to proactively address it in response to the ratification of the Paris Agreement are likely to better manage their exposure to the financial risks associated with climate events (Feng et al., 2024). Before the Paris Agreement, managers, investors, and financial analysts might mostly focus on the negative impact of economic uncertainty on firm performance and how to mitigate those negative consequences and potential actions. There is less room for environmental issues before the Paris Agreement during heightened uncertainty, as the positive signaling role of climate-related actions is limited. Pan et al. (2020) show that policy uncertainty has a negative effect on corporate environmental information disclosure in China using the data from 2009 to 2014 – before the Paris Agreement. Chava et al. (2021) find an increase in environmental discussion in earnings calls following the Paris Agreement, with a rise in positive sentiment from 2016 onward. This suggests managers emphasize environmental issues more, possibly due to heightened media coverage or efforts to align with anticipated regulatory changes. Likewise, investors and financial analysts have been more interested in such topics. Based on that, we propose the following hypothesis:

H_2: Economic uncertainty is negatively associated with firm-level disclosures on climate change exposures before the Paris Agreement.

3. Research Design

3.1 Sample selection

To construct our sample, we employ the Morgan Stanley Capital International (MSCI) market classification index, including all developed countries from America, Europe, the Middle East and Africa (EMEA), and Asia-Pacific (APAC) regions. Our sample includes publicly quoted firms from 24 developed countries for the years spanning between 2002 and 2021[3]. We concentrate on developed nations since they are the major players in international climate debates and policy, with higher levels of environmental awareness and concerns being prevalent in these economies. These nations typically demonstrate stronger regulatory frameworks and more established environmental policies, which can amplify public pressure on firms to improve their exposure to climate change. For evaluating the advancement of global climate goals such as those outlined in the Paris Agreement, an analysis of how economic uncertainty affects firms' climate change exposures in developed countries is thus essential. To reach our final sample, financial firms (SIC codes between 6,000 and 6,999) are eliminated due to the incomparability of their financial statements with those of non-financial firms. Moreover, observations with missing values for the climate change exposure data are also omitted from the sample. The final sample comprises 3,635 unique firms, corresponding to an unbalanced panel of 34,841 firm-year observations.

We build our sample using a variety of sources. Climate change exposure data is extracted from Sautner et al. (2023b), economic uncertainty data from Ahir et al. (2022), firm-level data from Thomson Reuters Datastream and Refinitiv Eikon, and macro-level variables from the World Bank database. The distribution of our sample based on countries is displayed in Table 1 – Panel A. The USA makes up 62.6% of our sample, followed by Canada (7.8%) and the UK (4.6%).

[Insert Table 1 here]

[3] Our data set starts with 2002 because our climate change exposure proxy is available only after 2002.

On the other hand, Table 1 Panel B shows the sample distribution by industry, using two-digit SIC codes. Three industries account for 45.3%, 17.3%, and 14.6% of the sample, respectively: manufacturing, services, and transportation, and public utilities.

3.2 Variables

3.2.1. Dependent variable: Climate change exposure

The purpose of this study is to explore how economic uncertainty affects climate change exposure. Hence the primary dependent variable of this analysis is disclosures on climate change exposure. We collect firm-level data on climate change exposure disclosures developed by Sautner et al. (2023b), who adopted a contemporary methodology. They utilize an innovative method to pinpoint discussions about exposure to climate change within quarterly earnings conference calls. Sautner et al. (2023b) utilize transcripts from earnings calls to create a dynamic measure of how call participants consider firms' exposures to various aspects of climate change. During these calls, different stakeholders, including analysts, investors, and the media, listen to management and have the opportunity to ask questions about the current status and plans for the future. According to survey data of Brown et al. (2015), analysts view the question-and-answer segment of earnings conference calls as the second most informative form of management communication after private interactions with management. "Exposure" to an issue is considered as the proportion of the conversation in a transcript that focuses on a topic. Accordingly, climate change exposure is developed to capture how climate change topics are discussed during the meeting. Our study proposes that economic uncertainty increases firms' exposure to climate change after the Paris Agreement. Employing a machine learning algorithm, Sautner et al. (2023b) have developed metrics using an exhaustive inventory of climate change exposure bigrams (pairs of words) extracted from the conference calls. To be specific, this novel approach employs the count of a diverse range of climate change bigrams to capture disclosures regarding overall exposure to climate change (CC_Exp). This measure is calculated as the ratio of the total number of bigrams related to climate change to the total number of bigrams in the transcripts of conference calls.

Moreover, we also employ several other climate disclosure variables created by Sautner et al. (2023b). In addition to CC_Exp, which shows the general discussions of climate-related topics, Sautner et al. (2023) also provide data on three sub-categories of climate change exposure: opportunities (CC_Opp), regulatory interventions (CC_Reg) and physical threats (CC_Phy).

We obtain the scores for climate change discussions at the firm-year level from the authors' website, scale them by multiplying by a factor of 1000 to derive our dependent variables of interest. The definitions, notations, and sources of all variables used in the analysis are provided in Table 2.

[Insert Table 2 here]

3.2.2. Independent variable: Economic uncertainty

The key independent variable of this analysis is the World Economic Uncertainty Index (WUI). Data for the WUI is gathered from Ahir et al. (2022), who constructed a metric that uses text mining of the Economist Intelligence Unit's national reports to track uncertainty worldwide. Ahir et al. (2022) built this index by counting the frequency of the term "uncertainty" and terms resembling *uncertainty* in EIU country reports. It is a standardized forward-looking economic uncertainty measure across countries because it is derived from a single source, EIU country reports (Bilgin et al., 2021). Along with future policy-related and economic estimates, the EIU reports examine economic and political events in each nation. Scaling the raw counts of uncertainty by the total number of words in each report, Ahir et al. (2022) make the index comparable across nations. Higher numbers of WUI correspond to greater uncertainty and vice versa.

3.2.3. Control variables

To systematically explore the relationship between economic uncertainty and climate change exposure, in alignment with existing literature, we integrate an extensive array of firm and macro-level variables as controls in our empirical examination. Primarily, we incorporate firm size, denoted by the natural logarithm of total assets. Drawing on previous studies (Freedman and Jaggi, 2005; Chithambo et al., 2022), we expect a positive association between firm size and climate change exposure, suggesting that larger

companies usually undergo heightened scrutiny from internal and external stakeholders, including the media, policymakers, and regulators, prompting them to engage in more voluntary environmental disclosures as a proactive measure to mitigate potential adverse repercussions.

As our second firm-level control variable, we integrate profitability into our analysis, using return on assets (ROA: Ratio of earnings before interest and tax to total assets). Prior studies are inconclusive about the impact of profitability on non-financial disclosures. The impact could be positive, as profitable companies could be inclined to participate in climate-related endeavors, as they possess the resources necessary to incorporate climate considerations into their strategic planning (Waddock and Graves, 1997). In contrast to this, the impact could also be negative; as firms experience an increase in profitability, they tend to adhere more closely to socially accepted norms, thereby reducing the necessity to pursue legitimacy through alternative measures, such as disclosures related to climate change (Andrikopoulos and Kriklani, 2013).

Third, we incorporate leverage (ratio of total debt to total assets) into the analysis. Participating in environmental actions typically entails increased costs; hence, firms with higher leverage are expected to lack the requisite resources to undertake such activities (Benlemlih, 2017). Accordingly, we anticipate leverage to impact climate change exposures negatively.

Finally, we integrate tangibility (Net value of property plant and equipment scaled by total assets) into the estimation, as prior literature suggests that tangibility is likely to influence non-financial practices (Kang, 2013). Firms with higher tangibility are anticipated to provide more extensive disclosures regarding climate change exposures, potentially due to their heightened vulnerability to the physical ramifications of climate change, such as extreme weather events or resource scarcity (Assaf et al., 2024).

Lastly, we include two control variables at the national level in our analysis: GDP per capita growth and inflation. In alignment with prior studies, we expect GDP per capita growth to have a negative influence on climate change exposures because firms in countries with higher GDP per capita already typically conform to prevailing social norms

and hence exhibit reduced necessity for disclosing their climate change exposures (Andrikopoulos and Kriklani, 2013). Finally, we anticipate inflation to have a positive impact on climate change exposure, in line with the perspective that companies operating in countries experiencing higher inflation rates may encounter challenges in refinancing their ongoing operations, prompting them to disclose greater volumes of non-financial information as a means of signaling their quality (Assaf et al., 2024).

3.2.4. Moderating variables:

One of the main goals of this analysis is to explore how the Paris Agreement, which represents the first major international pact on climate change in which the US got engaged, affects the association between economic uncertainty and climate change exposure. Paris Agreement is widely regarded as a pivotal occurrence that catalyzed heightened awareness regarding climate change. Accordingly, it garnered substantial media coverage, which is expected to be also reflected in firms' earnings conference calls. Hence, we treat the 2015 Paris Agreement as an exogenous shock, examining whether economic uncertainty influences ex-ante versus ex-post-climate change disclosures differently. Accordingly, we create a dummy variable, i.e., Paris, that gets the value 1 for the years starting with 2015 and ending with 2021 and 0 for the years between 2002 and 2014.

In further analysis, exploring only the period after the Paris Agreement, we investigate whether different ownership features affect the nexus between economic uncertainty and climate change exposure. We operationalize ownership with three different proxies: institutional ownership (percentage of ownership held by institutions), foreign ownership (percentage of ownership held by foreign parties), and state ownership (percentage of ownership held by the State in respective countries).

3.3 Methodology

We explore the impact of economic uncertainty on climate change disclosure with the subsequent model:

$$CC_{Disclosure^{i,t}} = \alpha_0 + \beta WUI^{i,t} + \gamma' X_{it} + \theta' Y_{ct} + \eta^{c} + \eta^{t} + \eta^{i} + \nu^{itc} \quad (1)$$

where X_{it} stands for firm-level control variables, Y_{ct} for macro-level control variables, η^{i} for industry fixed effects, η^{c} for country fixed effects, η^{t} for year fixed effects and finally ν_{itc} stands for the error terms.

For climate change disclosure, we employ climate change exposure and also the three different types of climate change exposure, including disclosures regarding opportunities (Opportunity Exposure), regulatory interventions (Regulatory Exposure), and physical threats (Physical Exposure).

To estimate Model 1, we employ panel data estimation methods, incorporating fixed effects verified through Hausman tests. We incorporate country-fixed effects to mitigate heterogeneity across nations and address potential concerns regarding omitted country-level variables (Doidge et al., 2007). To account for the industry-specific features that are crucial determining factors for non-financial disclosures, we integrate industry fixed effects, operationalized with the first two digits of the SIC codes. Finally, we employ year-fixed effects to account for the influence of varying economic conditions within each year.

3.4 Descriptive statistics

According to the summary statistics presented in Table 3, WUI has a median of 0.207 and a standard deviation of 0.126. The average climate change exposure is 1.278, with a minimum of 0 and a maximum of 16.565. Within the three climate change exposure types, disclosures regarding opportunities have the highest maximum value (7.632), with the regulatory interventions and physical threats' maximum values standing at 1.447 and 0.351, respectively, suggesting that firms prioritize disclosing information on opportunities rather than regulatory interventions or physical threats.

[Insert Table 3 here]

We present the pairwise correlation coefficients between the main variables employed in the analysis in Table 4. Multicollinearity does not constitute an issue since the correlation coefficients are not high.

[Insert Table 4 here]

4. Results

4.1 Baseline regressions

We present baseline regressions in Tables 5 and 6. In Table 5, we explore how economic uncertainty affects firms' disclosures about general climate change exposures without yet considering the Paris Agreement's impact. We conduct the estimations using panel data estimation methods, incorporating industry, country, and time-fixed effects. Columns 1-3 use CC Exposure as the dependent variable. Column 1 includes only WUI as an explanatory variable, Column 2 adds firm-level control variables, and Column 3 incorporates macro-economic controls in the regressions. The negative and significant coefficients for WUI in Columns 1-3 indicate that an increase in WUI significantly decreases firms' disclosures on climate change exposures during the whole sample period (2002-2021). This shows that before considering the influence of the Paris Agreement in 2015, we find that economic uncertainty decreases firms' discussions of climate change disclosures in conference calls for the whole sample period. Columns 4-6 examine which types of climate disclosures are particularly informative for investors. Specifically, we use climate change disclosures related to opportunities (Opportunity Exposure), regulatory interventions (Regulatory Exposure), and physical threats (Physical Exposure). Our findings reveal that the decrease is driven primarily by discussions of climate-related opportunities (e.g., green energy investments) rather than regulatory interventions and physical exposures.

[Insert Table 5 here]

4.2. Paris Agreement

Table 6 displays the WUI- climate change exposure regressions after considering the impact of the 2015 Paris Agreement. Paris is a dummy variable that takes a value of 1 after adopting the Paris Agreement (i.e., for years from 2015 to 2021) and 0 otherwise. We include the Paris dummy and the interaction term between WUI and Paris in all model specifications to investigate whether there are any differences in the relationship between WUI and climate change exposures before and after the Paris Agreement. Column 1 uses CC Exposure as the dependent variable, and the positive and significant

coefficient for Paris*WUI in Column 1 shows that an increase in WUI significantly increases firms' disclosures on climate change exposures after the Paris Agreement (2015-2022). The significant and negative coefficient of WUI in Column 1 shows that economic uncertainty continues to decrease firms' discussions of climate change exposures before the Paris Agreement (2002-2014). Thus, there is a change in how economic uncertainty affects climate change disclosures before vs. after the Paris Agreement. While economic uncertainty reduces disclosures on climate change before Paris, it increases climate change disclosures after Paris. This shows that firms start caring about the environment and climate change after the Paris Agreement. Before the agreement, economic uncertainty had a negative impact on climate disclosures since firms had other priorities. Columns 2-4 examine which types or topics of climate disclosures are particularly relevant after Paris, i.e., we investigate the impact of WUI on opportunities (Opportunity Exposure), regulatory interventions (Regulatory Exposure), and physical threats (Physical Exposure), respectively. After the Paris Agreement, economic uncertainty increases disclosures on climate-related opportunities and regulatory exposures but not on physical threats.

On the other hand, within the control variables, many are significant with the expected signs. The findings show that larger firms disclose more about climate change exposures in conference calls. This aligns with the studies that have observed a positive relationship between firm size and environmental disclosures (see Freedman and Jaggi, 2005; Chithambo et al., 2022). Large enterprises could be subject to greater scrutiny from the media, policymakers, and regulators, leading to increased voluntary environmental disclosures to avoid negative consequences. We next find that firms with higher tangible assets disclose more about climate change exposures, probably because these firms may be more vulnerable to the physical impacts of climate change (see Assaf et al., 2024). Meanwhile, firms with higher profitability are observed to disclose less on climate change exposures. This could be because these firms already conform to socially acceptable standards as their profitability rises, lowering the need to seek legitimacy through alternative actions, such as climate change disclosures (Andrikopoulos and Kriklani, 2013). We next observe that firms with higher leverage disclose less on climate change. This aligns with the view that highly leveraged enterprises may not have the necessary resources to engage in costly environmental conservation activities (Benlemlih, 2017;

Assaf et al., 2024). Regarding the country-level control variables, higher GDP per capita is negatively associated with disclosures on climate change exposures. This could be because firms in countries with higher GDP per capita already comply with socially acceptable standards and have less need to disclose climate change exposures (Andrikopoulos and Kriklani, 2013). Finally, higher inflation is positively associated with such disclosures. This is consistent with the view that firms in higher-inflation countries may face difficulties refinancing their current activities and are more likely to disclose more non-financial information to signal their quality (Dhaliwal et al., 2011; Assaf et al., 2024).

Overall, our findings specify that prior to the Paris Agreement in 2015, economic uncertainty leads to a decrease in climate disclosures, potentially because firms might have other priorities under uncertainty. Economic uncertainty influences firms' investment decisions and long-term planning processes, and firms might be less willing to invest in climate change initiatives due to concerns about their costs. However, after the Paris Agreement, our findings reveal a position association between economic uncertainty and climate change disclosures. This shows that the Paris Agreement acts as an exogenous shock, and firms start to care more about the environment and climate change, especially when facing economic uncertainty. To address the challenges regarding climate change and the environment, firms recognize the importance of transparency and accountability in addressing climate change risks and opportunities, even during uncertain times.

[Insert Table 6 here]

4.3. Robustness tests

We perform various robustness checks for the baseline findings regarding the positive association between economic uncertainty and climate change exposure after the Paris Agreement, and we present them in Table 7. All specifications use CC Exposure as a dependent variable. Columns 1 and 2 display the WUI-climate change exposure regressions for separate samples before Paris (2002-2014) and after Paris (2015-2022), corresponding to the Paris dummy equal to 0 and 1, respectively. We observe that while the coefficient of WUI is insignificant before Paris, it is positive and significant after the

Paris Agreement, confirming our baseline findings. For the rest of the columns in Table 7, we use the period after the Paris Agreement (2015-2022). Columns 3 and 4 use alternative WUI measures (WUI2 and WUI3, respectively). Our results remain robust under these alternative WUI specifications, i.e., economic uncertainty is positively associated with firms' disclosures of climate change exposures after Paris. Column 5 uses an alternative sample and excludes the U.S. from the sample. This is because the U.S. accounts for 63% of the firm-year observations in our sample, which could mean that the findings may originate only from the U.S. sample. Thus, we drop the observations from the U.S., replicate our estimations, and find confirming results with our baseline findings.

Columns 6 and 7 in Table 7 use instrumental variable (IV) estimation techniques with two-step estimations (2SLS) to account for potential endogeneity. Following Wu et al. (2020) and Bilgin et al. (2021), we use two instruments for WUI. First, we use the corresponding largest export market country's WUI index for each country. The economic uncertainty in major export partners is likely to be contagious, increasing the country's uncertainty. Meanwhile, economic uncertainty in the major export country is less likely to directly affect climate change exposures in the current country. Second, following Baker and Bloom (2013), we use high-casualty terrorist attacks as an instrument. Column 6 presents the first stage regressions where WUI is the dependent variable, and the two instruments and control variables are taken as explanatory variables. Column 7 displays the second-stage regressions where CC Exposure is the dependent variable, and the predicted WUI and control variables are independent variables. The coefficient of predicted WUI is positive and significant, confirming baseline findings. The reliability and validity tests for IV estimation are at the bottom of Table 7. The first stage F statistics for weak instruments, and Wu-Hausman F statistics for endogeneity are both significant, confirming the reliability of the IV estimation. Columns 8-10 include additional country controls for country-level investor protection and governance differences. Specifically, we add the anti-self-dealing index (ASDI) (Djankov et al. 2008), the revised anti-director rights index (ADRI) (Spamann, 2010), and the Extent of Disclosure Index (World Bank). The definitions and sources of these variables may be found in Table 2. Since these variables tend to be correlated, we add them one at a time. Findings in Columns 8-10 are in line with baseline estimations.

[Insert Table 7 here]

4.4. The moderating impact of ownership

We investigate the moderating impact of different ownership features on the WUI-climate change exposure relationship after the Paris Agreement. According to the findings in the previous sections, there is a positive association between economic uncertainty and firms' disclosures on climate change after the Paris Agreement. In this section, we aim to understand how different ownership features at the firm level affect the positive relationship between economic uncertainty and climate change exposures after Paris. For this purpose, we consider the share of institutional, foreign, and government ownership. The findings are displayed in Table 8. To explore the moderation effects of ownership, we analyze the impact of the interaction terms between WUI and different ownership features, and we focus on the years after the Paris Agreement (2015-2022).

Columns 1 and 2 investigate the impact of institutional ownership. Column 1 uses the continuous share of institutional ownership variable (Ins Own), whereas Column 2 uses the dummy variable, which equals one when firms' institutional ownership is greater than the median and zero otherwise (Ins Own Dummy). The interaction term coefficient (WUI*Ins Own) is positive and significant in both columns, suggesting that economic uncertainty increases disclosures on climate change exposures for firms with higher institutional ownership. Meanwhile, the coefficient of WUI is negative and significant, showing that economic uncertainty decreases the disclosures on climate change exposures for firms with lower institutional ownership.

Columns 3 and 4 examine the influence of foreign ownership by using the continuous foreign ownership variable (For Own) and For Own Dummy, which equals one for firms with foreign ownership higher than the median and zero otherwise, respectively. The interaction term coefficient (WUI*For Own) is again positive and significant in both columns, whereas the coefficient of WUI is negative and significant. Firms with higher foreign ownership disclose more on climate change exposures when there is uncertainty. Meanwhile, firms with lower foreign ownership disclose less about climate change in uncertain times. Columns 5 and 6 consider the impact of government ownership (Gov

Own), focusing on the continuous and dummy variables (Gov Own Dummy), respectively. The interaction terms WUI * Gov Own and WUI * Gov Own Dummy are insignificant, showing that government ownership does not significantly moderate the relationship between WUI and CC Exposure.

[Insert Table 8 here]

Overall, our findings show that firms with higher institutional and foreign ownership disclose more on climate change exposures in uncertain times after the Paris Agreement. Meanwhile, government ownership does not significantly impact the association between economic uncertainty and climate change exposures. These findings align with the studies in the literature showing that institutional and foreign ownership positively affects governance, and these investors support sustainability-related activities (Aggarwal et al., 2011; McGuinness et al., 2017; Dyck et al., 2019).

4.5 Additional analyses

In this section, we perform additional tests for further insights. We consider the moderating impact of selected country-level environmental performance indicators on the link between economic uncertainty and climate change exposures after the Paris Agreement. Table 9 Column 1 investigates the moderating effect of the ND Gain Index, and Columns 2 and 3 investigate its two components: Vulnerability and Readiness. ND Gain Index is the Notre Dame Global Adaptation Initiative's (ND-GAIN) Country Index and measures countries' vulnerabilities to climate disruptions. Some countries are particularly sensitive to climate change due to their geographical positions or socioeconomic status. Meanwhile, other countries are better prepared and ready to adapt by leveraging public and private sector investments, including government actions, community awareness, and facilitating private sector responses. ND Gain Index measures both of these dimensions: vulnerability and readiness. The positive and significant interaction coefficient in Column 1 reveals that firms in countries that are both more ready to adapt to climate change and less vulnerable disclose more after the Paris Agreement. The findings in Column 2 and Column 3 confirm this finding. Column 2 shows that firms in more vulnerable countries disclose less about climate change when they face economic uncertainty. The positive and significant coefficient in Column 3 shows that

firms in countries with higher readiness (in terms of ability to leverage investments and convert them to adaptation actions) disclose more about climate change when they face economic uncertainty.

Colum 4 investigates the moderating impact of the Environmental Policy Stringency Index (EPSI) from OECD, a country-specific measure of the stringency of environmental policy, demonstrating the extent to which environmental laws impose an explicit or implicit price on environmentally hazardous actions. The coefficient of the interaction term in Column 4 is positive and significant, meaning that firms in countries with more stringent environmental policies disclose more on climate change exposures under economic uncertainty. A similar pattern emerges from the moderating impact of the climate change performance index (CCPI) in Column 5, which compares countries' climate protection performance. Our findings demonstrate that CCPI positively moderates the connection between economic uncertainty and climate change exposure. This implies that firms in nations with better climate protection make even more disclosures on climate change exposures as economic uncertainty increases. Finally, Column 6 displays the moderating impact of high environmental litigation risk industries. Specifically, looking into firms' two-digit SIC codes, we create an indicator variable (ELRG) that equals one for firms in the high environmental litigation risk sectors and zero for the low environmental litigation risk sectors, respectively. The coefficient of the interaction term is positive and significant, showing that firms in industries with higher environmental litigation risk disclose more on climate change exposures under economic uncertainty. Overall, findings from additional analyses reveal that firms in countries that are more ready to adapt to climate change, less vulnerable to climate disruptions, have more stringent environmental policies, and have better climate protection performances disclose more about their climate change exposures when they face economic uncertainty. Moreover, firms in high environmental litigation risk sectors disclose more about climate change in uncertain times.

[Insert Table 9 here]

5. Conclusion

This study examines how economic uncertainty (proxied by the World Uncertainty Index (WUI), affects firm-level climate change exposure constructed by Sautner et al. (2023b) considering the 2015 Paris Agreement. Using a comprehensive data set covering the period from 2002 to 2022 from 24 countries, we find that before the Paris Agreement, an increase in economic uncertainty is associated with a decrease in climate change exposure. However, as an exogenous shock, the Paris Agreement appears to alter this relationship as our results show that economic uncertainty leads to increased climate change exposure after the Paris Agreement. The findings suggest that the Paris Agreement effectively raises awareness and urgency around climate-related issues, encouraging firms to engage more actively in climate-related discourse during heightened economic uncertainty. Furthermore, our analysis reveals that among the categories of climate change exposure, after the Paris Agreement, economic uncertainty increases opportunities and regulatory exposures but not physical threats. The findings are robust to a battery of checks, such as different model specifications, sample variations, alternative measures of economic uncertainty, and endogeneity tests. We also investigate the moderating role of ownership structures on the relationship between economic uncertainty and climate change exposure. Our findings demonstrate that firms with higher institutional and foreign ownership are more likely to increase their exposure to climate change during uncertainty. In contrast, government ownership does not have a significant moderating effect. These results align with existing literature suggesting that institutional and foreign investors promote better governance and support sustainability efforts. Lastly, we explore the moderating impact of country-level indicators and find that firms operating in less climate-vulnerable countries and those with higher readiness for climate change have higher climate change exposure in uncertain times. Firms in countries with more stringent environmental policies and higher climate change performance index disclose more on climate change exposures under economic uncertainty. Additionally, firms with higher environmental litigation risks tend to increase their disclosures on climate change when faced with economic uncertainty.

Our findings provide implications for different parties. Managers should recognize that economic uncertainty does not reduce the need for climate change exposures. Rather, it can increase the demand of stakeholders for more information regarding the strategies

of firms on climate change. They should proactively communicate about their firm's climate change exposure opportunities and how they tackle related regulations. Such information can provide positive signals to stakeholders, reducing negative perceptions and fostering long-term competitive advantages. As economic uncertainty increases, environmental issues become a focal point for stakeholders. Firms are motivated to showcase how they integrate climate-related practices into their strategies and benefit from potential opportunities to enhance their image, bolster their reputation, and address regulation risks.

Investors can pay close attention to climate change exposures, particularly during economic uncertainty. Firms that disclose more climate-related information during earnings calls may be better prepared to handle long-term environmental risks and regulations and capitalize on climate-related opportunities. To explore this and make better-informed decisions, investors and financial analysts can attend Q&A sessions and engage more actively to discuss firms' behaviors. Moreover, the companies that disclose more on climate change-related opportunities and regulatory readiness during uncertainty can position themselves to thrive in a low-carbon economy and create long-term value, and identifying such companies can provide investors with valuable insights for investment and aligning their portfolios with sustainable trends. Institutional and foreign investors that positively influence firms' climate change exposure should continue to push for greater transparency and comprehensive reporting on climate change exposures to mitigate information asymmetry and gain competitive advantage during uncertainty.

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Table 1. Panel A. Sample distribution across countries

Country	No of observations	No of firms	%
Australia	984	179	2.8%
Austria	168	16	0.5%
Belgium	190	21	0.5%
Canada	2699	335	7.8%
Denmark	291	28	0.8%
Finland	326	22	0.9%
France	747	63	2.1%
Germany	823	82	2.4%
Hong Kong	549	88	1.6%
Ireland	117	11	0.3%
Israel	327	33	0.9%
Italy	309	29	0.9%
Japan	1,323	169	3.8%
Netherlands	334	28	1.0%
New Zealand	218	44	0.6%
Norway	263	24	0.8%
Portugal	110	9	0.3%
Russia	260	25	0.7%
Singapore	137	19	0.4%
Spain	283	26	0.8%
Sweden	511	62	1.5%
Switzerland	463	42	1.3%
UK	1,597	150	4.6%
USA	21766	2,078	62.6%
Total	**34,795**	**3,583**	**100.0%**

Table 1. Panel B. Sample distribution across sectors

Industry	No of observations	No of firms	%
Agriculture, Forestry & Fishing	128	22	0.4%
Mining	2,412	275	6.9%
Construction	852	74	2.4%
Manufacturing	15,761	1,510	45.3%
Transportation & Public Utilities	5,097	441	14.6%
Wholesale Trade	1,297	124	3.7%
Retail Trade	3,212	303	9.2%
Services	6,036	834	17.3%
Total	**34,795**	**3,583**	**100%**

Note: This table presents the country and industry breakdowns of the sample, consisting of 34,841 observations from 2002 to 2021. The industry breakdown is established on a two-digit standard industrial classification (SIC) (SIC codes between 6000 and 6999 are excluded from the sample).

Table 2. Variable definitions & Data sources

Variables	Notation	Description	Data source
Dependent variables			
Climate Change exposure	CC_Exp	Ratio of the firm-level discussions on overall climate change exposure topics in earnings conference calls to the total number of bigrams in each year. $CC_{Exp} = \sum_{year} \frac{no.\ of\ climate\ change\ bigrams}{total\ no.\ of\ bigrams} x\ 1000$	Sautner et al. (2023b)
Opportunity Exposure	CC_Opp	Mean of the firm-level discussions capturing opportunities related to climate change exposure over the four quarters of each year. $CC_{Opp} = \sum_{year} \frac{no.\ of\ climate\ change\ opportunity\ bigrams}{total\ no.\ of\ bigrams} x\ 1000$	Sautner et al. (2023b)
Regulatory Exposure	CC_Reg	Mean of the firm-level discussions capturing regulatory shocks related to climate change exposure over the four quarters of each year. $CC_{Reg} = \frac{\sum_{year} \frac{no.\ of\ clim.\ chng\ regulation\ big.}{total\ no.\ of\ bigrams} \text{x } 1000}{4}$ $CC_{Reg} = \sum_{year} \frac{no.\ of\ climate\ change\ regulation\ bigrams}{total\ no.\ of\ bigrams} x\ 1000$	Sautner et al. (2023b)
Physical Exposure	CC_Phy	Mean of the firm-level discussions capturing physical shocks related to climate change exposure over the four quarters of each year. $CC_{Phy} = \frac{\sum_{year} \frac{no.\ of\ clim.\ chng\ physical\ big.}{total\ no.\ of\ bigrams} \text{x } 1000}{4}$ $CC_{Phy} = \sum_{year} \frac{no.\ of\ climate\ change\ physical\ bigrams}{total\ no.\ of\ bigrams} x\ 1000$	Sautner et al. (2023b)
Independent variables			
World Uncertainty Index	WUI_1	Mean of the quarterly country-specific World Uncertainty Index (WUI)	Ahir et al. (2022)
World Uncertainty Index2	WUI_2	Weighted average of the quarterly country-specific WUI, assigning weights of 1 and 2 for the initial and last six months within a year	Ahir et al. (2022)
World Uncertainty Index3	WUI_3	Weighted average of the quarterly country-specific WUI, assigning weights from 1 to 4 to each successive quarter within a year	Ahir et al. (2022)

Firm-level control variables			
Firm Size	Size	Natural logarithm of the book value of assets	Thomson Reuters Datastream
Profitability	ROA	Ratio of earnings before interest and tax to total assets	Thomson Reuters Datastream
Leverage	Lev	Ratio of total debt to total assets	Thomson Reuters Datastream
Tangibility	Tang	Net value of property plant and equipment scaled by total assets	Thomson Reuters Datastream
Country-level control variables			
GDP per capita Growth	GDP pcg	Real GDP per capita growth rate (Annual %)	World Development Indicators (WDI) from the World Bank
Inflation	Inf	Inflation (Annual %)	World Development Indicators (WDI) from the World Bank
Moderating variables			
Paris Agreement	Paris	Dummy variable that gets the value of 1 with the adoption of the Paris Agreement (i.e., years from 2015 to 2022), and 0 otherwise (Years from 2002 to 2014)	Self-Calculation
Institutional ownership	InsOwn	Percentage of ownership held by institutions (hedge funds, mutual funds, pension funds, insurance companies, banks, etc.)	Refinitiv Eikon
Foreign ownership	ForOwn	Percentage of ownership held by foreign parties	Refinitiv Eikon
State ownership	StateOwn	Percentage of ownership held by the State in respective countries	Refinitiv Eikon
Additional variables			
Anti-self-director index	ASDI	Ranging from 0 to 1, ASDI assesses the safeguarding of minority investors from potential expropriation by corporate insiders. It encompasses the efficacy of laws that prevent self-dealing and their enforcement mechanisms.	Djankov et al. (2008)
Anti-director-rights-index (revised)	ADRI	Spanning from 0 to 6, ADRI utilizes six components to gauge the degree to which investors can assert their rights in reaction to opportunistic conduct.	Spamann (2010)
Extent of disclosure index	EDI	Ranging from 0 to 10, EDI gauges the degree of protection provided to investors by ownership and financial transparency disclosures.	World Bank, Doing Business Project
Notre Dame Global Adaptation Initiative	NDGain	It encapsulates a nation's "vulnerability" to climate change and other worldwide adversities and its "readiness" to enhance resilience.	https://gain.nd.edu/
Readiness	Read.	Readiness gauges a nation's capacity to take investments and turn them into adaption measures.	https://gain.nd.edu/
Vulnerability	Vuln.	Vulnerability assesses how exposed, sensitive, and capable a nation is to the adverse effects of climate change.	https://gain.nd.edu/

Environment Policy Stringency index	EPS	Ranging from 0 to 6, EPS shows the extent to which actions that pollute or impair the environment are penalized, either explicitly or implicitly, by environmental laws.	OECD
Climate Change Performance Index	CCPI	Compares countries' climate protection performance.	German watch
High environment litigation risk group	ELRG	Splits the sample into firms with high and low environmental litigation risk based on their sectors: Dummy variable gets the value of 1 if two-digit SIC codes = 49, 28, 29, 37, 13, 36, 35, 33, 38, 26, and 10; 0 otherwise	Fard et al. (2020) & Hossain et al. (2023)

Note: This table displays the variables used in the analysis, their notation, description, and data source.

Table 3. Summary statistics

	N	Mean	min	Median	max	Std. Dev.
WUI	34,841	.232	.019	0.207	.539	.126
CC Exp	34,841	1.278	0	0.367	16.565	2.69
CC Opp	34,841	.393	0	0.000	7.632	1.162
CC Reg	34,841	.065	0	0.000	1.447	.217
CC Phy	34,841	.011	0	0.000	.351	.05
Firm Size	34,515	14.765	5.187	14.644	21.065	2.424
ROA	33,792	.026	-16.364	0.066	.478	.316
Leverage	34,490	.253	0	0.230	9.114	.242
Tangibility	34,452	.292	0	0.217	.969	.244
GDP pcg	34,841	1.118	-11.6	1.540	23.305	2.607
Inflation	34,841	1.989	-4.478	1.812	15.534	1.345

Note: This table displays the summary statistics for the key variables used in the analysis.

Table 4. Correlation matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) WUI	1.000										
(2) CC Exp	0.006	1.000									
(3) CC Opportunity exp	0.012*	0.911*	1.000								
(4) CC Regulatory exp	0.010	0.628*	0.462*	1.000							
(5) CC Physical exp	-0.013*	0.235*	0.160*	0.136*	1.000						
(6) Firm Size	-0.044*	0.126*	0.103*	0.130*	0.043*	1.000					
(7) ROA	-0.013*	-0.002	-0.010	0.012*	0.017*	0.278*	1.000				
(8) Leverage	0.026*	0.071*	0.056*	0.060*	0.019*	0.150*	-0.192*	1.000			
(9) Tangibility	0.002	0.270*	0.198*	0.235*	0.101*	0.232*	0.079*	0.215*	1.000		
(10) GDP per Capita Growth	-0.293*	0.015*	0.011*	0.041*	0.007	-0.016*	0.026*	-0.025*	-0.028*	1.000	
(11) Inflation	-0.302*	0.029*	0.015*	0.061*	0.013*	-0.102*	-0.001	-0.011*	0.025*	0.436*	1.000

Note: This table displays the Pearson correlations between the main variables used in the analysis. ***, ** and * refer to statistical significance at .01, .05 and .10 levels, respectively.

Table 5. Impact of WUI on climate change exposures

	(1) CC_Exp	(2) CC_Exp	(3) CC_Exp	(4) CC_Opp	(5) CC_Reg	(6) CC_Phy
WUI	**-.566*** **	**-.596*** **	**-.565*** **	**-.172** **	**-.015**	**-.006**
	(-3.458)	**(-3.62)**	**(-3.393)**	**(-2.21)**	**(-.845)**	**(-1.366)**
Firm Size		.011	.011	.007**	.007***	0***
		(1.618)	(1.635)	(2.165)	(11.152)	(-2.871)
ROA		-.229***	-.228***	-.11***	-.013***	.002***
		(-4.328)	(-4.32)	(-4.204)	(-3.849)	(2.997)
Leverage		-.147**	-.149**	-.059**	-.013***	-.001
		(-2.468)	(-2.504)	(-2.199)	(-3.181)	(-1.261)
Tangibility		1.449***	1.454***	.492***	.101***	.006***
		(15.847)	(15.898)	(11.832)	(11.788)	(2.782)
GDP per capita growth			-.039***	-.008	-.007***	0
			(-3.05)	(-1.299)	(-4.949)	(-.487)
Inflation			.015	.002	-.003	.001
			(.802)	(.281)	(-1.487)	(1.077)
Constant	1.426***	.898***	.887***	.216***	-.047***	.017***
	(34.764)	(7.982)	(7.317)	(3.903)	(-4.178)	(5.939)
Industry fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	34104	32987	32987	32987	32987	32987
R-squared	.419	.427	.427	.322	.226	.057

Note: This table displays the findings from the regressions of CC exposure and its components on WUI. The dependent variable is CC exposure and its components. The independent variable is WUI. The firm-level control variables are firm size, ROA, leverage, and tangibility. The country-level control variables are GDP per capita growth and inflation. The definitions of all variables are provided in Table 2. We include industry, year, and country-fixed effects in all the models. We adjust the error terms for heteroscedasticity at the company level. Robust t-statistics are displayed in parentheses. Statistical significance at 1%, 5%, and 10% are indicated with ***, **, and *, respectively.

Table 6. The impact of WUI on climate change exposures: The Influence of the Paris Agreement

	(1) CC_Exp	(2) CC_Opp	(3) CC_Reg	(4) CC_Phy
WUI	**-.453*** **	**-.175** **	**-.064*** **	**-.003**
	(-2.916)	**(-2.497)**	**(-4.436)**	**(-.672)**
Paris	.233***	.117***	-.015***	.002
	(4.148)	(4.354)	(-2.889)	(1.228)
Paris * WUI	**.862*** **	**.371*** **	**.201*** **	**-.001**
	(4.261)	**(3.919)**	**(10.222)**	**(-.186)**
Firm Size	.014**	.008**	.007***	0***
	(2.002)	(2.504)	(11.211)	(-2.834)
ROA	-.237***	-.114***	-.013***	.002***
	(-4.378)	(-4.293)	(-3.765)	(3.043)
Leverage	-.149**	-.059**	-.013***	-.001
	(-2.499)	(-2.203)	(-3.067)	(-1.308)
Tangibility	1.437***	.485***	.101***	.006***
	(15.736)	(11.677)	(11.833)	(2.714)
GDP per capita growth	-.094***	-.034***	-.013***	0**
	(-14.811)	(-11.236)	(-18.035)	(-2.351)
Inflation	.032**	.008	.005***	0
	(2.564)	(1.515)	(4.219)	(.546)
Constant	.618***	.109**	-.067***	.016***
	(5.35)	(2.069)	(-6.587)	(6.272)
Industry fixed effect	Yes	Yes	Yes	Yes
Country fixed effect	Yes	Yes	Yes	Yes
Observations	32987	32987	32987	32987
R-squared	.422	.318	.215	.055

Table 7. Robustness tests

	(1) CC_Exp (Paris = 0)	(2) CC_Exp (Paris = 1)	(3) CC_Exp (Alternative independent var: WUI2)	(4) CC_Exp (Alternative independent var: WUI3)	(5) CC_Exp (Alternative sample: exclude USA)	(6) WUI (Alternative methodology: 2SLS) First step	(7) CC_Exp (Alternative methodology: 2SLS) Second step	(8) CC_Exp (Additional country-level control var.)	(9) CC_Exp (Additional country-level control var.)	(10) CC_Exp (Additional country-level control var.)
WUI	**-.158**	**.539*** **			**.594** **		**1.301*** **	**.522*** **	**.52*** **	**.548*** **
	(-.959)	**(3.632)**			**(2.046)**		**(6.815)**	**(4.079)**	**(4.07)**	**(4.263)**
WUI_2			**.518*** **							
			(3.743)							
WUI_3				**.484*** **						
				(3.733)						
Firm Size	-.02**	.056***	.056***	.056***	.121***	-.007***	.085***	.079***	.068***	.081***
	(-2.38)	(4.943)	(4.951)	(4.955)	(5.518)	(-19.33)	(9.965)	(8.086)	(7.07)	(8.46)
ROA	-.22***	-.301***	-.301***	-.301***	-.114	0.018***	-.356***	-.333***	-.322***	-.333***
	(-3.16)	(-3.946)	(-3.949)	(-3.95)	(-.557)	(5.86)	(-4.892)	(-4.362)	(-4.218)	(-4.362)
Leverage	-.294***	.006	.004	.004	.171	0.005*	-.075	-.059	-.022	-.053
	(-5.004)	(.059)	(.046)	(.044)	(1.005)	(1.69)	(-1.004)	(-.643)	(-.242)	(-.582)
Tangibility	1.087***	1.703***	1.703***	1.702***	1.398***	.0156***	1.633***	1.688***	1.697***	1.691***
	(9.723)	(12.12)	(12.113)	(12.111)	(6.856)	(3.46)	(15.425)	(12.021)	(12.049)	(12.01)
GDP per capita growth	-.039***	-.126***	-.129***	-.131***	-.13***	-.003***	-.113***	-.123***	-.119***	-.121***
	(-4.796)	(-14.111)	(-14.704)	(-15.003)	(-10.292)	(-10.18)	(-15.149)	(-14.321)	(-13.978)	(-14.071)
Inflation	.003	.019	.014	.012	-.032	-.002**	-.018	-.022	-.025	-.031
	(.216)	(.761)	(.57)	(.473)	(-.892)	(-2.41)	(-.94)	(-1.048)	(-1.22)	(-1.511)
WUI_Export Country						.722***				
						(122.66)				
Terrorist attack						.052***				
						(17.74)				
ASDI								-.079		
								(-.613)		
ADRI_Revised									.146***	
									(4.954)	
Extent of Disclosure Index										.039***
										(3.15)

Constant	1.219***	.063	.078	.092	-.769**	.188***	-.885**	-.151	-.542***	-.508***
	(8.645)	(.356)	(.445)	(.526)	(-2.043)	(11.82)	(-2.342)	(-.794)	(-3.087)	(-2.758)
Industry fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effect	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No
Observations	16619	16368	16368	16368	6766	16,482	16482	16368	16368	16368
R-squared	.415	.448	.448	.448	.464	.526	.44	.442	.443	.442
First-stage F statistic						7534.12***				
First-stage F stat. p-value						0.000				
Wu-Hausman F statistic							31.1792 ***			
Wu-Hausman F stat. p-value							0.000			

Note: This table presents the findings from the robustness tests. In Columns 1 and 2, we analyze the years before and after the Paris Agreement, respectively. In Columns 3 and 4, we employ two alternative definitions for WUI. In Column 5, we construct an alternative sample by excluding the USA from the sample. In Columns 6 and 7, we present the findings from the first and second stages of 2SLS regressions, respectively. In Columns 8 – 1, we include additional country-level control variables. We adjust the error terms for heteroscedasticity at the company level. Robust t-statistics are displayed in parentheses. Statistical significance at 1%, 5%, and 10% are indicated with ***, **, and *, respectively.

Table 8. The impact of WUI on climate change exposures after the Paris Agreement: The moderating impact of Ownership

	(1) CC_Exp	(2) CC_Exp	(3) CC_Exp	(4) CC_Exp	(5) CC_Exp	(6) CC_Exp
WUI	**-1.241*** **	**-1.147*** **	**-1.078*** **	**-.911*** **	**-.604** **	**-.705** **
	(-3.722)	**(-3.306)**	**(-3.5)**	**(-2.958)**	**(-2.214)**	**(-2.533)**
Ins Own	**-.004*** **					
	(-3.718)					
WUI * Ins Own	**.014*** **					
	(3.717)					
Ins Own Dummy		**-.115**				
		(-1.233)				
WUI * Ins Own Dummy		**.844*** **				
		(2.836)				
For Own			**-.003***			
			(-1.696)			
WUI * For Own			**.019*** **			
			(3.299)			
For Own Dummy				**-.011**		
				(-.123)		
WUI * For Own Dummy				**.565** **		
				(2.007)		
Gov Own					**-.003**	
					(-.667)	
WUI * Gov Own					**.007**	
					(.558)	
Gov Own Dummy						**-.301***
						(-1.928)
WUI * Gov Own Dummy						**.671**
						(1.594)
Firm Size	.059***	.055***	.053***	.049***	.088***	.088***
	(5.007)	(4.614)	(4.323)	(3.958)	(6.426)	(6.42)
ROA	-.278***	-.296***	-.341***	-.334***	.035	.024
	(-3.448)	(-3.631)	(-3.521)	(-3.447)	(.318)	(.22)
Leverage	-.034	-.035	-.038	-.034	-.157**	-.16**
	(-.389)	(-.393)	(-.425)	(-.377)	(-2.164)	(-2.213)
Tangibility	1.737***	1.724***	1.733***	1.735***	1.662***	1.659***
	(12.079)	(11.995)	(11.752)	(11.762)	(11.034)	(11.025)
GDP per capita growth	-.05**	-.048**	-.038*	-.042**	-.048**	-.046**
	(-2.416)	(-2.337)	(-1.838)	(-2.043)	(-2.277)	(-2.205)
Inflation	-.061*	-.058*	-.067*	-.067*	-.053	-.061
	(-1.776)	(-1.678)	(-1.883)	(-1.895)	(-1.411)	(-1.623)
Constant	.634***	.55***	.62***	.623***	.024	.083
	(3.12)	(2.656)	(2.978)	(2.977)	(.102)	(.347)
Industry fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	15385	15385	14851	14851	12262	12262
R-squared	.449	.449	.452	.452	.504	.504

Note: This table displays the findings from the regressions of CC exposure on WUI after the Paris Agreement, exploring the moderating impact of ownership attributes. The dependent variable is CC exposure. The independent variable is WUI. The moderating variables are the different features of ownership: Institutional, foreign, and state ownership. The firm-level control variables are firm size, ROA, leverage, and tangibility. The country-level control variables are GDP per capita growth and inflation. The definitions of all variables are provided in Table 2. We include industry, year, and country-fixed effects in all the models. We adjust the error terms for heteroscedasticity at the company level. Robust t-statistics are displayed in parentheses. Statistical significance at 1%, 5%, and 10% are indicated with ***, **, and *, respectively.

Table 9. The impact of WUI on climate change exposures after the Paris Agreement: The moderating impact of country-level differences

	(1) CC_Exp	(2) CC_Exp	(3) CC_Exp	(4) CC_Exp	(5) CC_Exp	(6) CC_Exp
WUI	-10.501**	6.01***	-4.776*	-3.092**	-1.915***	-.83***
	(-2.234)	(3.102)	(-1.721)	(-2.445)	(-3.816)	(-2.762)
ND Gain Index	.002					
	(.119)					
WUI * ND Gain Index	**.15****					
	(2.218)					
Vulnerability		3.762**				
		(1.999)				
WUI * Vulnerability		**-20.232*****				
		(-3.121)				
Readiness			.864			
			(.746)			
WUI * Readiness			**7.055***			
			(1.758)			
Env Policy Stringency Index (EPSI)				-.392***		
				(-2.692)		
WUI * EPSI				**.78***		
				(1.956)		
CCPI					-.001	
					(-.161)	
WUI * CCPI					**.03*****	
					(3.069)	
Env Litigation Risk Group (ELRG)						1.417***
						(13.56)
WUI * ELRG						**.628***
						(1.817)
Firm Size	.074***	.068***	.07***	.051***	.058***	.19***
	(7.693)	(6.678)	(7.329)	(4.38)	(5.685)	(14.705)
ROA	-.335***	-.32***	-.326***	-.305***	-.331***	-.399***
	(-4.366)	(-4.201)	(-4.272)	(-3.978)	(-4.309)	(-4.91)
Leverage	-.033	-.044	-.028	-.009	-.037	.117
	(-.359)	(-.474)	(-.304)	(-.093)	(-.394)	(1.207)
Tangibility	1.621***	1.64***	1.627***	1.659***	1.677***	2.8***
	(11.688)	(11.82)	(11.721)	(11.644)	(11.918)	(26.524)

GDP per capita growth	-.077***	-.076***	-.085***	-.061***	-.052***	-.05**
	(-4.155)	(-4.077)	(-4.591)	(-2.812)	(-2.81)	(-2.121)
Inflation	-.075***	-.086***	-.075***	-.082**	-.072***	-.066*
	(-3.022)	(-3.444)	(-3.142)	(-2.255)	(-2.772)	(-1.787)
Constant	-.006	-.921	-.433	1.795***	.541***	-2.507***
	(-.004)	(-1.617)	(-.542)	(3.809)	(2.819)	(-11.922)
Industry fixed effect	Yes	Yes	Yes	Yes	Yes	No
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	16121	16121	16121	15737	15908	16482
R-squared	.444	.443	.444	.442	.443	.198

Note: This table displays the findings from the regressions of CC exposure on WUI after the Paris Agreement, exploring the moderating impact of environmental country-level variables. The dependent variable is CC exposure. The independent variable is WUI. The moderating variables are the ND gain index and its components (readiness and vulnerability), the environment policy stringency index, CCPI, and the environment litigation risk group. The firm-level control variables are firm size, ROA, leverage, and tangibility. The country-level control variables are GDP per capita growth and inflation. The definitions of all variables are provided in Table 2. We include industry and year-fixed effects in all the models. We adjust the error terms for heteroscedasticity at the company level. Robust t-statistics are displayed in parentheses. Statistical significance at 1%, 5%, and 10% are indicated with ***, **, and *, respectively.