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Climate Risk, Corporate Social Responsibility, and Firm Performance

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We examine the impact of climate risk on firm performance with a focus on the moderating role of corporate social responsibility (CSR). Further, we explore how the interaction between climate risk and CSR changes with national culture and religion. Our findings show that firms in countries with greater climate risks are associated with higher levels of CSR activities, possibly suggesting that firms respond to climate risks by engaging in more CSR activities. We then provide robust evidence that higher CSR significantly mitigates the performance-reducing impact of climate risk. Importantly, the moderating effect of CSR is more pronounced in countries characterized by low individualism and high religiosity. Overall, our findings provide an alternative perspective on the risk-management benefits of CSR, suggesting that CSR can be considered as a response to climate-change related risks for corporations.

Introduction

This paper examines how climate risk affects firm performance, with a focus on the moderating role of corporate social responsibility (CSR). Furthermore, we investigate how national culture and religiosity impact the extent to which CSR alleviates the adverse effects of climate risk. It is widely acknowledged that the exposure of corporations to climate risks and the associated costs are significant. For instance, according to a recent report published by the World Economic Forum (2019), extreme environmental events are the most significant global threats for corporations. The cost of climate risk to corporations is expected to be about $1 trillion, half of which is anticipated to be incurred over the next 5 years (Roston, 2019). Climate change is also expected to hit supply chains across the globe owing to adverse weather conditions, with significant disruption of the delivery of goods and services. Several studies also suggest that climate change is significantly linked to political instability, which is likely to impact firms' operations as well as their strategic decisions (Henderson *et al.*, 2015; Jia and Li, 2020). Additional costs may arise for firms in their response to climate change, such as through the costs of adapting new technologies and measures to address society's concerns and expectations. Another climate-related risk concerns the legal risk that may arise when firms act against environmental regulations. Firms that are held accountable for the negative impact of climate risk may be faced with litigation cases as well as with significant business costs. In support of this view, it is reported that climate litigation cases have nearly doubled since 2017 (Setzer and Byrnes, 2020). With increasing awareness of the significant consequences of climate change, efforts to slow down climate change have dominated the agenda of policymakers across the world. The United States recently announced investments worth $1.7 trillion over the next 10 years to fight climate change, with a pledge to reduce US greenhouse gas (GHG) emissions to half

of the 2005 levels by 2030.[1] In 2019, the European Commission initiated the European Green Deal to transform the EU into a modern, resource-efficient, and competitive economy, with an ambitious target of net-zero GHG emissions in the member states of the EU by 2050.[2]

We set the conceptual framework of the paper as follows. We begin with the assertion that climate-related negative events are costly for firms and adversely impact their performance and value. It is hence expected that firms will seek to manage the costs and risks of climate-related events. Next, we argue that the risk-management benefits of CSR engagement are also relevant in mitigating the costs associated with climate-related risks, and hence firms are expected to increase their CSR activities when they are faced with significant climate risks. It is predicted that this in turn moderates the negative effects of climate risks on firm performance. We test these predictions empirically and examine how the moderating impact of CSR changes with national culture and religion.

There is a great deal of research investigating the effects of climate risks on corporations (e.g. Berkhout, Hertin and Gann, 2006; Gasbarro and Pinkse, 2016; Linnenluecke, Griffiths and Winn, 2013). However, the research examining the direct impact of climate risks on firm performance is limited. In one study examining the impact of climate risks on business performance, Huang, Kerstein and Wang (2018) show that firms in countries with higher climate risks have lower performance and more volatile earnings. Related to this, there is also an ongoing debate on how corporations should respond to the challenges of climate change. Several studies have explored whether firms can turn climate risk into a competitive advantage by investing in sustainability or CSR; by adapting their business practices to the changing technological environment; and by shifting customer demand towards green practices (see e.g. Chemmanur *et al.*, 2022; Clarkson *et al.*, 2011; He *et al.*, 2022; Pinkse and Kolk, 2012). For example, Chemmanur *et al.* (2022) reveal the positive relationship between CSR engagement and long-term survival probability. Similarly, He *et al.* (2022) find that firms are more likely to increase their CSR activities following a natural disaster and to experience better firm performance compared with non-disaster periods. Our analysis complements these studies but is also distinct in several important ways. First, we directly examine whether climate-related risks, measured based on negative actual climate events and their impact on society, lead to greater CSR engagement by firms using an international sample. Second, unlike in previous studies, we incorporate in the analysis the role of national culture and religion in impacting the interplay among climate risk, CSR, and firm performance. Accordingly, our research strategy is to examine whether corporations respond to climate-related risks by enhancing their CSR performance; whether CSR moderates the negative effects of climate risk on firm performance; and if national culture and religion play a significant role in moderating the impact of CSR.

We empirically investigate these research questions in an international setting with a large dataset comprising 2063 listed firms in 49 countries over the period 2010−2017. Our analysis consists of two distinct stages. In the first stage, we investigate the relation between climate risk and CSR. We find that firms in countries with greater climate-related risks adopt higher levels of CSR activities. In the second stage, we examine whether superior CSR performance helps firms to alleviate the negative impact of climate risk on performance. The findings strongly suggest that they do. Importantly, we also examine the role of country-level characteristics in determining the nature of the relation between climate risk and performance, and the interplay between climate risk and CSR in influencing firm performance.

Prior research shows that climate-related actions differ significantly across firms, industries, and countries (Graafland and Noorderhaven, 2020). Importantly, there is extensive evidence in the literature documenting the importance of cultural values in explaining the climate change adaptation strategies of countries and corporations (see e.g. Adger *et al.*, 2013; Baiocchi, Minx and Hubacek, 2010; Jenkins, Berry and Kreider, 2018). Consistent with this line of research, we consider how the degree of individualism/collectivism and of religiosity influence the relations we estimate in our analysis. We find that CSR exerts a stronger influence in countries with higher degrees of collectivism and religiosity. Our results are robust after controlling for endogeneity of CSR and using alternative measures for climate risk.

[1] https://www.theguardian.com/us-news/2021/apr/22/us-emissions-climate-crisis-2030-biden

[2] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

Our study contributes to the growing literature on climate risk and the extensive research on CSR in several important ways. Firstly, although previous research has identified several country-specific factors as determinants of CSR (e.g. Bansal and Roth, 2000; Galbreath, 2010; Ioannou and Serafeim, 2012; Young and Makhija, 2014), our study directly considers the relation between climate risk and CSR. Second, our study focuses on the role of CSR in moderating the adverse effects of climate risk on firm performance. In doing so, we add to the literature on the risk-reduction benefits and relevance of CSR by identifying additional potential benefits for corporations in relation to mitigating climate-related risks. Thirdly, we show the influence exerted by climate risk and CSR on firm performance as well as how this impact changes with national culture and religiosity. Overall, our study also contributes to the debate on climate change by providing additional insights into the effects of climate-related risks for corporations, investors, and policymakers.

The remainder of the paper is structured as follows. We discuss the relevant literature and develop our hypotheses in the next section. In the following section, we present our data and methodology. Thereafter, we present the main results and provides robustness checks. We conclude the paper with a discussion of the implications of our analysis and directions for future research.

Literature review and hypothesis development

In this section, we first provide explanations of why climate risk is expected to lead to greater levels of CSR engagement. We then focus on the moderating effects of CSR in reducing the negative impact of climate risk on firm performance. Our main approach in doing so is to discuss the risk-management and performance-enhancing benefits of CSR engagement and to establish the relevance of CSR for reducing the costs associated with climate-related risks.

The performance and risk-management benefits of CSR

The main benefits of CSR for corporations revolve around two related themes, namely risk management and firm performance. It is well established in the literature that there is a negative relation between CSR and firm risk. It is argued that investing in CSR activities can provide firms with 'insurance-like protection' through moral capital against firm-specific idiosyncratic risk (Godfrey, 2005; Godfrey, Merrill and Hansen, 2009). Building on this theory, Lins, Sarvaes and Tamayo (2017) suggest that CSR engenders social capital as it supports civic engagement, shared beliefs, and trust between a firm and its stakeholders. CSR and firm risk are also linked through a theoretical framework that considers CSR as a technological investment to increase product differentiation (Albuquerque, Koskien and Zhang, 2019). Furthermore, Kim, Lee and Kang (2021), using option-implied volatility as a proxy for the financial markets' expectations of a firm's future risk, show that CSR is associated with lower implied volatility. It is also shown that CSR can lower firms' cash flow volatility (Sun and Ding, 2020), reduce the likelihood of financial distress (Al-Hadi *et al.*, 2019), and provide protection for firms during adverse events (Minor and Morgan, 2011). Furthermore, firms can benefit from CSR investment through reduced downward pressure on stock price and any consequent stock price crash risk (Jia, Gao and Julian, 2020). There has also been ample research examining the impact of CSR on firm performance (see e.g. Cochran and Wood, 1984; McWilliams and Siegel, 2000; Nelling and Webb, 2009; Waddock and Graves, 1997; Walker, Zhang and Ni, 2019). The majority of prior research shows that there is a positive relationship between CSR engagement and firm performance. For example, Gregory, Tharyan and Whittaker (2014) show that CSR is directly linked to profitability and the cost of capital in the long run. Saeidi *et al.* (2015) argue that CSR impacts firm performance positively through increasing customer satisfaction, reputation, and competitive advantage. Based on a meta-analysis, Wang, Dou and Jia (2016) argue that the strengthened relationship between a firm and its key stakeholders gained by investing in CSR activities builds bilateral value, thus increasing firms' financial performance through the accumulation of moral capital.

There are several studies in the literature investigating the role of CSR in driving stakeholder support. It is argued that firms acting in a socially responsible manner can obtain reputation and the trust of their key stakeholders (Doney and Cannon, 1997). The trust established between the firm

and its stakeholders through CSR investments also helps to protect firms from negative economic events (Lins, Servaes and Tamayo, 2017). Furthermore, firms with higher social responsibility can establish more favourable relationships with their key stakeholders than can those with lower social responsibility, which in turn enhances firm performance by increasing competitive advantage (McAlister, Srinivasan and Kim, 2007). Similarly, Hillenbrand, Money and Ghobadian (2013) find that the CSR experiences of customers and employees amplify social trust. In support of this finding, Flammer (2015) argues that higher CSR engagement can boost stakeholder support by increasing employee satisfaction and meeting customer expectations. This, in turn, not only enhances positive attitudes towards corporations but also helps firms to shield against negative externalities. Therefore, it is reasonable to expect that firms located in countries with higher climate risk engage more in CSR to alleviate the negative consequences of climate change, through establishing social trust, boosting stakeholder support, and differentiating themselves from other firms by investing in innovative and environment-friendly products. Additionally, it is often argued that corporations can preserve legitimacy by devoting resources to CSR activities. Individuals in countries with higher exposure to extreme climate events are more sensitive to sustainable practices, which would in turn lead firms to invest more in CSR. In support of this argument, Huang and Lin (2022), using natural disasters as exogenous shocks to climate change beliefs, show that corporate environmental, social, and governance (ESG) ratings are higher in countries where beliefs are stronger regarding the negative consequences of climate change. They argue that firms tend to hedge against potential climate risks by investing more in CSR when they are located in areas with greater awareness of climate change. Importantly, they also show that the experience of natural disasters such as hurricanes and floods significantly alters the climate change perception of residents, which in turn motivates firms to engage more in CSR. Similarly, He *et al.* (2022) provide evidence of a direct relationship between the presence of natural disasters and the CSR engagement of Chinese firms. They find that Chinese firms tend to increase their CSR performance in the aftermath of a serious natural disaster. The occurence of natural disasters has also an impact on sustainability disclosures. Huang *et al.* (2022) investigate how firms react to natural disasters with respect to their ESG disclosure. They document that firms strategically increase their ESG disclosures following natural disasters to change investors' perception about the firm.

In our context, we argue that the experience of natural disasters increases the public awareness of climate change, reduces the social trust in corporations, and increases the demand for social responsibility. It is important to note that CSR engagement *per se* does not alleviate climate risk, which is exogeneous to firms. Instead, it is considered to help firms partly protect themselves from the adverse consequences of climate-related negative risks and events. We formulate our first hypothesis as follows:

Hypothesis 1: Firms in countries with greater exposure to climate risk have greater CSR engagement.

Climate risk and the moderating effects of CSR

Given the above arguments that emphasize the benefits of CSR engagement of firms, we postulate that CSR engagement helps to mitigate the negative impact of climate risk on financial performance through the reputation and social capital channels. Earlier studies revealed that CSR initiatives can mitigate adverse reactions from stakeholders in difficult times by informing them about the firm's efforts to protect its stakeholders in terms of the adverse effects of those times (Christensen, 2016; Flammer, 2013). Engagement in CSR activities in crisis periods is well received by society, and hence firms can strengthen their corporate image, influencing stakeholders to adopt a positive attitude towards the firm (Qiu et al., 2021). Given that climate risk increases the social awareness of environmental issues and the need for reputation insurance, we argue that investing in CSR mitigates the negative effects of climate risk on firm performance, through the reputation insurance channel.

Although climate risk adaptation strategies are generally linked to environmental strategies, the social dimension of CSR engagement can be relevant, especially in countries that are susceptible to crises and risks, including those associated with climate change. There are several ways in which the social dimension of CSR can

mitigate the negative impact of climate risk on firm performance. For example, the significant adverse effects of the climate crisis can lead to an increase in social awareness and social pressure on corporations to act against climate change. One of the ways in which corporations can gain social trust and build social capital is through social responsibility investments (Kim, Ha and Fong, 2014; Muthuri, Matten and Moon, 2009). By doing this, corporations can differentiate themselves from their rivals, strengthen their social capital, and gain competitive advantage (Andersson, Forsgren and Holm, 2002). Lins, Sarvaes and Tamayo (2017) provide evidence demonstrating that social capital can protect corporations from the negative effects of crises. They highlight that the benefits of social trust (capital) are more likely to emerge during crises. We expect that corporations can rebuild their social capital through social responsibility investments and hence have better performance during the climate crisis. Furthermore, low levels of social responsibility may adversely affect corporate brand as well as product quality if a natural disaster occurs. For example, ignoring safety measures may result in recalls of products and/or monetary penalties, which may result in significant losses to corporations. Therefore, in addition to the most visible CSR strategies such as public donations, 'avoiding harm' can also act as a reputation protection mechanism, especially when the public awareness of climate change is high and there is significant pressure on corporations in terms of responding to climate change. Employing a large sample of US firms for the period 2008–2009, Lins, Sarvaes and Tamayo (2017) compare the stock market performance of firms with high and low CSR scores. They hypothesize that high social capital is more valuable in times of unexpectedly low trust, such as the period of the global financial crisis. They use CSR as a measure of social capital. Their results reveal that firms with high social capital significantly outperformed otherwise similar firms during the crisis.

Ahn and Park (2018) argue that the long-term survival of a firm depends on its social performance as well as on its financial performance. They examine the role of various CSR engagements in the long-term survival and resilience of firms. It is found that firms can form social capital with their key stakeholders by engaging in common CSR activities, which in turn increases their long-term survival possibilities and success. Borghesi, Chang and Li (2019) state that firms need to be 'well-prepared' to survive in an uncertain environment, and they investigate the role of social capital in periods of economic policy uncertainty. The authors argue that forming social capital is an imperative for firms to be well prepared and sustain competitive advantage during such periods. Further, social capital encompasses the firm's strong relationship with society, and moral capital, which cannot be easily imitated by competitors (Naseem *et al.*, 2020).

There are several studies in the literature providing direct evidence on the role of CSR engagement in impacting financial outcomes when firms face natural disasters. In a recent study, Chemmanur *et al.* (2022) stress the role of CSR engagement in affecting firm survival, particularly under adverse climate conditions. Their findings support the argument that firms with greater CSR engagement are more likely to survive in the long term and less likely to be delisted when they are subject to extreme weather events. They also show that high-CSR firms are subject to less capital constraints and have increased access to finance, which helps them to survive during periods of high uncertainty. In a similar vein, He *et al.* (2022) document that engagement with CSR activities during periods of natural disaster rewards firms with higher financial performance later, compared with the situation during non-disaster periods. The authors argue that, in particular, larger and financially constrained firms are more likely to invest in CSR in the aftermath of natural disasters to preserve their reputation, aiming at better access to finance and lower cost of capital in the long term.

Therefore, it is reasonable to expect that CSR can reduce the adverse effects of climate risk on firm performance by serving as a governance tool and an insurance mechanism, and preserving social trust. Following the arguments above, we formulate our second hypothesis as:

Hypothesis 2: Greater CSR engagement reduces the negative impact of climate risk on firms' financial performance.

Moderating factors of the climate risk, CSR, and performance relationship

One of the important factors that affects the pro-environmental behaviour of individuals and their willingness to pay for socially responsible

products is a shared culture and shared experiences (Skirbekk *et al.*, 2020). We recognize that national culture and religion can influence the moderating effects of CSR. In what follows, we develop our predictions for these factors.

Individualism vs. collectivism: According to a national survey about climate change published by the European Commission in 2018, there are significant country-specific differences in public attitude towards climate change. For example, about 76% of individuals in Sweden believe that climate change is one of the most serious problems facing the world. On the other hand, only 22% of people in the Czech Republic consider climate change to be a serious problem. Further, prior research provides evidence of the role of cultural dimensions on a society's response to climate change adaptation (see e.g. Adger *et al.*, 2013; Kuruppu and Liverman, 2011; Higueras-Castillo *et al.*, 2019). Baiocchi, Minx and Hubacek (2010) studied the importance of sociodemographic differences in explaining CO_2 emissions and found that individual behaviour and lifestyle differences significantly predict consumer behaviour towards CO_2 emissions. Adger *et al.* (2013) argue that society's response to climate change is significantly determined by culture. In this study, we incorporate the view that the differing perceptions of climate change across nations can affect the way in which CSR interacts with climate risk in influencing firm performance. In this respect, we consider the individualism vs. collectivism dimension of national culture. Most of the prior work in the literature bases inferences on the individualism vs. collectivism dimension (Ballew *et al.*, 2020; Leiserowitz, 2006), asserting that individualism is a strong predictor of support for or opposition to climate change policies by a society.[3]

Hofstede (2001) defines individualism as 'a preference for a loosely-knit social framework in which individuals are expected to take care of only themselves and their immediate families'. On the other hand, collectivism is defined as 'a preference for a tightly-knit framework in society in which individuals can expect their relatives or members of a particular in-group to look after them in exchange for unquestioning loyalty'. We expect that the impact on firm performance of responding to climate change by investing in CSR is more pronounced in collectivist cultures for two reasons. First, prior literature reveals that collectivist cultures are more influential in pro-environmental behaviour (Cho *et al.*, 2013). In a recent study, Higueras-Castillo *et al.* (2019) investigated the effects of collectivism on attitudes towards renewable energy investments and found that pro-environmental behaviour is stronger in collectivist countries. Second, it has been shown that the willingness to behave in environmentally friendly ways is stronger in collectivist cultures than in individualistic cultures. This is expected to have both direct and indirect impacts on the performance effect of climate change responses (see e.g. Jia *et al.*, 2017). McCarty and Shrum (2001) find that there is a strong positive relationship between collectivism and pro-environmental actions such as engaging in recycling behaviour. The individualism vs. collectivism dimension of culture also has a direct influence on the willingness to pay for eco-friendly products. Pinto *et al.* (2011) find that the social orientation of individuals influences responsible consumption directly. They conclude that socially oriented individuals exhibit greater awareness of the environmental impacts of their actions, which in turn leads to higher levels of responsible consumption. Therefore, we formulate our next hypothesis as follows:

Hypothesis 2a: The moderating impact of CSR is more pronounced in collectivist cultures.

Religion. Understanding the link between climate change and social behaviour requires comprehending the role of religion in shaping human behaviour and the responses to climate change. Extant literature provides a strong connection between religious affiliation and differences in beliefs and opinions about climate change (see e.g. Jenkins, Berry and Kreider, 2018; Morrison, Duncan and Parton, 2015). Haluza-DeLay (2014) argue that religion is one of the significant determinants of 'sayings and doings' about climate change. According to Posas (2007), religions encourage their adherents to act against climate change and to use their influence to force world leaders to take a firmer stance and more ambitious measures

[3]There are also some studies that investigate the direct impact of national culture on CSR. However, the evidence is quite mixed. For example, Ioannou and Serafeim (2012) find a positive relationship between individualism and firm-level CSR practices. On the other hand, Liang and Renneboog (2017) find no significant relationship between individualism and CSR.

against climate change. Chester (2005) points out that in many regions where natural disasters are frequent and climate risk is high, religion is one of the most basic components of culture, which alters the interpretation of and individual responses to natural disasters. Previous research also emphasizes the social norm perspective of religion. For example, the organizational research literature argues that individual religiosity is linked to attitudes towards CSR and climate change (Kennedy and Lawton, 1998; Haluza-DeLay, 2014). Similar to the role of national culture, it is argued that a shared culture or religion affect consumption preferences or the willingness to adopt eco-friendlier products among the individuals of a society (Skirbekk *et al.*, 2020). In addition, it is also shown that individuals with strong religious beliefs tend to have more ethical intentions and are less likely to endorse morally questionable decisions. Given that responses to climate change are directly linked to the social norms and shared culture that reinforce environment-friendly behaviour, we expect that the influence on firm performance of responding to climate change by investing in CSR is stronger in countries with a higher level of religiosity. Therefore, we predict the following moderating impact:

Hypothesis 2b: The moderating impact of CSR is more pronounced in countries with a greater percentage of people self-identify as religious population.

Data and methodology

Measurement of climate risk

Following Huang, Kerstein and Wang (2018), as a measure of climate risk (*Climate risk*) we use the climate risk index, which has been published by Greenwatch since 2006 (Eckstein *et al.*, 2019). The global climate risk index evaluates countries for each year based on the occurrence of weather-related events such as storms, floods, and temperature extremes. There are four main indicators of the climate risk index, namely the number of deaths, the number of deaths per 100,000 habitants, the sum of losses in $US in real terms, and the losses per unit of GDP. The climate risk index uses relative rankings instead of absolute values to enable realistic comparisons across countries with different levels of population, economic output, and economic growth.

The climate risk score for each country is measured annually. However, annual scores are based on data from 2 years before the publication year. For example, the 2019 annual climate risk index is based on the weather-related events of 2017. Greenwatch also publishes a long-term climate risk index (*Long-term climate risk*), which is based on the previous 20 years of weather-related events and serves as a cumulative measure of climate risk over 20 years. We used the long-term climate risk index as an alternative measure of climate risk. Because lower values of both annual and long-term climate risk indices indicate higher climate risk, we multiplied these measures by −1 before conducting the empirical analysis.

To ensure the robustness of our analysis, we use the annual vulnerability index (*Vulnerability*) of the University of Notre Dame[4] as an alternative measure of climate risk. The vulnerability index measures a country's sensitivity to the adverse effects of climate change. This index calculates the overall vulnerability of countries considering six aspects, namely food, water, health, ecosystem service, human habitat, and infrastructure. Different from *Climate risk*, *Vulnerability* is not an event-based measure. Finally, we measure climate risk using the exposure dimension of vulnerability (*Exposure*), which considers the degree to which a country is exposed to climate-related events independently of social context. Unlike the other two measures, *Exposure* is time-invariant.

Measurement of CSR

Following El Ghoul, Guedhami and Kim (2017) and Luo *et al.* (2015), we calculate our CSR measure based on the Asset4 ESG data available from the Refinitiv Eikon database. The Asset4 database publishes the ESG index for each firm using more than 400 data points. Our CSR measure is the average of the environmental and social scores of the firms. Environmental score (*Environmental score*) indicates the capacity and effectiveness of the environmental strategies of firms to produce eco-friendly solutions that can help reduce environmental emissions. The environmental component of ESG is based on three sub-dimensions,

[4]https://gain.nd.edu/our-work/country-index/methodology/

namely resource use, emissions, and innovations. On the other hand, the social dimension of ESG (*Social score*) indicates the degree of social trust and loyalty within the overall society, including among employees and customers. Prior literature documents the role of the social activities of corporations in mitigating the negative consequences of climate risk on financial outcomes. For example, Chemmanur *et al.* (2022) stress the importance of community engagement, product quality and safety, and employee relations in helping firms to survive in the long term during the pandemic and climate crisis. The social score comprises four sub-dimensions, namely workforce, human rights, community, and product responsibility.

Table 1 presents, by country, the sample distribution and summary statistics of the variables of interest used in the analysis. The United States has the highest number of observations (4176), followed by Japan and the UK with 2432 and 1376 firm-year observations, respectively. Regarding the climate risk index, the Philippines, India, and the United States have the highest climate risk values over the sample period. As for the average CSR score, European firms have the highest CSR scores, especially those located in Portugal (0.759), France (0.727), and Spain (0.744). On the other hand, firms in Qatar (0.155), Egypt (0.279), and China (0.350) have the lowest CSR scores.

Methodology

In the first stage of the analysis, we test the impact of climate risk on CSR using the following regression model.

$$CSR_{i,t} = Climate\ risk_{i,t} + X_{i,t-1} + Y_{i,t-1} + \varepsilon_{i,t} \quad (1)$$

In Equation 1, X and Y denote firm- and country-specific variables, respectively. Subscripts i and t represent the firm and year, respectively. In line with earlier studies, we control for firm size (*Firm size*), leverage (*Leverage*), property, plant, and equipment (*PPE*), intangible assets (*Intangibles*), market-to-book ratio (*Market to book*) and return on assets (*ROA*) as firm-specific variables. Furthermore, we control for several corporate governance measures, which are expected to influence the CSR score of firms. Specifically, in the analysis we include board size (*Board size*), board independence (*Board independence*), duality (*Duality*), board diversity (*Board diversity*), and equity-linked CEO compensation (*CEO compensation*) as corporate governance controls. Regarding the country-specific factors, we control for GDP per capita (*GDP*), GDP growth rate (*GDP growth*), and the legal system of the country (*Legal origin*).[5] We also include year and industry fixed effects in all estimations. To minimize the effects of outliers, we winsorize all firm-specific variables at the 1% and 99% levels. Given the significant differences in the number of observations across countries, we use weighted least squares (WLS) estimation. This is done to prevent a country or a small number of countries with a large number of observations from dominating the sample and hence impacting the results significantly. Specifically, we weigh the standard errors by the inverse number of observations per country. Variable definitions and data sources are presented in Table 2.

In the second stage of our analysis, we test how climate risk and CSR interact in explaining firm performance, by estimating the following specification.

$$\begin{aligned} Performance_{i,t} = {} & Climate\ risk_{i,t} + CSRpred_{i,t} \\ & + Climate\ risk_{i,t} \times CSRpred_{i,t} \\ & + X_{t-1} + Y_{t-1} + \varepsilon_{i,t}. \end{aligned} \quad (2)$$

In Equation 2, we employ both accounting and market-based measures of performance. Our first proxy is operating performance (*EBITDA*), which is defined as the ratio of earnings before interest, taxes, and depreciation to total assets. Our second proxy is return on assets (*ROA*), defined as the ratio of net income before extraordinary items to total assets. As our third accounting-based performance measure, we use the ratio of cash flows from operations to total assets (*Cash flow*). Additionally, we use *Tobin's Q* as our market-based performance measure.

We acknowledge that the relationship between climate risk and CSR, which is predicted in the first stage of our analysis, may lead to biased results in estimating the performance specification given in Equation 2. To account for endogeneity, which can arise from the relationship between climate risk and CSR, we adopt a two-stage least-squares instrumental variable method (2SLS IV) in estimating the joint impact of climate risk and CSR on firm performance. Specifically, we

[5]The p-value of *Climate risk* is 0.001.

Table 1. Distribution of sample and country-level measures

Country	No. of obs.	*Climate risk*	*Vulnerability*	*Exposure*	*CSR*	*Social score*	*Environmental score*
Australia	1072	−0.394	0.296	0.480	0.464	0.485	0.443
Austria	56	−0.677	0.316	0.350	0.595	0.577	0.613
Belgium	120	−0.667	0.361	0.340	0.613	0.592	0.633
Brazil	272	−0.551	0.381	0.501	0.635	0.648	0.623
Canada	1016	−0.545	0.297	0.433	0.492	0.502	0.481
Chile	104	−0.590	0.345	0.384	0.472	0.451	0.494
China	296	−0.312	0.391	0.448	0.350	0.311	0.389
Colombia	40	−0.405	0.388	0.501	0.554	0.626	0.482
Czech Republic	8	−0.730	0.309	0.273	0.402	0.374	0.430
Denmark	136	−0.870	0.340	0.441	0.632	0.643	0.622
Egypt	32	−0.948	0.425	0.360	0.279	0.295	0.264
Finland	152	−1.011	0.307	0.443	0.674	0.611	0.737
France	536	−0.520	0.297	0.397	0.727	0.698	0.757
Germany	424	−0.542	0.293	0.347	0.676	0.691	0.662
Greece	48	−0.739	0.349	0.425	0.634	0.594	0.674
Hong Kong	736	−1.107	N/A	N/A	0.368	0.357	0.379
Hungary	24	−0.794	0.367	0.349	0.695	0.726	0.664
India	280	−0.255	0.505	0.572	0.596	0.605	0.586
Indonesia	136	−0.489	0.448	0.518	0.542	0.587	0.496
Ireland	40	−0.762	0.345	0.411	0.533	0.520	0.546
Israel	64	−0.797	0.338	0.284	0.428	0.425	0.430
Italy	160	−0.531	0.321	0.441	0.679	0.692	0.666
Japan	2432	−0.488	0.370	0.520	0.542	0.487	0.598
Kuwait	8	−1.070	0.434	0.397	0.647	0.674	0.620
Malaysia	184	−0.774	0.375	0.443	0.465	0.490	0.441
Mexico	80	−0.426	0.382	0.487	0.569	0.594	0.544
Morocco	8	−0.904	0.378	0.338	0.438	0.464	0.413
Netherlands	168	−0.864	0.350	0.397	0.685	0.690	0.680
New Zealand	64	−0.677	0.330	0.452	0.514	0.481	0.547
Norway	120	−0.830	0.272	0.389	0.585	0.607	0.562
Philippines	64	−0.196	0.461	0.492	0.468	0.442	0.493
Poland	80	−0.604	0.325	0.334	0.489	0.432	0.547
Portugal	56	−0.549	0.346	0.394	0.759	0.766	0.752
Qatar	8	−1.112	0.374	0.397	0.155	0.208	0.102
Russia	136	−0.551	0.333	0.440	0.505	0.502	0.508
Saudi Arabia	32	−0.703	0.388	0.358	0.354	0.353	0.356
Singapore	192	−1.094	0.416	0.538	0.421	0.413	0.428
South Africa	200	−0.462	0.403	0.431	0.645	0.665	0.625
South Korea	416	−0.729	0.376	0.494	0.600	0.570	0.631
Spain	224	−0.594	0.308	0.361	0.744	0.761	0.727
Sri Lanka	8	−0.371	0.475	0.499	0.677	0.652	0.702
Sweden	232	−0.891	0.303	0.410	0.707	0.688	0.726
Switzerland	264	−0.683	0.274	0.309	0.601	0.600	0.601
Thailand	112	−0.370	0.410	0.458	0.618	0.667	0.570
Turkey	96	−0.821	0.340	0.415	0.548	0.542	0.554
UAE	16	−1.000	0.380	0.367	0.473	0.478	0.468
UK	1376	−0.628	0.300	0.390	0.613	0.606	0.620
USA	4176	−0.270	0.339	0.481	0.550	0.565	0.535
Average		−0.665	0.359	0.419	0.550	0.550	0.550

This table presents the distribution of sample and the mean values of the variables across countries.

use the predicted values of CSR (*CSRpred*), obtained in the first stage, in the second stage of our analysis. Following prior studies (e.g. Bhandari and Javakhadze, 2017; Kim, Li and Li, 2014; Wang, Zhang and Xu, 2020), we also include the average CSR scores of the firms (*Industry CSR*) in the same industry and the initial CSR scores of firms (*Initial CSR*) as additional determinants for

Table 2. Variable definitions and data sources

Variable	Definition	Source
Climate risk	Annual climate risk index from Greenwatch multiplied by −1. Higher values indicate higher climate risk.	Greenwatch
Long-term climate risk	Cumulative climate risk index based on the previous 20 years multiplied by −1.	Greenwatch
Vulnerability	A country's sensitivity and capacity to adapt to the negative effects of climate change	Notre Dame Global Adaptation Initiative
Exposure	Degree to which a country is exposed to significant climate change from a biophysical perspective	Notre Dame Global Adaptation Initiative
Readiness	Degree to which a country has the ability to leverage investments and convert them to adaptation actions	Notre Dame Global Adaptation Initiative
CSR	Firm-specific corporate social responsibility score based on the Asset4 database of Thomson Reuters, which is the average of Environmental and Social scores of the firm	Refinitiv Eikon
Environmental score	Firm-specific environmental performance score based on the Asset4 database of Thomson Reuters	Refinitiv Eikon
Social score	Firm-specific social performance score based on the Asset4 database of Thomson Reuters	Refinitiv Eikon
Industry CSR	Average CSR scores of the firms in the same industry	Refinitiv Eikon
Initial CSR	Initial CSR scores of the firms that are available in the Eikon database.	Refinitiv Eikon
Tobin's Q	Tobin's Q ratio obtained from Thomson Reuters Eikon	Refinitiv Eikon
EBITDA	Earnings before interest, taxes and depreciation, scaled by total assets	Refinitiv Eikon
ROA	Net income before extraordinary items, scaled by total assets	Refinitiv Eikon
Cash flow	Cash flow from operations, scaled by total assets	Refinitiv Eikon
Market to book	Market capitalization plus total debt, scaled by the total assets	Refinitiv Eikon
Firm size	Natural logarithm of total assets	Refinitiv Eikon
Leverage	The ratio of total debt to total assets	Refinitiv Eikon
PPE	The ratio of property, plant and equipment to total assets	Refinitiv Eikon
Intangibles	The ratio of intangible assets to total assets	Refinitiv Eikon
Board size	Total number of board members	Refinitiv Eikon
Board independence	The ratio of independent board members to board size	Refinitiv Eikon
Duality	Dummy variable equals 1 if the CEO is the board director	Refinitiv Eikon
Board diversity	Percentage of foreign or female representation on the board	Refinitiv Eikon
CEO compensation	Dummy variable equals 1 if CEO compensation is linked to equity performance	Refinitiv Eikon
GDP	Natural logarithm of gross domestic product in US dollars	World Bank
GDP growth	Growth rate in gross domestic product	World Bank
Legal origin	Dummy variable equals 1 if the country is a Common Law country and 0 otherwise	Djankov *et al.* (2008)
Individualism	Country-specific individualism score based on Hofstede (2001).	Hofstede (2001)
Religion	Percentage of religious individuals to the total population based on the ARDA database.	The Association of Religion Data Archives

This table presents the definitions and data sources of the variables used in this study.

CSR in the first stage. We control for the year and industry fixed effects in all regressions.

Main results

Summary statistics

Table 3 presents the descriptive statistics of the variables used in the analysis. The average values of *Climate risk*, *Long-term climate risk*, *Vulnerability*, and *Exposure* are −0.506, −0.715, 0.340, and 0.456, respectively. Our sample firms have mean *CSR*, *Environmental*, and *Social* scores of 0.554, 0.559, and 0.549, respectively. Regarding the performance indicators, the average values of *EBITDA*, *ROA*, *Cash flow*, and *Tobin's Q* are 0.122, 0.059, 0.097, and 1.462, respectively.

In Table 4, we present the changes in CSR over time across industries. It is evident that CSR for the whole sample increased from 0.518 in 2010 to 0.605 in 2017. However, the changes in CSR scores over time vary across industries. For example, the

Table 3. Summary statistics

	No. of obs.	Mean	Std dev.	Minimum	Maximum
Climate risk	16,228	−0.506	0.261	−1.262	−0.022
Long-term climate risk	16,228	−0.715	0.323	−1.792	−0.190
Vulnerability	15,768	0.340	0.042	0.261	0.511
Exposure	15,768	0.456	0.057	0.273	0.572
Readiness	15,768	0.653	0.103	0.290	0.802
CSR	16,504	0.554	0.207	0.055	0.985
Environmental score	16,504	0.559	0.226	0.025	0.992
Social score	16,504	0.549	0.221	0.037	0.991
Tobin's Q	15,149	1.462	1.077	0.364	6.380
EBITDA	16,302	0.122	0.095	−0.225	0.430
ROA	16,504	0.059	0.081	−0.285	0.313
Cash flow	16,504	0.097	0.071	−0.094	0.336
Market to book	16,504	1.456	1.114	0.337	6.631
Firm size	16,504	22.506	1.427	18.865	25.958
Leverage	16,504	0.257	0.175	0.000	0.763
PPE	16,504	0.339	0.238	0.009	0.908
Intangibles	16,410	0.176	0.196	0.000	0.761
Board size	16,495	2.284	0.336	0.000	3.526
Board independence	16,314	0.548	0.275	0.000	1.000
Duality	16,168	0.399	0.490	0.000	1.000
Board diversity	16,188	0.133	0.122	0.000	0.667
CEO compensation	16,048	0.364	0.481	0.000	1.000
GDP	16,504	10.482	0.735	7.213	11.424
GDP growth	16,504	0.024	0.019	−0.091	0.251
Legal origin	16,504	0.577	0.494	0.000	1.000
Individualism	16,504	0.662	0.255	0.130	0.910
Religion	16,504	0.817	0.093	0.484	0.999

This table presents the summary statistics of the variables used in this study.

Table 4. CSR by industry and year

	2010	2011	2012	2013	2014	2015	2016	2017	*Mean*	*SD*
Basic materials	0.525	0.527	0.532	0.533	0.539	0.551	0.561	0.566	0.542	0.016
Consumer cyclicals	0.518	0.528	0.533	0.540	0.546	0.576	0.602	0.615	0.557	0.036
Consumer non-cyclicals	0.511	0.530	0.538	0.546	0.554	0.574	0.599	0.620	0.559	0.036
Energy	0.536	0.541	0.545	0.556	0.563	0.580	0.588	0.593	0.563	0.022
Healthcare	0.517	0.523	0.525	0.532	0.550	0.603	0.641	0.673	0.570	0.060
Industrials	0.508	0.520	0.525	0.529	0.531	0.565	0.588	0.598	0.545	0.033
Technology	0.527	0.538	0.536	0.547	0.560	0.602	0.635	0.651	0.575	0.048
Telecommunications	0.514	0.528	0.544	0.554	0.563	0.568	0.587	0.591	0.556	0.027
Utilities	0.500	0.502	0.508	0.512	0.524	0.544	0.574	0.572	0.529	0.030
Mean	0.518	0.527	0.532	0.538	0.545	0.572	0.594	0.605		
SD	0.011	0.011	0.011	0.014	0.014	0.020	0.026	0.035		

This table presents the changes in the average CSR scores by industry over time.

average CSR score for the healthcare firms increases from 0.517 to 0.673 between 2010 and 2017. A similar trend is also observed for the technology firms. On the other hand, the firms in the basic materials and energy sectors have relatively stable and consistent CSR scores over the years. The lowest CSR score during the sample period is for the utility firms (0.529).

The effect of climate risk on CSR

Table 5 presents the estimation results for the impact of climate risk on CSR. In column (1), we estimate our baseline CSR specification including only conventional firm- and country-specific variables. The results suggest that firm size and intangible assets positively impact CSR score. Furthermore,

Table 5. Climate risk and corporate social responsibility

	(1) *CSR*	(2) *CSR*	(3) *CSR*
Climate risk		0.096***	0.064***
		(0.029)	(0.025)
Firm size	0.046***	0.046***	0.033***
	(0.008)	(0.008)	(0.009)
Leverage	0.011	0.006	0.004
	(0.052)	(0.050)	(0.052)
PPE	0.003	−0.007	−0.010
	(0.056)	(0.054)	(0.052)
Intangibles	0.136**	0.117*	0.044
	(0.068)	(0.066)	(0.058)
Market to book	0.010	0.007	0.007
	(0.011)	(0.011)	(0.011)
ROA	−0.100	−0.054	−0.019
	(0.114)	(0.102)	(0.083)
GDP	−0.004	0.007	−0.005
	(0.014)	(0.012)	(0.013)
GDP growth	−1.280***	−1.219***	−0.939***
	(0.324)	(0.309)	(0.254)
Legal origin	0.005	0.003	−0.037**
	(0.019)	(0.017)	(0.017)
Board size			0.128***
			(0.027)
Board independence			0.105**
			(0.041)
Duality			−0.040***
			(0.015)
Board diversity			0.281***
			(0.067)
CEO compensation			0.052***
			(0.016)
Intercept	−0.439	−0.488*	−0.469*
	(0.279)	(0.262)	(0.252)
No of observations	14347	14071	13372
No. of firms	2063	2063	1975
R^2	0.201	0.218	0.314

This table presents the regression results of the impact of climate risk on corporate social responsibility. Regressions include year and industry fixed effects. The standard errors in brackets are heteroscedasticity-robust and clustered at the firm level. Variables are defined in Table 2. ***, **, and * denote the significance level at 1%, 5%, and 10%, respectively.

GDP growth rate negatively impacts firm CSR. However, other firm- and country-specific factors do not exert a significant impact on CSR. In column (2), we add climate risk to our empirical specification. The estimated coefficient of *Climate risk* (0.096) is positive and significant at the 1% level, suggesting that firms in countries with higher climate risk invest more in CSR.[5] Therefore, Hypothesis 1 is supported.

Table 6. Climate risk and corporate social responsibility: Alternative measures of climate risk

	(1) *CSR*	(2) *CSR*	(3) *CSR*
Long-term climate risk	0.069**		
	(0.027)		
Vulnerability		0.678*	
		(0.384)	
Exposure			0.381***
			(0.136)
Controls	Yes	Yes	Yes
No. of observations	13,372	13,004	13,004
R^2	0.320	0.317	0.317

This table presents the regression results of the impact of alternative climate risk measures on corporate social responsibility. Regressions include year and industry fixed effects. The standard errors in brackets are heteroscedasticity-robust and clustered at the firm level. Variables are defined in Table 2. ***, **, and * denote the significance level at 1%, 5%, and 10%, respectively.

Previous literature documents that corporate governance and board structure have a strong influence on CSR (see Bear, Rahman and Post, 2010; Hong, Li and Minor, 2016; Jo and Harjoto, 2012; Johnson and Greening, 1999; Rao and Tilt, 2016). We therefore incorporate in column (3) the proxies for *Board size*, *Board independence*, *Duality*, *Board diversity*, and *CEO compensation*. The results show that *Climate risk* continues to exert a significant impact on CSR. Overall, the results of our analysis of CSR are consistent with Hypothesis 1, that firms in countries characterized by high climate risk have greater levels of CSR.

Alternative measures of climate risk

To test the robustness of the positive relation between climate risk and CSR, we incorporate alternative measures of climate risk in examining the link between climate risk and CSR. To this end, we use three other measures of climate risk, namely *Long-term climate risk*, *Vulnerability*, and *Exposure*. For brevity, we do not report the estimated coefficients of the control variables. The results presented in Table 6 show that all measures of climate risk have a positive and significant relation with CSR.

Effect of climate risk on CSR dimensions

As explained above, our primary measure of CSR is the average value of the environmental and

Table 7. Climate risk and corporate social responsibility: Dimensions of CSR

	(1) *Environmental score*	(2) *Social score*
Climate risk	0.062 **	0.066**
	(0.026)	(0.026)
Controls	Yes	Yes
No. of observations	13,372	13,372
R^2	0.302	0.260

This table presents the regression results of the impact of climate risk on sub-dimensions of CSR. The standard errors in brackets are heteroscedasticity-robust and clustered at the firm level. Variables are defined in Table 2. ***, **, and * denote the significance level at 1%, 5%, and 10%, respectively.

social scores of corporations. In our analysis, we also separately investigate the impact of climate risk on these two dimensions of CSR. Accordingly, in Equation 3 (Equation 4), we use the environmental (social) score of corporations as our dependent variable. The firm- and country-specific variables on the right-hand side of our empirical specification are the same as discussed above.

$$Enviromental\ score_{i,t} = Climate\ risk_{i,t} + X_{i,t-1} + Y_{i,t-1} + \varepsilon_{i,t}, \quad (3)$$

$$Social\ score_{i,t} = Climate\ risk_{i,t} + X_{i,t-1} + Y_{i,t-1} + \varepsilon_{i,t}. \quad (4)$$

We present the results in Table 7, which indicate that the impact of climate risk on the separate dimensions of CSR remains unchanged. Furthermore, in support of our previous findings, the estimated relation between climate risk and the levels of both the environmental and social dimensions of CSR is positive and statistically significant.

Climate risk, CSR, and firm performance

To investigate the role of CSR in mitigating the negative effects of climate risk, we conduct a two-stage instrumental variable regression analysis (2SLS IV) that helps us control for endogeneity. In the first stage, we predict the CSR scores of firms (*CSRpred*) using two additional control variables, namely *Initial CSR* and *Industry CSR*, and use predicted values of CSR (*CSRpred*) in the second-stage regressions. The first-stage regression results are presented in Table 8 column (1). The results suggest that both *Initial CSR* and *Industry CSR* significantly determine the current CSR scores of the corporations.

The second-stage results presented in Table 8 columns (2)–(5) provide several important insights. First, the negative estimated coefficients of *Climate risk* support the view that, on average, climate risk reduces firm performance measured by operating profit (*EBITDA*), return on assets (*ROA*), and cash flow from operations (*Cash flow*). The results are in line with the findings of Huang, Kerstein and Wang (2018). However, we do not observe a significant negative impact of climate risk on *Tobin's Q*. Second, a significant relationship between *CSRpred* and performance is observed only for the operating profit measure (*EBITDA*) of performance and *Cash flow*. On the other hand, the estimated coefficient of the interaction term (*Climate risk* × *CSRpred*) is positive and significant for all three accounting-based performance measures. We do not find a significant impact of the interaction term when we use *Tobin's Q* as a proxy for performance. In line with Hypothesis 2, the findings support the notion that firms can mitigate the negative impact of *Climate risk* on accounting performance by investing in CSR activities. Overall, the findings also support the view that the effectiveness of CSR in improving firms' accounting performance is greater in countries with higher climate risk.

The role of national culture and religion

To test Hypotheses 2a and 2b, we divide our sample into two sub-groups based on the median value of the individualism dimension of national culture and the religiosity level of countries. We obtained religiosity data from the Association of Religion Data Archives (ARDA).[6] We then estimate our empirical specification for each sub-group. This allows us to compare the results of the impact of CSR and climate risk on performance, and the role of CSR in moderating the negative impact of climate risk.

Table 9 presents the results for each sub-group across four performance measures separately. In line with our earlier findings, the estimated relationship between CSR and performance is not

[6]http://www.thearda.com/Archive/CrossNational.asp

Table 8. Climate risk, CSR, and firm performance

	First stage	Second stage	Second stage	Second stage	Second stage
	(1) CSR	(2) *EBITDA*	(3) *ROA*	(4) *Cash flow*	(5) *Tobin's Q*
Climate risk	0.086***	−0.069***	−0.084***	−0.052**	0.037
	(0.025)	(0.019)	(0.027)	(0.026)	(0.734)
CSRpred		0.053***	0.016	0.027*	0.390
		(0.018)	(0.015)	(0.015)	(0.416)
Climate risk × CSRpred		0.106***	0.117**	0.071*	−0.113
		(0.032)	(0.046)	(0.043)	(1.237)
Firm size	0.030***	0.000	0.005***	0.001	−0.178***
	(0.006)	(0.002)	(0.002)	(0.001)	(0.042)
Leverage	0.006	−0.037***	−0.024**	−0.074***	−0.987***
	(0.043)	(0.013)	(0.010)	(0.011)	(0.220)
PPE	−0.015	0.047***	−0.008	0.086***	−0.123
	(0.043)	(0.015)	(0.014)	(0.011)	(0.207)
Intangibles	0.106**	0.036**	−0.002	0.055***	−0.036
	(0.052)	(0.014)	(0.013)	(0.011)	(0.242)
Market to book	0.001	0.054***	0.045***	0.039***	
	(0.008)	(0.002)	(0.002)	(0.002)	
GDP	0.024***	−0.008***	−0.004**	−0.000	−0.027
	(0.009)	(0.003)	(0.002)	(0.002)	(0.059)
GDP growth	−0.760***	−0.010	0.126	0.067	3.283***
	(0.251)	(0.079)	(0.096)	(0.072)	(1.126)
Legal origin	0.002	−0.010**	−0.004	−0.008**	0.057
	(0.014)	(0.004)	(0.004)	(0.004)	(0.090)
Initial CSR	0.556***				
	(0.000)				
Industry CSR	1.450***				
	(0.236)				
Intercept	−1.213***	0.071	−0.068	−0.033	5.453***
	(0.205)	(0.044)	(0.045)	(0.041)	(1.127)
No. of observations	13677	13510	13677	13677	12628
R^2	0.425	0.477	0.408	0.482	0.209

This table presents the regression results of the moderating impact of corporate social responsibility on the relationship between climate risk and firm performance. Regressions include year and industry fixed effects. The standard errors in brackets are heteroscedasticity-robust and clustered at the firm level. Variables are defined in Table 2. ***, **, and * denote the significance level at 1%, 5%, and 10%, respectively.

convincing. We find a significant relation only in low-individualism countries when we use *EBITDA* and *Cash flow* as the performance measure. Interestingly, firms in countries with higher levels of individualism have better market performance if they engage more in CSR. This finding supports the findings of Griffin *et al.* (2021), which suggest that there is a stronger positive relationship between corporate social performance and firm value in individualistic cultures.

The results for the interaction term are mixed. Specifically, the moderating role of CSR engagement is stronger for firms in countries associated with lower levels of individualism (i.e. with higher levels of collectivism) and higher levels of religiosity for accounting performance measures, supporting Hypotheses 2a and 2b. However, similar to the results obtained for the full sample, we do not find a significant moderating effect of CSR on the climate risk–market performance (*Tobin's Q*) relationship for any of the sub-samples.

Additional analysis for endogeneity

In our analysis so far, we have controlled for several firm- and country-level factors and industry

Table 9. Climate risk, CSR, and firm performance: The role of national culture and religiosity

	(1) High individualism	(2) Low individualism	(3) High religiosity	(4) Low religiosity
Panel A: Dependent variable = *EBITDA*				
CSRpred	−0.025	0.061***	0.049*	0.010
	(0.036)	(0.022)	(0.025)	(0.025)
Climate risk	0.022	−0.074***	−0.068***	−0.026
	(0.045)	(0.021)	(0.024)	(0.025)
Climate risk × CSRpred	−0.054	0.116***	0.114***	0.019
	(0.066)	(0.035)	(0.042)	(0.043)
Difference (p-value)	0.004		0.067	
R^2	0.428	0.510	0.512	0.406
No. of observations	6877	6633	8096	5414
Panel B: Dependent variable = *ROA*				
CSRpred	−0.019	0.012	−0.001	−0.003
	(0.027)	(0.018)	(0.019)	(0.018)
Climate risk	−0.018	−0.086***	−0.086***	−0.043**
	(0.035)	(0.030)	(0.032)	(0.021)
Climate risk × CSRpred	−0.023	0.134***	0.136**	0.027
	(0.050)	(0.052)	(0.056)	(0.034)
Difference (p-value)	0.012		0.039	
R^2	0.408	0.426	0.441	0.361
No. of observations	6968	6709	8196	5481
Panel C: Dependent variable = *Cash flow*				
CSRpred	−0.038	0.032*	0.029	−0.012
	(0.027)	(0.019)	(0.021)	(0.018)
Climate risk	0.032	−0.055*	−0.045	−0.025
	(0.034)	(0.028)	(0.032)	(0.022)
Climate risk × CSRpred	−0.058	0.077*	0.064	0.018
	(0.053)	(0.047)	(0.054)	(0.040)
Difference (p-value)	0.023		0.357	
R^2	0.400	0.518	0.512	0.418
No. of observations	6968	6709	8196	5481
Panel D: Dependent variable = *Tobin's Q*				
CSRpred	2.508***	0.148	0.385	0.294
	(0.738)	(0.415)	(0.497)	(0.500)
Climate risk	1.151	−0.105	0.301	−0.113
	(0.904)	(0.831)	(0.959)	(0.427)
Climate risk × CSRpred	−2.333	0.068	−0.740	0.465
	(1.516)	(0.084)	(1.685)	(0.724)
Difference (p-value)	0.291		0.252	
R^2	0.312	0.230	0.241	0.214
No. of observations	6236	6392	7638	4990
Controls	Yes	Yes	Yes	Yes

This table presents the regression results of the moderating impact of corporate social responsibility on the relationship between climate risk and firm performance for sub-samples of countries based on national culture and religiosity. Regressions include year and industry fixed effects. Difference (p-value) tests the significance level of *Climate risk × CSRpred* between sub-samples (high vs. low individualism and religiosity). The standard errors in brackets are heteroscedasticity-robust and clustered at the firm level. Variables are defined in Table 2. ***, **, and * denote the significance level at 1%, 5%, and 10%, respectively.

fixed effects and conducted a two-stage regression analysis to mitigate endogeneity-related problems. However, we acknowledge that the results may still be biased owing to several factors such as unobserved omitted variables, selection bias, and reverse causality (Li, 2016). For example, our 2SLS IV results for performance analysis may suffer from sample selection bias because firms with higher CSR scores can significantly differ from those with lower CSR scores, and these factors can also be correlated with financial performance (Wang and Qian, 2011). We therefore perform several further robustness tests. First, we incorporate additional control variables in our analysis. One such measure is *Readiness*, which is expected to be significantly correlated with the CSR engagement of firms and to exert an influence on firm performance. *Readiness* is reported by Notre Dame Global Adaptation Initiative. It measures a country's ability to adapt environmental actions, considering economic, governance, and social factors. Second, we include corporate governance variables such as board size, board independence, etc. in Equation 2. Finally, we employ the Heckman 2SLS approach, which combines the Heckman selection process with 2SLS instrumental variable analysis to simultaneously correct for selection bias and unobserved heterogeneity (Liu *et al.*, 2021). Specifically, before moving on to our original 2SLS IV regression analysis, we first run a probit model in which the dependent variable is 1 for firms with above-median CSR scores and 0 otherwise. In this Heckman probit regression, we include all covariates in Equation 1, including the corporate governance variables as additional instruments. From the probit model, we calculate the *Inverse Mills Ratio* as an adjustment term for selection bias and include this term in our original 2SLS IV regression analysis as a control variable, in both the first- and second-stage regressions. Similar to our original 2SLS IV model, we use *Initial CSR* and *Industry CSR* as the instruments in our first-stage IV regression analysis. Our untabulated results are qualitatively similar to those of two-stage regressions.

Excluding firms from the United States, the United Kingdom, and Japan

As discussed above, US firms enter our analysis with the largest number of firms. Although we employ WLS estimation to avoid the domination of countries with significantly greater numbers of observations, there may still be concerns about the validity of our results owing to sample-size heterogeneity. To avoid these concerns, we re-ran our models by excluding firms from the United States and from the United States, the United Kingdom, and Japan separately. Our results remain qualitatively unchanged.

Limitations of the analysis

As with other CSR studies, our study faces dataset limitations. Although several studies in the literature have used the Thomson Reuters Asset4 database, there are also other databases, such as Bloomberg or KLD, that report the CSR scores of companies. Therefore, in conducting our analysis, we depend on the reliability of CSR scores reported by Asset4. In addition, our sample period starts from 2010, because we were unable to obtain CSR scores for the majority of the companies before 2010. Furthermore, we acknowledge that our analysis is not likely to capture only the climate-risk-related risk-management and performance benefits of CSR. Similarly, climate-related risks are not the main reason why firms engage in CSR. In this respect, the reliability of our results depends partly on the extent to which our measures of firm-level CSR engagement capture the aspects that are relevant for our analysis of the impact of climate risk. Although we incorporate in the analysis different definitions of CSR engagement, there is not a CSR measure that more directly captures climate-risk-specific CSR engagement. Another caveat relates to the main measure of climate risk, which is not firm-specific. It is time-variant but measured at the country level. Measuring the vulnerability of firms to climate change would further improve the reliability and interpretation of the results.

Concluding remarks

In this paper, we have examined how climate risk affects firm performance and what role CSR plays in moderating the negative impact of climate risk on firm performance. Although it can be argued that climate-related risks affect firm performance, it is not easy to quantify how firms respond to climate risks. There are two main reasons for this. First, it is difficult to measure firm-specific climate risk. Second, there is no directly observable infor-

mation about the actions that firms can take to alleviate their exposure to climate-related risk. This study attempted to overcome these difficulties by combining firm- and country-level data in a two-stage analysis. In the first stage of the analysis, we investigated the nature of the relationship between climate risk and CSR. Specifically, controlling for other factors that are likely to impact CSR, we showed that firms respond to climate-related risks by engaging more in CSR, supporting the view that CSR activities can be considered as a response to climate risk. In the second stage, we investigated the direct impact of climate risk on firm performance and examined whether CSR engagement alleviates the negative impact of climate risk on performance. We found that climate risk is positively associated with CSR. This suggests that firms respond to climate-related risks by increasing CSR engagement. Furthermore, we provided robust evidence that climate-related extreme events adversely impact firm performance and that firms can mitigate the performance-lowering effects of climate risk by enhancing their CSR performance. Taken together, our main findings lend support to the view that CSR has risk-management benefits. The analysis so far contributes to the previous research on the climate risk–firm performance relationship (Huang, Kerstein and Wang, 2018) by identifying CSR as a way of reducing the adverse effects of climate risk on performance. In this respect, it also adds to the literature that explores the potential benefits of CSR.

We extended our main analysis in important ways. First, we investigated whether the moderating impact of CSR changes with national culture. We argued that the perception and hence the value of CSR vary with the cultural attitudes in countries. To capture this, we used the degrees of individualism and religiosity to estimate our performance models for sub-samples of countries. The results show that the moderating impact of CSR is more pronounced in countries characterized by low individualism and high religiosity. Conducting this analysis in the context of climate risk is a novel approach, and the findings suggest that in assessing the relevance and value of CSR, national cultural attitudes should be added as an additional dimension.

The findings of our analysis are useful to firms and investors for evaluating the expected costs of climate change and the benefits of CSR. Our analysis can also help policymakers in encouraging business organizations and providing the regulatory framework to improve their CSR performance. In this respect, our paper provides an additional perspective, enriching the understanding of the importance of CSR engagement. Importantly, our analysis also provides a useful setting in which the relevance of CSR can be investigated for the COVID-19 episode. Climate and COVID-19 pandemic risks have similarities, in that the consequences in both cases can be measured by mortality rates and economic losses (see e.g. Ozkan *et al.*, 2021). An interesting avenue for future research would therefore be to examine the correlation between the costs of both climate and pandemic risks and the role of CSR in helping corporations to manage these risks.

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