Received: 13 October 2022 | Revised: 30 June 2023 | Accepted: 12 July 2023

DOI: 10.1002/bse.3518

RESEARCH ARTICLE

Business Strategy and the Environment

WILEY

Stemming the tide: Does climate risk affect M&A performance?

Suman Lodh [1] | Nitin Deshmukh [2] | Alireza Rohani [2]

[1]Kingston Business School, Kingston University, Kingston Upon Thames, UK

[2]Middlesex University Business School, Middlesex University, London, UK

Correspondence
Suman Lodh, Associate Professor in Finance, Kingston University, Kingston Business School, Kingston Upon Thames, Surrey, KT2 7LB, UK.
Email: s.lodh@kingston.ac.uk

Funding information
We acknowledge the funding for the CDP database by the Middlesex University Business School.

Abstract

We examine the effect of climate change risks (CCR) on firms' decision of engaging in mergers and acquisitions (M&A) and M&A performance. In this study we use the responses by firms on '*climate change-related risks and opportunities*' of the Carbon Disclosure Project (CDP) survey and 1372 deals of US listed firms during 2010–2020. Consistent with risk vulnerability theory, our evidence indicates that firms with higher CCR have a lower probability of engaging in M&As. After controlling for possible endogeneity, our results also indicate that if acquirers with higher climate change risks choose to engage in M&A, it significantly reduces the announcement returns. These findings suggest that extant measures of climate change risks should be rethought when evaluating M&A efficiency. More broadly, our paper provides causal evidence that managers need to integrate CCR into their formal risk management systems to avoid unsuccessful M&As.

KEYWORDS
background risk, CDP, climate change risks, mergers and acquisitions, risk vulnerability theory

1 | INTRODUCTION

Developing an effective organisational strategy to act against climate change is one of the biggest issues in recent times (Broadstock et al., 2018; Hong et al., 2020; Shaw et al., 2018). In their commentary, Pinner and Sneader (2019) contend that firms cannot treat 'climate change as a far-off risk'. Rapid urbanisation and industrialisation significantly increased the consumption of energy leading to a growing concentration of CO2 emissions in the atmosphere (Shaari et al., 2020), which is one of the global environmental challenges. For instance, a recent analysis by Trucost[1] reveals that at least one asset of 66% of major global firms faces the high physical risk of climate change and 13% of earnings of these global firms are at risk. In addition, Trucost documents that many of these global players are US firms with the largest carbon pricing risks. Thus, formulating firms' response to climate change risks (hereafter CCR) due to carbon emissions and carbon-related activities is becoming increasingly central to firms' strategy (Jung et al., 2018).

A growing body of literature documents the purpose of mergers and acquisitions (hereafter M&A) (e.g., Cassiman et al., 2005; Lehmann et al., 2012; Lodh & Battaggion, 2015; Todtenhaupt et al., 2020). However, the literature in the same area also indicates how different aspects of risks such as cultural risks (Alexandridis et al., 2021), litigation risks (Huang et al., 2023) and employment risks

Abbreviations: CAR, Cumulative Abnormal Return; CCR, climate change risk; CDP, Carbon Disclosure Project; CRI, Climate Risk Index; CSR, Corporate Social Responsibility; GDP, gross domestic product; KLD, Kinder, Lydenberg & Domini; KMO, Kaiser–Meyer–Olkin; M&A, mergers and acquisition; PCA, principal component analysis; ROA, return on assets; 2SLS, two stage least square.

[1]https://www.spglobal.com/esg/education/essential-sustainability/climate/physical-risks

(Doukas & Zhang, 2020) can affect the success and the performance of the firms involved in the M&As. Heinle and Smith (2017) find that managers of the acquirer firms justify the value of the M&As by reviewing the target firms' financial health, and hence try to convince the shareholders. Unsurprisingly, managers also exercise their discretionary power to disclose only favourable information related to M&As to avoid any shareholders' uncertainty (Jorgensen & Kirschenheiter, 2003). Hence, in a recent study, Renneboog and Vansteenkiste (2019) argue that despite several studies on M&A by practitioners and scholars, the factors determining a deal's ultimate success remain a puzzle. Climate change risks can be considered as one of those factors affecting M&A engagement and performance. Bose et al. (2021) argue that nowadays firms are more likely to evaluate carbon risks in making investment, especially acquisitions. Thus, we argue that by examining the impact of climate change risk, a possible undisclosed channel of risks, much can be learned and applied for M&A engagement, performance, and greater environmental sustainability. In this paper, we examine the role played by CCR in M&A activity and subsequent post M&A performance. More specifically, we explore two aspects concerning the same—(i) do firms facing CCR choose to engage in M&As? and (ii) if they do so, how does that M&A fare in terms of abnormal announcement period return? We posit that CCR has a negative relation in which higher CCR maps to a decreased probability of M&A. We further posit that firms with high CCR who do engage in M&A will produce poor post announcement performance as measured using Cumulative Abnormal Returns (CAR).

Firms can mitigate the effect of climate change risks by externalising the cost of carbon emissions. However, firms are more likely to internalise carbon emissions' costs because of the emergence of carbon-related policies and regulations making CCR a significant business concern (Clarkson et al., 2015). Hence, CCR and its impact on M&A engagement and performance are important issues that require thorough investigation. Over the recent years, few studies (e.g., Arouri et al., 2019; Boone & Uysal, 2020; Bose et al., 2021; Hussaini et al., 2023) investigate the association between CSR, environmental reputation, carbon risks, ESG performance and M&A. Arouri et al. (2019) investigate the effect of CSR of acquirers on mergers and acquisitions (M&A) completion uncertainty. Using arbitrage spreads following initial acquisition announcements as a measure of deal uncertainty and an international sample of 726 M&A operations over the 2004–2016 period, they conclude a negative association between arbitrage spreads and acquirers' CSR. Their results suggest that CSR of acquirers is an important determinant influencing the way markets assess the outcome of M&As and of the perceived risk surrounding M&A operations.

Boone and Uysal (2020) examine the extent to which corporate acquirers consider environmental reputation when planning and structuring takeover. They found that firms with lower environmental reputation have a lower associated probability of being both targets and acquirers. They argue that acquirers are more likely to pair with firms with the same environmental reputation and are less likely to acquire firms with lower environmental reputation. They conclude that managers consider potential negative spillover effects when it comes to acquisition decisions. In another study from the similar research stream, Bose et al. (2021) examine the extent to which acquirer's level of carbon emissions (a proxy for carbon risk) matters in acquisitions. They found that firms with higher carbon emissions are more likely to acquire foreign targets than domestic targets, especially those operating in countries with low gross domestic product (GDP) and/or weak regulatory, governance, or environmental standards. They also found that cross-border acquisition announcement returns are higher when acquirers with high level of carbon emissions acquire targets in countries with weaker environmental standards or fewer regulations.

Our study complements and extends the above-mentioned literature further as well as provides some new insights into the climate change risks, as assessed by the firms from different aspects, and M&A. Such complementing of prior studies is common in the existing literature of mergers and acquisition, sustainability, and corporate social responsibilities for the further contribution to knowledge. Using a conditional logit model for 1372 deals of 296 listed US firms during 2010–2020 and consistent with risk vulnerability theory, our findings show that the CCR of firms negatively impacts their M&A performance as measured by CAR. In addition, addressing the endogeneity and self-selection bias we document a robust evidence that the CCR of firms negatively impacts their M&A performance as measured by cumulative abnormal return (CAR). We argue that this is due to the presence of background risk in the form of CCR, which makes the firms more risk-averse and thus they avoid engaging in M&A activity which would usually bring additional risk to the firm.

We contribute to the literature in several ways by distinguishing our analyses from prior studies on climate change risks. First, in this study we use more comprehensive measure of climate change risks. Previous studies such as Bose et al. (2021) use level of carbon emissions to estimate carbon risk. Carbon risk is just one dimension of climate change risks and it is naïve to believe that firm's carbon emissions capture all dimensions of a firm's climate change risks. We argue that without considering all aspects of climate change-related risk, the evidence of the relationship might not be plausible based on confounding effects. Hence, we use Carbon Disclosure Project (CDP) survey data and construct the CCR variable to estimate the impact of climate change risk factors for various firms. Our measure considers more aspects of climate change risk such as physical risk, regulatory risk and reputation risk. Thus, we employ a principal component analysis (PCA) on the phrases and keywords (see Appendix B) related to physical risk, regulatory risk, and reputation risk extracted from risk and opportunity question of CDP (see Section 3.1) to calculate a score for each of these three risks categories. PCA allows us to construct a comprehensive measure that considers multiple dimensions of risk into one single quantifiable measure.

Second, since the deal characteristics are fundamental to the success of M&A (Tanna & Yousef, 2019), we investigate the

association between CCR and several deal characteristics including deal completion, deal value, cross border deals and environmentally exposed industry deals.

Third, to the best of our knowledge, this is the first study that employs risk vulnerability theory as a theoretical framework in the areas of M&A and climate change risks. This theory states that in the presence of background risk, individuals become more risk averse. Since literature supports that M&A brings additional risk to the firm, CCR as background risk and the additional risk-aversion that it leads to will results in firms choosing not to go for M&As. This will be discussed in more details in the hypotheses development section.

The remainder of this paper is organised as follows. The next section defines the theoretical background and develops the hypotheses. Section 3 explains the sample, empirical model, variables' measurement and presents the results followed by the conclusion in Section 4.

2 | LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

2.1 | Channels of climate change risk and their impact

Hoffmann and Busch (2008, p. 514) define climate change risk (CCR) as 'any corporate risk related to climate change or the use of fossil fuels'. Climate change risk can affect a firm's financial health through several channels—(a) climate change itself, such as floods, drought and very high atmospheric temperatures, known as the physical risk (Dietz et al., 2016); (b) stricter climate policies by government and environment agencies affecting the asset values, transition to a low carbon economy by imposing emission trading schemes and/or carbon taxes, called regulatory risk[2] (Batten et al., 2016). These two types of risks are also echoed by CERES, a US-based non-profit organisation, that use them to tackle sustainability challenges such as global climate change. There is another kind of risk that may result in possible legal liability, financial loss or adverse impact on the reputation of firms if things go wrong. On many occasions, firms collapse because of failure of managing their reputational risk in time. Nikolaou et al. (2015) include a fourth category, termed as litigation risk. Following Jung et al. (2018) and Elijido-Ten and Clarkson (2019), we focus on physical risk, regulatory risk and reputational risk in our study.

A limited number of studies (e.g., Nguyen, 2018; Nikolaou et al., 2015; Sun et al., 2020) have investigated the effect of climate change risk on a firm's financial performance. Using a simulation model, Nikolaou et al. (2015) examine this relationship by dividing climate change risks into four categories, namely, physical, regulatory, reputational and litigation risks. Their findings show that physical risks are likely to have a strong impact on a firm's financial performance while the effect of climate change regulatory risks is mixed, and it depends on the nature of strategies adopted to address climate change policy. They also find that reputational risks negatively affect financial performance and can lead to customer attrition. Similarly, by creating a dummy variable to measure carbon risk,[3] Nguyen (2018) finds a negative and significant correlation between carbon risk and firm performance (Tobin's Q and return on equity) for Australian firms over a period of 2000–2014. The study argues that polluters are more likely to incur higher costs related to environmental protection, such as clean-up, reporting and risk management costs. In a more recent study, Sun et al. (2020) examine the effect of climate change risk on the financial performance of China's listed mining companies using a return on assets (ROA) to capture financial performance and an Integrated Climate Risk Index (CRI)[4] to measure climate change risk. They find a positive but non-significant relationship between CRI and the financial performance of China's mining companies. They argue that high temperature negatively affects the working environment of the mining industry which results in reduced labour productivity, and cryogenic freezing is a serious threat to the supply chain.

Therefore, these previous studies show that CCR mainly affects a firm's performance in a negative way. In other words, higher restrictions and costs faced by firms due to carbon-related regulations and policies can handicap them and negatively impact their performance (Nikolaou et al., 2015). In this scenario, firms need to invest in mitigation and adaptation strategies to meet new governments' policies and regulations. This can impose significant costs on firms. Likewise, the negative reputation of firms regarding climate change activities could negatively affect a firm's financial performance. Skjærseth and Skodvin (2001) argue that the general demand for environmental quality and growing awareness of climate change encourage consumers towards more environmentally friendly firms. Hence, any unexpected environmental accidents can negatively impact the reputation of firms, the views of suppliers, the demand for corporate products, and investors' decisions about firms. The aforementioned restrictions and costs imposed by different CCR categories may force firms to spend time, money, and other resources on these restrictions and costs.

2.2 | Mergers and acquisitions

M&A is an important area to examine mainly because it has a significant impact on the acquiring firms' futures. Despite several studies on M&A by scholars, Renneboog and Vansteenkiste (2019) argue that the factors determining the ultimate success of a deal remain a puzzle. We argue that one of the important factors impacting M&A behaviour and performance can be CCR. Several past studies, as listed in the next section, show that M&A is an inherently risky activity. Those risks exist for all firms that engage in M&A. However, for firms with high CCR there is an additional risk. This can make the firms more risk-averse and thus lead them to avoid engaging in M&A activity.

[2]TCFD (2017) mentions two major categories—physical risk and risk related to transition to low carbon economy.

[3]1 if the firm belongs to a carbon-intensive industry and 0 otherwise.

[4]The CRI is based on five climate risk indicators including 'Rain-waterlogging Index (CYRI), Drought Index (CYDI), Typhoon Index (CYTI), High-Temperature Index (CYHI) and Cryogenic-Freezing Index (CYFI)' (Sun et al., 2020, p. 5).

Hence, it is important to investigate how firms react in the presence of CCR and what would be the potential effect of CCR on M&A post announcement performance.

King et al. (2004) in their meta-analysis paper on M&A, indicate that it is possible for subgroups of firms to experience significantly positive returns from M&A activity. Recent literature has tried to find these subgroups. Cui and Leung (2020) using managerial ability data find that of all US firms that engaged in M&A activity between 2000 and 2012, those acquiring firms that had higher managerial ability achieved better long-term performance. Similarly, Glambosky et al. (2020) find that dividend-paying acquirers result in more successful M&A as compared to non-dividend paying acquirers. This is due to the disciplining role played by the existing dividend policy which directs managers towards acquiring targets that can produce free cash flows and away from empire-building acquisitions. Deng et al. (2013) focus on Corporate Social Responsibility (CSR) and M&A performance; they find that high CSR acquirers result in higher merger announcements and long-term returns as compared to low CSR acquirers. They argue that high CSR acquirers inspire trust and confidence amongst their stakeholders which in turn makes it easier for them to ride out the M&A-related uncertainties. More recently, Arouri et al. (2019) find that the M&A activity of high CSR acquirers is viewed more positively by the market as opposed to low CSR acquirers.

The literature on climate change and M&A is sparse. Bose et al. (2021) investigate the impact of a firm's carbon emissions on its decision to engage in M&A and subsequent acquisition returns. They use carbon emissions as a proxy for climate change risk. We believe that this is a blunt measure that does not consider the various aspects that contribute to climate change risk and focusses solely on one aspect, that is, carbon emissions. Boone and Uysal (2020) examine the issue of environmental reputation and M&A. They use data from KLD Research & Analytics (KLD) to estimate the environmental performance of a firm. KLD reports on a firm's environmental performance using dummy variables for 13 categories—6 for environmental strengths and 7 for environmental concerns. For each category KLD sets a threshold; if the firm meets or exceeds that threshold then it is assigned a value of 1 (otherwise 0) for that category. This is a significant improvement over using simply carbon emissions; however, we believe that our new measure is an improvement over these two previous studies. Our new measure of CCR is more robust and comprehensive. It considers more aspects of climate change-related risk such as physical risk, regulatory risk and reputation risk. We use principal component analysis which allows us to construct a comprehensive measure that considers multiple dimensions of risk into one single quantifiable measure. Our climate change risk measure is discussed in more detail in Section 3.1.

2.3 | Hypotheses development

The fact that M&A activity is inherently risky is well established. Shecter (1996) presents a thorough analysis of the various factors that make M&A risky, such as, product line expansion and associated liabilities, labour and employment law issues, identifying and managing environmental risks and intellectual property issues. Mantecon (2009) argues that cross border M&A brings with it many additional challenges for the acquirer, such as local cultural values that are new to the acquirer, different accounting and disclosure practices in the target country, and the overall nature of how business is conducted in the foreign country. This has also been presented as a key reason for the poor performance of cross border M&A (Moeller & Schlingemann, 2005). Chui (2011) presents a risk management model for M&A and in doing so identify the main risks involved as, Cost risk, Quality risk (Compatibility and Integration risk) and Time risk (Project delay risk). A report on M&A success by McKinsey (2012) finds that large M&A deals tend to be hit or miss. A recent report by Deloitte (2020) confirms that the risk factors in M&A identified several years ago, remain consistent even today.

The concept of risk aversion is well established in the literature (Pratt, 1964). It states that investors and decision-makers have a concave utility function; in other words, they choose to prioritise the preservation of capital over aiming for higher returns. Gollier and Pratt (1996) introduce the concept of *Risk Vulnerability* and show that adding additional background risk makes risk-averse individuals behave in a further risk-averse manner. In their view, the presence of said background risk reduces the value of the investment being evaluated. As previously discussed, M&A is an inherently risky activity; in addition to that, for the set of firms in this study, there exists the additional background risk of climate change, captured using CCR. We posit that this presence of an additional background risk should make the firms more risk-averse and thus lead them to avoid engaging in M&A activity. Hence, following the above discussion, it is expected that in the presence of CCR,[5] firms will be averse to taking on the additional risk arising from the M&A activity. Thus, the following hypothesis is developed.

> **H1.** Climate change risk (CCR) is negatively associated with M&A activity.

Another set of risks arise from post-merger integration challenges. For example, Ahuja and Katila (2001) find that acquirer firms tend to underestimate the magnitude of the integration task due to hubris. Zollo and Singh (2004) show that post-acquisition decisions play a major role in M&A success and that these require an extensive investment of time and effort. As discussed previously, dealing with CCR also requires significant amounts of time and effort; and hence, firms with CCR are likely to struggle to find the necessary time and effort needed for successful post-M&A integration. Thus, negatively impacting their post-M&A performance. This should be reflected in the post M&A announcement returns as measured using CAR. Secondly, a common problem in M&A's is overpaying for the deal, also known as the winner's curse. Acquirers overestimate the value of targets and hence, pay too high a price for it, such that

[5] As aforementioned, following Jung et al. (2018) and Elijido-Ten and Clarkson (2019), we focus on physical risk, regulatory risk, and reputational risk as proxies of CCR.

post-M&A gains turn out to be negative (Díaz et al., 2009; Ismail, 2011; Varaiya & Ferris, 1987). For our firms, this issue is further compounded by the presence of background risk in the form of CCR, because according to Gollier and Pratt (1996), underestimating the background risk can lead to overestimation of the price of a risky asset resulting in overpayment. Therefore, upon M&A announcement, the shareholders respond by reducing the demand and consequently the price of the acquirer's shares, which results in a negative CAR. Following above discussion, we posit that the presence of background risk in the form of CCR results in poor post-M&A announcement performance for the firms.

> **H2.** Firms that engage in M&A despite their climate change risk (CCR) will show poor post-M&A performance.

3 | DATA AND METHODS

3.1 | Data and variable description

We start with the Carbon Disclosure Projects (CDP) database. CDP is an independent non-profit organisation that has created a large database of voluntarily reported greenhouse gas (GHG) emission data from firms around the world since 2000. This database is increasingly used in environmental and sustainability research, such as Dawkins and Fraas (2011), Kim and Lyon (2011), and Luo et al. (2012), Qian and Schaltegger (2017), Lemma et al. (2021), amongst others. In our analysis, we use all the firms with headquarters in the US that participated in the CDP survey from 2010 to 2020. The year 2010 is selected as the starting year because the challenge of climate change was brought to sharp attention in December 2009 at the United Nation's Climate Change Conference in Copenhagen, Denmark (Abd Rahman et al., 2014). Since then, firms have gradually realised the urgency of managing climate change and its associated risks as corporate carbon management activities and innovation are encouraged by introducing market incentive schemes such as carbon pricing.

The CDP gathers environment and climate-related information through an annual survey under the headings such as climate change-related risks and opportunities, climate change strategy, initiatives, target, communications, governance, emissions methodology, emissions data, energy and carbon pricing. Following prior literature (Elijido-Ten & Clarkson, 2019; Jung et al., 2018), we construct three proxy variables for climate change risk, (a) *physical risk* (due to physical climate change), (b) *regulatory risk* (due to regulation change) and (3) *reputation risk (due to firm's reputational change*). In this study, we consider the '*climate change-related risks and opportunities*' category of the CDP survey to calculate the above-mentioned proxies. Questions of this category including climate change risks are modified after 2018 which results in more and slightly different risk types provided by CDP. Hence, to be consistent over the period of investigation (i.e., 2010–2020), we focus on risk descriptions/comments provided by companies[6] rather than CDP risk types to capture physical, regulatory and reputation risks.

These descriptions[7] are obtained for each of the categories of physical,[8] regulatory, and reputational risks flagged by the CDP. Following several prior studies (e.g., Elijido-Ten & Clarkson, 2019; Fiordelisi et al., 2013; Jung et al., 2018; Heidinger & Gatzert, 2018; Nordhaus, 2019; Pineiro-Chousa et al., 2017), we create a dictionary of keywords and phrases that can indicate the risks driven by the above-mentioned categories.[9] We employ a text mining algorithm to extract the keywords or similar expressions from the description/comments. Each successful hit is coded and dated with a dummy variable, for instance, if the sample firm mentions 'loss of public image' or 'loss of consumer trust' in the reputation category we code it as 1 and 0 otherwise.[10] So, we have several binary variables for each category of CCR.

The physical risk consists of 10 variables such as precipitation, induced change human nature, supply chain, temperature, extreme weather, seal level, snow, cyclone, physical risks and uncertainty. The regulatory risk includes 21 variables for instance air pollution, carbon cap and trade, carbon taxes, emission reporting, fuel energy, environmental regulation, exposure supplier, international agreement, lack of regulation, regulatory drivers, product efficiency, product labelling, renewal energy, uncertain regulation, voluntary, policy, compliance, assessment, scheme, impact and energy. Finally, the reputational risk is constructed out of 23 variables such as media, client, external reputation, loyalty, image, pressure, expectation, market share, competition, damage, confidence, disadvantage, mandatory, fail to enact, climate policy, regulatory requirement, proactive, shifting, consumer attitude, compliance, induced change, fail to identify and uncertainty. These variables are used in the principal component analysis (PCA) to reduce the dimensions that load in a similar category. The PCA gives us the scores for physical, reputational and regulatory risk. The factor loadings satisfy the criteria of eigenvalues greater than 1 on a scree plot and the KMO equals 0.891 for physical risks, 0.922 for regulatory risks and 0.831 for reputational risks. This exercise gives us a comprehensive list of US firms with three different types of CCR scores.

In the next stage, we match these firms by ISIN with a large sample of Mergers and Acquisitions (M&As) for all the non-financial listed US firms available in the Thomson Reuter's Eikon database and Bloomberg database. Our initial sample includes all deals, where the acquirers are US firms and valued at least $1 million from 2010 through 2020. We exclude any deals with acquiring firms that the Eikon database records as 'unknown location' for both acquirers and targets. Following Cornaggia and Li (2019), we consider all deals irrespective of whether the M&A resulted in a 100% acquisition or a change in controlling interest. Concerning the nature of the target

[6]We retrieve the risk related descriptions for acquirer firms. Data for most of the target firms are not available.

[7]A sample of comments and descriptions for each risk category is given in Appendix B.

[8]Since 2018, the risk driven by physical climate change is categorised as *acute* and *chronic* physical risks. Similarly, the risk driven by regulation change is divided into *current* and *emerging* regulations from 2018 onwards. The reputational risk category remains unchanged throughout the sample period 2010–2020.

[9]Refer to the Appendix A for the list of keywords

[10]A similar method is followed by Lechner and Gatzert (2018).

firm, we include M&As of all public and private targets except government-owned ones, which are excluded. We observe that most M&A targets are private firms. As our primary focus of this study is to analyse the M&A activities of the US acquirers, we consider both private and public targets across the world. However, all the acquirers in our sample are publicly traded firms; this enables us to collect financial data from DataStream and Capital IQ for them. We record the industry classifications (SIC) of both acquirers and targets, deal value, deal completed or withdrawn and other deal-related information from the Eikon database.

To capture the M&A activity and performance of the above-mentioned firms, we use two variables in our base model—(1) a binary variable that is equal to 1 if the acquirer has at least one M&A activity in the following year of participating in the CDP survey and thereafter within our study period and 0 otherwise (see Section 3.3.1 for more details); and (2) acquisition performance measured by five-day cumulative abnormal return (CAR) using a market model. These two variables are the dependent variables in our base line models. After merging these two datasets, as well as other firm-level financial and deal level control variables, our final data set consists of 1372 deals from 296 US acquirers.

3.1.1 | Control variables

The control variables are obtained from DataStream for the sample US acquirers. Since most targets are private firms, the financial data for these firms are difficult to retrieve and sometimes unavailable; thus, our control variables include only the financial characteristics of the acquirer firms. We use *capital intensity* (measured as capital expenditure divided by total sales) to control for the firm's ability in deploying its assets efficiently. This in turn can impact the M&A performance. The larger the firm is, the greater the attention it receives from the media (Stanny & Ely, 2008), and the *firm size* can also affect the legitimacy pressure faced by the firm; thus, we control for firm size (measured as the logarithm of total assets). De Villiers et al. (2011) argue that liquid firms can allocate adequate cash to improve their operations and accommodate environmental compliance costs more easily; thus, we control for *liquidity*, measured as net cash flow from operations divided by the beginning period total assets. We control for *profitability* (measured as earnings before interest and taxes divided by total assets) as recent studies highlight that improved environmental performance can enhance financial performance (e.g., Tzouvanas et al., 2020). Newer equipment employs fewer polluting technologies that can reduce the environmental risk of the firms; thus, following Gallego-Álvarez et al. (2011), we control for *asset newness* (the ratio of annual net property, plant and equipment [PPE] to gross annual PPE). Highly levered firms are more concerned about disclosing carbon emission-related information (see Akbaş & Canikli, 2019; Ferguson et al., 2002); thus, we include *leverage* as a control variable, measured as the ratio of book value of total debt and total assets at the end of the fiscal year before the announcement date. We use *book-to-market ratio* as a proxy for investment opportunity or growth (see Smith & Watts, 1992), which can affect the relationship between the firm's M&A activities and environmental awareness. Following Mohana-Neill (1995), we control for the *acquirer's age* (the difference between the sample year and incorporation date) as older firms have the relevant infrastructure to manage environmental issues at lower costs. Moeller et al. (2004) and Banerjee et al. (2014) argue that deal competition can reduce the acquirers' post M&A returns, we also include deal level control variables such as deal competition—a binary variable takes 1 if there are more than one bidder for a target, 0 otherwise; *Stock Only*—an indicator variable if the deal is financed by only stock, 0 otherwise; *Cash Only*—takes 1 if the deals are financed by only cash, 0 otherwise; and *Toehold*—if the acquirer already holds a certain percentage of shares of target firms at the announcement date in our sample, 0 otherwise. Additionally, we include CEO duality (a dummy variable that equals 1 when the CEO is also the Chairman of the firm, and 0 otherwise). As deal numbers in our sample considerably vary across industries and years, we include industry and year dummies to control for industry and year heterogeneity. Furthermore, in our analysis of only cross-border deals in the robustness tests, we include few country level control variables—such as language distance—the language difference between acquirer and target countries (Zhu et al., 2015), legal enforcement (Rossi & Volpin, 2004), capital control and as Capital control provides policy makers the degree of freedom to regulate the capital flow (Heinemann, 2012) and GDP growth in the target countries. All variables are defined in the Appendix A.

3.2 | Descriptive statistics and correlation matrix

We present the summary statistics in Table 1a for the variables of interest. The mean (standard deviation) of physical, regulatory and reputational risks are −0.29 (1.03), 0.02 (0.48) and 0.02 (0.78), respectively. 71% of CEOs in our sample firms are also chairman (chairwoman) of the board, and 53% and 5% of our sample firms use only cash and only stock for payments respectively. Only a small number of acquirers engage in competition. In Table 1b, we report the year-wise distribution of physical, regulatory, and reputational risks. We can also observe that during 2015 and 2016, over about 21% of deals take place. The number of deals decreases in 2019–2020 due to the impact of the pandemic and uncertainty in the international markets. In Table 1c, we present the number of deals within the Fama–French 10 industries. It shows that around 28% of deals occur in the business equipment sector.

Table 2 presents the correlation matrix of the variables used in our estimations. The table shows a negative relation between physical and reputational risks and M&A performance, but positive correlation between regulatory risk and M&A performance. The correlation between physical and regulatory risks is positive, indicating that physical risk can drive the regulatory restrictions. On the other hand, reputational risk is negatively correlated to both physical and regulatory risks. It indicates that firms are cautious about the impact of physical and regulatory risks on their reputation.

TABLE 1a Descriptive statistics.

	Obs.	P1	Mean	Median	SD	p99	VIF
CAR (−2, +2)	1372	−0.1097	0.0002	0.0009	0.0388	0.1139	1.06
Physical risk	1257	−4.0003	−0.2918	−0.0634	1.0253	0.9659	1.04
Regulatory risk	1279	−0.7671	0.0217	0.0128	0.481	0.7894	1.02
Reputational risk	1155	−2.0704	0.0246	−0.0385	0.7823	2.3400	1.05
Capital intensity	1268	0.0528	3.6714	2.9476	3.0993	15.5784	1.21
Firm size	1313	20.5828	23.9780	23.8937	1.4595	27.7406	1.09
Liquidity	1313	−0.0018	0.1075	0.1033	0.0592	0.2780	2.87
Profitability	1311	−0.0852	0.0905	0.0904	0.0678	0.2599	2.78
Asset newness	1206	0.2155	0.4860	0.4685	0.1300	0.7911	1.30
Leverage	1313	0.0000	0.2948	0.2778	0.1596	0.7186	1.13
Book to market	1166	0.0984	1.4555	0.7412	2.5839	14.706	1.34
Log (acquirer age)	1319	1.0986	3.5087	3.4965	0.8063	5.0752	1.12
CEO duality	1372	0.0000	0.7150	1.0000	0.4516	1.000	1.07
Competition	1372	0.0000	0.0211	0.0000	0.1439	1.000	1.03
Toehold	1372	0.0000	0.0576	0.0000	0.233	1.000	1.03
Cash only	1372	0.0000	0.5306	1.0000	0.4992	1.000	1.14
Stock only	1372	0.0000	0.0547	0.0000	0.2274	1.000	1.12

Note: The table reports the summary statistics of the variables of our analyses for the 1372 deals of the US acquirers during 2010 and 2020 (deal announcement years). The target firms are from US and non-US countries. The number of observations (Obs.), P1 (1 percentile), Mean, Standard deviation (St Dev), P99 (99 percentile) and variance inflation factor (VIF) are presented from left to right of the table. Detailed definition of the variables can be found in Appendix A.

TABLE 1b Year-wise distribution of number of deals and CCR.

			Climate change risk		
Year	No. of deal	%	Physical risk	Regulatory risk	Reputational risk
2010	162	11.81	−38.64	8.13	−0.47
2011	144	10.5	−46.32	10.53	6.40
2012	133	9.69	−28.57	6.24	10.09
2013	104	7.58	−50.21	0.99	−7.94
2014	137	9.99	−41.11	−3.83	12.16
2015	144	10.5	−32.37	15.23	3.17
2016	137	9.99	−43.39	7.20	10.50
2017	116	8.45	−60.42	3.68	−9.78
2018	122	8.89	−6.67	−10.26	9.38
2019	91	6.63	−8.39	−0.11	−2.08
2020	82	5.98	−10.74	−10.09	−0.41
Total	1372	100			

Note: The table shows the distribution of number of deals by US acquirer between 2010 and 2020 and CCR variables by announcement year in our sample. Acquirers are public firms and while targets are either public or private.

3.3 | Identification strategy and baseline results

Prior literature such as Brooks et al. (2018) and Bose et al. (2021) indicates that analysing multiple deal characteristics of M&A with other variables in a research question is a complex process. In this section, we estimate if a firm's climate change risks (CCR) in the current year have any effect on the probability of engaging in an M&A in the following year. The underlying hypothesis is that firms which already have CCR are less likely to take on the additional risks that come from engaging in M&A activities.

TABLE 1c M&A deal distribution by Fama–French industries.

Fama–French industry code (10 industries)	Number of deals	Percent
Consumer non-durables	105	7.65
Consumer durables	53	3.86
Manufacturing	186	13.56
Oil, gas, and coal extraction and production	32	2.33
Business equipment	380	27.70
Telephone and television transmission	62	4.52
Wholesale, retail, and some services	66	4.81
Healthcare, medical equipment, and drug	204	14.87
Utilities	58	4.23
Other—mines, construction, building materials, trans, and so on	226	16.47
Total	1372	100

Note: The table presents the number of deals distributed in the Fama–French 10 industries categorisation (based on acquirer's 4 digit SIC code). Our sample consists of a total number of 1372 deals by the US acquirers during the 2010–2020 announcement year. The acquirers are public firms, but targets are either public or private firms.

3.3.1 | The likelihood of firms with climate change risks becoming acquirers

We begin with testing the relationship between CCR (physical, regulatory and reputational risks) and the probability of firms engaging in M&As as an acquirer. Following Bena and Li (2014) and Brooks et al. (2018), for each sample acquirer that participated in the CDP survey and described their CCR awareness, we identify a potential acquirer (with bootstrapping). To do so, we find all possible potential acquirers in the same Fama–French 10 industries in the same year of announcement date with similar market capitalisation and book to market ratio (within a 20% range). This matching algorithm allows us to create a binary dependent variable that equals 1 if the sample firm (participated in the CDP survey) and becomes an acquirer in the following year, and 0 for the firms that participated in the CDP survey but never participated in M&A during 2010–2020. The year-wise distribution of firms is presented in Appendix D. The independent variables are physical, regulatory and reputational risks,[11] with firm and deal level control variables. We estimate the following Equation (1) by the discrete choice model—a conditional logit regression on the cross-sectional dataset as of the fiscal year-end before the deal announcement. According to Cameron and Trivedi (2005) and McFadden (1973), this method is also known as quasi-fixed effects model that limits the calibrations across firm-feature groups.

$$MA_{i(t+1)} = \begin{cases} = 1 \text{ if } K\left(\beta_0 + \sum \beta_m X_{it} + \sum \beta_n C_{it} + \sum d_t + \sum ffi(10)_i + \in_i\right) > 0 \\ = 0 \text{ otherwise} \end{cases} \quad (1)$$

where $MA_{i(t+1)}$ is a binary variable as described above. K(.) is the non-linear function. Variable X_{it} is a vector of our main independent variables that include physical, regulatory, and reputational risks. C_{it} are the vector of firm and deal level control variables for acquirers that includes capital intensity, firm size, liquidity, profitability, asset newness, leverage, book-to-market, firm age, stock only, cash only, deal competition and toehold and CEO duality. All variables are defined in Appendix A. The Fama–French 10 (ffi10) industries and year (d) heterogeneity are also controlled in Equation (1). $\in_i$ is the idiosyncratic error. The coefficients of interest refer to β_m. The results are presented in Table 3.

All the three columns show that the coefficients of physical ($\beta = -.4526$, $p < .01$), regulatory ($\beta = -.1305$, $p < .01$) and reputational ($\beta = -.1569$, $p < .10$) risks are negative and statistically significant. In economic terms, with a 1% increase in physical, regulatory and reputational risks, the odds of engaging in M&A by an acquirer decreases by 45%, 13% and 15%, respectively. These results support our first hypothesis that the increased risk driven by climate change leads to a decrease in the probability of firms becoming acquirers as compared to other potential firms with similar characteristics. M&As are risky for all firms; for firms with pre-existing CCR, a higher level of CCR as measured by the three components of physical, regulatory and reputational risks, deter those firms from engaging in M&A activity. Our results support the risk vulnerability theory, that is, firms with pre-existing background risk in the form of CCR tend to behave in a more risk averse manner and hence avoid indulging in M&A activity which is inherently risky.

In terms of control variables, only firm size and book to market are statistically significant. For instance, the firm size shows that a 1% increase in firm (acquirer), the odds of engaging in M&A by an acquirer increases over 75%. This is also evident from the book to market ratio as increase of book to market ratio leads to decrease in likelihood of M&A.

3.3.2 | The effect of climate change risks on acquisition performance

In this section, we analyse how the investor's reaction (a measure of acquisition performance) to M&A announcement changes with the change in CCR of an acquirer. To do this, we calculate the cumulative abnormal returns ($CAR_{(t-2),\ (t+2)}$)[12] for the five-day event window around the deal announcement date ($t = 0$). We follow Suk and Wang

[11]We obtain two different scores for regulatory and reputational scores that are loaded with eigen value more than 1. But we report only one measure of these variables in our analyses. We use the second score of reputational risk in unreported regressions and find that it gives similar results.

[12]We follow Bose et al. (2021) and Delis et al. (2022). The model is estimated using at least 30 non-missing daily return (Brooks et al., 2018) for 200-day of estimation period and value-weighted market return as benchmark. In addition, we exclude 30-day window immediately prior to the announcement date to avoid the impact of leak or rumour of deal information in the market.

TABLE 2 Pairwise correlations.

Variables	1	2	3	4	5	6	7	8
1. CAR (−2, +2)	1.0000							
2. Physical risk	−0.0100	1.0000						
3. Regulatory risk	0.09***	0.0100	1.0000					
4. Reputational risk	−0.0400	−0.0400	−0.0300	1.0000				
5. Capital intensity	−0.0200	−0.0200	−0.0100	−0.11***	1.0000			
6. Firm size	−0.09***	−0.11***	−0.08***	0.07**	−0.09***	1.0000		
7. Liquidity	0.0200	0.0100	−0.0200	0.0000	0.19***	−0.12***	1.0000	
8. Profitability	0.0100	−0.0100	−0.0200	0.0200	0.06**	−0.07**	0.78***	1.0000
9. Asset newness	−0.0400	0.0300	0.0200	−0.06**	0.23***	0.07**	−0.24***	−0.27***
10. Leverage	0.06**	0.08***	0.0400	−0.0200	0.0300	−0.10***	−0.0100	0.0400
11. Book to market	−0.0300	−0.07**	−0.0100	−0.07**	−0.0400	0.32***	−0.42***	−0.36***
12. Log (Acq age)	0.0000	−0.0100	0.06**	0.07**	−0.0300	0.11***	0.07***	0.17***
13. CEO duality	−0.07**	0.08***	0.0000	0.0200	−0.07**	0.08***	−0.05*	−0.07**
14. Competition	0.0000	0.0000	0.0200	−0.0200	0.0400	−0.07**	0.0000	−0.0400
15. Toehold	0.05*	0.0200	−0.0100	−0.0100	0.0200	0.0300	−0.0300	−0.0400
16. Cash only	0.0000	−0.0100	0.0100	0.0100	−0.10***	−0.08***	−0.0100	−0.0100
17. Stock only	0.0200	0.0300	0.0300	−0.0100	−0.07**	0.0300	0.0000	0.0300

Note: The table shows the pairwise correlation of the variables used in the data analyses for 1372 deals by the US acquirers during 2010–2020. Detailed definitions of all variables can be found in Appendix A. Stars behind coefficients indicate the significance level.
***1%, **5%, and *10%.

TABLE 2 (Continued)

Variables	9	10	11	12	13	14	15	16	17
1. CAR (−2, +2)									
2. Physical risk									
3. Regulatory risk									
4. Reputational risk									
5. Capital intensity									
6. Firm size									
7. Liquidity									
8. Profitability									
9. Asset newness	1.0000								
10. Leverage	0.17***	1.0000							
11. Book to market	0.24***	0.0200	1.0000						

TABLE 2 (Continued)

Variables	9	10	11	12	13	14	15	16	17
12. Log (Acq age)	−0.12***	0.0400	−0.12***	1.0000					
13. CEO duality	0.0300	0.07***	0.0400	0.11***	1.0000				
14. Competition	−0.09***	0.05*	−0.0300	0.0200	0.0300	1.0000			
15. Toehold	0.06**	0.0300	0.05*	0.06**	0.0200	0.05*	1.0000		
16. Cash only	−0.07**	−0.06**	−0.06**	0.0100	0.0100	0.06**	−0.0400	1.0000	
17. Stock only	0.0200	−0.0100	−0.06*	0.10***	0.0400	−0.0400	−0.0200	−0.26***	1.0000

Note: The table shows the pairwise correlation of the variables used in the data analyses for 1372 deals by the US acquirers during 2010–2020. Detailed definitions of all variables can be found in Appendix A.
Stars behind coefficients indicate the significance level.
***1%, **5%, and *10%.

(2021) and Dong et al. (2021) and use a market model estimated using the CRSP value-weighted index return as a proxy for market returns. An OLS regression with industry and year fixed effects can provide us inconsistent results. Our investigation suggests that the CCR and choice of deal announcement can occur simultaneously; that is, the deal can be predetermined due to the level of CCR of the acquirers. To address this endogeneity due to the above-mentioned simultaneity and omitted variable bias, we employ a two-stage least square (2SLS) regression model in which each CCR of sample acquirers is instrumented by the Fama–French 10 industry median value of CCR of in each year. The instruments (INDCCR) are exogenous to the dependent variable. Our instrument also passes the under-identification and weak instrument tests. We use the predicted value of each CCR variable from the first stage to the relevant second stage of 2SLS regression model. Table 4 presents both the first and second stage of regressions with F-statistics and R-squared of the first stage to reject the weak instrument hypothesis.

The results are reported in Table 4. In Columns 1–3 we present the first stage OLS regression of 2SLS where the dependent variable is physical, regulatory and reputational risks. The instrument is used as independent variable along with the control variables. Columns 4–6 show the coefficients for each of the CCR components. We find that only the coefficients of physical ($\beta = -.0334$, $p < .05$) and regulatory ($\beta = -.0772$, $p < .10$) risks are statistically significant and negative. In terms of economic significance, 1% increase in physical and regulatory risks leads to 0.033 and 0.77 points decrease in CAR, respectively. The reputational risks depend on many other factors, which we will investigate in our subsequent analyses. Overall, for findings imply that with the increase of physical and regulatory risks of the acquirer, the investors react negatively. This is in line with Bose et al. (2021) (although their study is based on carbon emission). Thus, M&A decreases the value of firms with higher CCR. In other words, higher CCR creates an increased barrier for the firms' post-M&A performance. This supports our Hypothesis 2. In terms of control variables, firm size is negatively associated with the CAR (-2, $+2$) implying that larger firms may have lower investor's reaction around the announcement date. There might be several reasons. One possible reason is in a good governance country such as US, larger firms offer extra managerial protection and thus reduce shareholder's wealth (Humphery-Jenner & Powell, 2014).

3.4 | Robustness tests

Risk factors are present for all firms that engage in M&A activity; however, for firms with higher CCR, these risk factors add to the already present background risk that comes from climate change. That additional CCR is not equal for all firms as shown by our CCR measure which varies across firms depending on their respective exposure to the physical, regulatory and reputational risk factors. Yang et al. (2019) find that firms with cash reserves are more likely to go for M&A whereas firms with high debt ratios are less likely to use cash to pay for the M&A (Uysal, 2011). Cash payments lead to

TABLE 3 Probability of firms being acquirers and climate change risk.

	(1)	(2)	(3)
Dependent variable	***Equals to 1 for sample acquirer, 0 for matched acquirer in the control group***		
Physical risk	−0.4526***		
	(0.1029)		
Regulatory risk		−0.1305***	
		(0.0441)	
Reputational risk			−0.1569*
			(0.0892)
Capital intensity	−0.0159	−0.0135	−0.0135
	(0.0417)	(0.0438)	(0.0444)
Firm size	0.7728***	0.7997***	0.792***
	(0.1800)	(0.1745)	(0.1797)
Liquidity	3.0057	3.2644	3.1686
	(2.784)	(3.1774)	(3.26)
Profitability	−1.532	−1.5557	−1.3199
	(2.5862)	(2.8857)	(2.6775)
Asset newness	0.1089	−0.0656	−0.0948
	(1.438)	(1.4522)	(1.4515)
Leverage	0.7926	0.7600	0.7150
	(0.7661)	(0.6961)	(0.6969)
Book to market	−0.0837*	−0.0823*	−0.0826*
	(0.0447)	(0.0457)	(0.0459)
Log (Acq age)	0.3668	0.3932	0.3976
	(0.3055)	(.3130)	(0.3265)
CEO duality	0.1888	0.1904	0.1913
	(0.3463)	(0.3092)	(0.2948)
Observations	1,271	1,271	1,271
Pseudo R^2	0.1310	0.1123	0.1152
Log likelihood	−452.6958	−462.4131	−460.9187
Industry dummy	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes

Note: This table presents the coefficient estimates from conditional logit regressions in which the dependent variable is equal to 1 for the firms engaged in M&A following participating in CDP survey in previous year, 0 for the matched acquirers in the control group. The acquirers in the control groups are from the same Fama–French 10 industries, within 20% range of book to market and market capitalization. The independent variables are risks related to physical, regulation and reputation due to climate change. Detailed definitions of all variables can be found in Appendix A. The control variables are lagged 1 year. The specification of Model 1–3 includes Fama–French 10 industry and year fixed effects. Robust standard errors are in parentheses. ***$p < .01$, **$p < .05$, and *$p < 0.1$.

better Cumulative Abnormal Returns (CAR), whereas firms issuing stock as payment for the M&A tend to exhibit a negative CAR (Alexandridis et al., 2021). Klitzka et al. (2021) find that larger uncertainty in the M&A leads to increased use of cash for payments. Thus, firms with higher CCR should prefer cash payments in order to reduce risk.

In this section, we further investigate how the investor's reaction (a measure of acquisition performance) to M&A announcement changes with the change in CCR of an acquirer. However, there is a possibility of self-selection bias because our sample dataset includes only those firms that describe their risks related to physical, regulatory, and reputational risk in the CDP survey. Moreover, the acquirer's decision to enter an M&A is not random (see Kai & Prabhala, 2007). To mitigate the effect of this self-selection bias, we use Heckman (1979) two-step method.

Following Bose et al. (2021), we construct an instrument—INDISC—that indicates the *industry pressure* on firms to disclose the climate change risk. We measured it as the ratio of the number of acquirers in the industry with carbon emissions data in CDP database to the total number of acquirers in the industry in our sample. This can influence the firm to participate in CDP survey and disclose their risks driven by physical, regulatory, and reputational risks. This

TABLE 4 Effect of climate change risk on investor's reaction.

	(1)	(2)	(3)	(4)	(5)	(6)
	First stage			Second stage		
Dependent variables	Physical risk	Regulatory risk	Reputational risk	CAR (−2, +2)	CAR (−2, +2)	CAR (−2, +2)
Physical risk				−0.0334**		
				(0.0166)		
Regulatory risk					−0.0772*	
					(0.0407)	
Reputational risk						−0.0919
						(0.0744)
INDCCR (instrument)	6.421*	3.0578***	2.2949			
	(3.6566)	(1.0872)	(1.7529)			
Capital intensity	0.004	.0061	−0.0308***	−0.0002	−0.0002	−0.0036
	(0.0189)	(0.0063)	(0.0098)	(0.0006)	(0.0007)	(0.0026)
Firm size	−0.0786*	0.0041	0.1011***	−0.006***	−0.0023	0.0065
	(0.0423)	(0.0176)	(0.0299)	(0.0021)	(0.0017)	(0.0079)
Liquidity	0.7303	−0.1368	0.9081	0.0057	−0.0193	0.0701
	(0.9676)	(0.485)	(0.9558)	(0.0496)	(0.0516)	(0.1047)
Profitability	−1.2141*	−0.1466	−0.2664	−0.0512	−0.0316	−0.0391
	(0.644)	(0.3536)	(0.5879)	(0.0422)	(0.0403)	(0.0625)
Asset newness	0.2218	0−.2224	0.1839	0.007	−0.0043	0.0146
	(0.331)	(0.1634)	(0.2787)	(0.017)	(0.0197)	(0.031)
Leverage	0.6149**	−0.039	−0.0478	0.0279**	0.0074	0.0106
	(0.2388)	(0.1073)	(0.2102)	(0.0138)	(0.0126)	(0.0186)
Book to market	0.0163	0.0007	−0.011	0.0006	−0.0001	−0.0008
	(0.0229)	(0.0113)	(0.0233)	(0.0014)	(0.0013)	(0.0023)
Log (Acq age)	−0.0598	0.0176	0.0624	−0.0074***	−0.0018	0.0005
	(0.0558)	(0.0241)	(0.0523)	(0.0025)	(0.0026)	(0.0063)
CEO duality	0.2149**	−0.0246	0.0094	−0.0038	−0.0108**	−0.0100
	(0.0912)	(0.0413)	(0.0713)	(0.0051)	(0.0043)	(0.0064)
Cash only	−0.1363*	0.0255	0.0087	−0.003	0.0051	0.002
	(0.0757)	(0.0315)	(0.060)	(0.0041)	(0.0037)	(0.0054)
Stock only	−0.201	0.0699	−.0666	−0.008	0.0059	−0.0083
	(0.1494)	(0.0727)	(0.0934)	(0.0082)	(0.0086)	(0.0132)
Competition	−0.0342	0.0828	−0.3692***	−0.0189	0.0003	−0.0451
	(0.2637)	(0.0947)	(0.139)	(0.0127)	(0.0138)	(0.0337)
Toehold	0.0753	0.0549	−0.0712	0.0136**	0.0139*	0.0024
	(0.1343)	(0.0551)	(0.0936)	(0.0065)	(0.0073)	(0.0117)
Constant	1.354	−0.1543	0.2333	0.1346***	−0.0055	0.0183
	(0.9803)	(0.4026)	(0.6649)	(0.0481)	(0.0534)	(0.0953)
Observations	1167	1202	1090	1167	1202	1090
Industry dummy	Yes	Yes	Yes	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes
R-squared (1st stage)	0.1723	0.1232	0.1121	0.2583	0.548	0.0898
F-statistics (1st stage)	14.65	81.99	16.40			
A C LM statistic	9.51***	8.58***	1.939			
C-D Wald F-statistic	9.06	8.18	1.83			

Note: 2SLS regression results. The dependent variable is 5-day cumulative abnormal return CAR (−2, +2) using a market model. In the selection model, we use the Fama–French 10 industry median value of CCR of in each year (INDCCR) as an instrument in the first step. The instrument is the industry pressure calculated as industry-year median values of physical, regulatory and reputational risks for independent (endogenous) variables -physical, regulatory and reputational risks. A C LM statistic is Anderson canon. corr. LM statistic (under-identification), C-D is Cragg–Donald Wald *F*-statistic (Weak identification). Robust standard errors are in parentheses. Fama–French 10 industry and Year fixed effects are controlled for in all regressions.

***$p < .01$, **$p < .05$, and *$p < .1$.

TABLE 5 CCR and CAR (−2, +2).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
		Full sample			*Cash only*			Stock only		
	Selection	Outcome	Outcome	Outcome	*Outcome*	*Outcome*	*Outcome*	Outcome	Outcome	Outcome
Physical risk		−0.0027*			−0.0025			−0.0008		
		(0.0016)			(0.002)			(0.007)		
Regulatory risk			−0.0046			−0.0086*			−0.0136	
			(0.0038)			(0.0049)			(0.0176)	
Reputational risk				−0.0032			−0.0046*			−0.0094
				(0.0019)			(0.0025)			(0.0126)
INDDISC	−5.967***									
	(1.8063)									
Capital intensity	−0.0091	−0.0005	−0.0005	−0.0006	0.0003	0.0005	0.0003	0.0009	0.0012	0.0012
	(0.0169)	(0.0005)	(0.0005)	(0.0005)	(0.0007)	(0.0007)	(0.0007)	(0.0018)	(0.0018)	(0.0018)
Firm size	−0.1517***	−0.0014	−0.0011	−0.0014	0.0006	0.001	0.0005	−0.0029	−0.0026	−0.0039
	(0.0414)	(0.0014)	(0.0014)	(0.0014)	(0.0019)	(0.0019)	(0.0019)	(0.0056)	(0.0053)	(0.0054)
Liquidity	2.6225*	0.0391	0.0283	0.0295	0.0281	0.0167	0.0137	0.1882	0.1725	0.159
	(1.4937)	(0.0506)	(0.0505)	(0.0504)	(0.0654)	(0.0648)	(0.0648)	(0.2206)	(0.2199)	(0.2223)
Profitability	−1.383	−0.0434	−0.0338	−0.0372	−0.0977**	−0.0906*	−0.0876*	−0.0526	−0.0415	−0.0621
	(1.1485)	(0.0400)	(0.0399)	(0.0398)	(0.0483)	(0.0481)	(0.0481)	(0.1479)	(0.1475)	(0.1471)
Asset newness	0.6607	−0.0076	−0.0063	−0.0051	−0.0275	−0.0264	−0.0257	−0.0559	−0.0537	−0.0558
	(0.4329)	(0.0144)	(0.0144)	(0.0144)	(0.0174)	(0.0174)	(0.0174)	(0.051)	(0.0508)	(0.0507)
Leverage	0.6128*	0.0105	0.0107	0.0109	0.0062	0.0076	0.0075	0.0066	0.013	0.0086
	(0.3389)	(0.0115)	(0.0116)	(0.0115)	(0.0145)	(0.0145)	(0.0145)	(0.0489)	(0.0491)	(0.0486)
Book to market	0.0392	−0.0014	−0.0016	−0.0015	−0.0119***	−0.0125***	−0.012***	−0.0085	−0.0089	−0.0092
	(0.0435)	(0.0014)	(0.0014)	(0.0014)	(0.0033)	(0.0033)	(0.0033)	(0.0095)	(0.0094)	(0.0094)
Log (Acq age)	0.0463	0.0004	0.0001	0.0003	0.0005	0.0001	0.0004	−0.0003	−0.0016	−0.001
	(0.0569)	(0.0019)	(0.0019)	(0.0019)	(0.0025)	(0.0025)	(0.0025)	(0.0084)	(0.008)	(0.0079)
CEO duality	0.0314	0.0039	0.0034	0.0039	−0.0008	−0.0018	−0.0008	−0.022	−0.0214	−0.0212
	(0.1027)	(0.0035)	(0.0035)	(0.0035)	(0.0047)	(0.0047)	(0.0047)	(.0154)	(0.0152)	(0.0152)
Competition	0.4614	−0.0103	−0.0107	−0.0109	−0.0172	−0.0179	−0.0179	−0.0106	−0.0176	−0.0063
	(0.3466)	(0.0126)	(0.0126)	(0.0126)	(0.0129)	(0.0129)	(0.0129)	(0.0361)	(0.0366)	(0.0355)
Toehold	−0.4029**	.023***	0.0231***	0.0235***	0.0214**	0.0208*	0.0212**	0.0591*	0.0598*	0.0584*
	(0.1856)	(0.0068)	(0.0068)	(0.0068)	(0.0108)	(0.0108)	(0.0108)	(0.0314)	(0.0313)	(0.0313)

(Continues)

TABLE 5 (Continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
		Full sample			*Cash only*			Stock only		
	Selection	Outcome	Outcome	Outcome	Outcome	Outcome	Outcome	Outcome	Outcome	Outcome
IMR		−0.0137**	−0.0147**	−0.0147**	−0.017*	−0.0171*	−0.0164*	−0.0048	−0.0017	−0.0005
		(0.0069)	(0.0069)	(0.0069)	(0.009)	(0.0089)	(0.009)	(0.0343)	(0.0334)	(0.0336)
Constant	3.6364***	0.0446	0.0400	0.0464	0.0225	0.0155	0.0253	0.0924	0.0824	0.1176
	(1.0613)	(0.0312)	(.0312)	(0.0313)	(0.0413)	(0.0413)	(0.0413)	(0.1388)	(0.1319)	(0.1332)
Observations	871	692	692	692	440	440	440	73	73	73
Pseudo/R-squared	0.1010	0.0468	0.0447	0.0465	0.0576	0.0608	0.0615	0.1593	0.1675	0.167
Industry dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: This table presents the estimates from the Heckman twostep regression for the impact of climate change risk on CAR (−2, +2) in which the dependent variable is 5-day cumulative abnormal return CAR (−2, +2) using a market model. The industry pressure of disclosing climate change risk (INDISC) is used as an instrument in the first stage. The inverse mills ratio (IMR) from the first stage is then included in the OLS regression model in the second step to control for selection bias (to save the space, the first stage is not reported). Columns 2–4 are subsamples for Cash only payment, and Columns 5–7 are for Stock only payment. The independent variables risks related to physical, regulation and reputation due to climate change. Detailed definitions of all variables can be found in Appendix A. Year and Fama–French 10 industry fixed effects included. Robust standard errors are in parentheses.

$^{***}p < .01$, $^{**}p < .05$, and $^{*}p < .1$.

instrument has a direct relationship with the choice of targets because M&A provides complementary knowledge sources to the acquirers (Lodh & Battaggion, 2015), but no relationship on investor's reaction around the announcement date. Moreover, in our analysis we want to exclude at least one variable in the selection model (see Table 5) that are related to acquisition performance. So, the use of instrumental variable in our selection model of Heckman two-step method satisfies the 'exclusion restriction'[13] (see Lennox et al., 2012). This procedure also reduces the bias in estimated coefficients that may appear for multicollinearity.

The following equation is the first stage model estimated by probit regression where the dependent variable is a binary variable (*Similar*) that takes 1 if the acquirer chooses a target in the same industry (2-digit SIC code), and 0 otherwise.

$$Pr(Similar=1)=\Phi\{\alpha+\beta INDSC+\gamma Control\ Variables+\epsilon\} \quad (2)$$

The first stage regression in Table 5 shows that there is a negative impact of industry pressure (INDDISC) to choose the target in the same industry. That means with the increase of industry pressure, the firms have lower probability of choosing a target in unrelated industry. We calculate the inverse Mills ratio (IMR) in the first stage selection model and include it in the second stage to mitigate the selection bias. The basic specification of our estimation is an industry and year fixed effects model given below:

$$\begin{aligned} CAR_{it} = {} & \beta_0+\sum\beta_m X_{it}+\beta_4 CapitalIntensity_{it}+\beta_5 AcquirerSize_{it} \\ & +\beta_6 Liquidity_{it}+\beta_7 Profitability_{it}+\beta_8 AssetNewness_{it} \\ & +\beta_9 Leverage_{it}+\beta_{10} BookToMarket_{it}+\beta_{11} AcquirerAge_{it} \\ & +\beta_{12} CEODuality_{it}+\beta_{13} DealControls+\beta_{14} IMR_{it} \\ & +IndusrtryDummy+YearDummy+\varepsilon_{it} \end{aligned} \quad (3)$$

The dependent variable in the second stage is the cumulative abnormal returns ($CAR_{(t-2),\ (t+2)}$)[14] for the 5-day event window around the deal announcement date ($t = 0$) using a market model. The results are shown in Columns 2–4. We found only coefficient of physical risk is statistically significant and negative. Note that the full sample consists of all types of payments for the deals. The coefficient for physical risk is consistent with our previous results. So, additionally, we examine whether the methods of payment for the deal have any impact on the investor's reaction. Previous research finds that M&As completed with cash payments tend to have a better performance as measured by CAR (Alexandridis et al., 2021). However, Columns 6–8 shows that regulatory and reputational risks have negative impact on CAR (−2, +2) if the deal is associated with cash only. So, while taking a decision on payment methods in M&As, firms need to take their climate change risks into account. We did not find any impact of CCR

[13]We conceptually exclude at least one variable from the M&A performance model with CAR (−2, +2) as dependent variable to satisfy the exclusion restriction.

[14]We follow Bose et al. (2021) and Delis et al. (2022). The model is estimated using at least 30 non-missing daily return (Brooks et al., 2018) for 200-day of estimation period and value-weighted market return as benchmark. In addition, we exclude 30-day window immediately prior to the announcement date to avoid the impact of leak or rumour of deal information in the market.

TABLE 6 CCR and Deal completion.

	(1)	(2)	(3)	(4)	(5)	(6)
	Positive CAR			Negative CAR		
Dependent variable	Completion	Completion	Completion	Completion	Completion	Completion
Physical risk	0.0415			−0.0406		
	(0.0576)			(0.0625)		
Regulatory risk		−0.1662			−0.0475	
		(0.1467)			(0.1308)	
Reputational risk			−0.159**			−0.0441
			(0.0682)			(0.0846)
Capital intensity	−0.0488***	−0.0425**	−0.0422*	−0.0535**	−0.0433*	−0.0527**
	(0.0172)	(0.0206)	(0.0232)	(0.024)	(0.0251)	(0.0239)
Firm size	0.0928*	0.0942*	0.0793	−0.0634	−0.09*	−0.0726
	(0.0557)	(0.0564)	(0.0631)	(0.0513)	(0.0523)	(0.0503)
Liquidity	0.9126	0.9829	0.7382	−1.1457	−2.3083	−0.9655
	(1.94)	(1.968)	(2.1501)	(1.9406)	(2.0417)	(1.9787)
Profitability	1.8668	1.3041	2.2252	1.4915	2.7932*	1.5832
	(1.3373)	(1.3934)	(1.5308)	(1.473)	(1.5623)	(1.4567)
Asset newness	−0.2367	−0.0915	0.078	0.8164	0.5721	0.9158
	(0.571)	(0.577)	(0.6314)	(0.579)	(0.6081)	(0.5789)
Leverage	−0.235	−0.0626	0.086	−0.2757	−0.1962	−0.1342
	(0.5071)	(0.5296)	(0.5532)	(0.4393)	(0.4105)	(0.4063)
Book to market	0.1644*	0.1566*	0.161	−0.112*	−0.0525	−0.1233**
	(0.0985)	(0.0846)	(0.1087)	(0.0595)	(0.0583)	(0.0614)
Log (Acq age)	−0.0102	0.0204	−0.0017	0.1294	0.0625	0.1366
	(0.1044)	(0.1123)	(0.1105)	(0.093)	(0.0899)	(0.1000)
Cash	−0.0823	−0.0927	−0.1531	0.2268	0.1992	0.2245
	(0.1452)	(0.1415)	(0.1483)	(0.1449)	(0.144)	(0.1505)
Stock	−0.2902	−0.2726	−0.4171	0.0675	0.0688	0.0627
	(0.3167)	(0.3045)	(0.3069)	(0.3838)	(0.3823)	(0.3824)
Toehold	0.285	0.0335	0.0547	−0.7372**	−0.8267***	−0.7157**
	(0.2567)	(0.2794)	(0.2968)	(0.3069)	(0.3058)	(0.3032)
Constant	−1.2153	−1.4236	−0.9637	1.5787	2.6341**	1.7609
	(1.3281)	(1.3499)	(1.5122)	(1.2927)	(1.2999)	(1.2637)
Observations	524	544	487	476	490	445
Pseudo R^2	0.1059	0.1024	0.1274	0.092	0.0996	0.0886
Industry dummy	Yes	Yes	Yes	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes

Note: This table presents the estimates from probit regression for the impact of climate change risk on deal completion in which the dependent variable is a dummy variable equals to one if the deal is completed and zero otherwise. The marginal effects are reported. The independent variables are physical, regulation and reputation risks due to climate change. Detailed definitions of all variables can be found in Appendix A. The specification of Models 1–6 includes year and Fama–French 10 industry fixed effects. Robust standard errors are in parentheses.
***$p < .01$, **$p < .05$, and *$p < 0.1$.

on CAR if pure stock is involved in the transaction. This may be due to fewer observations in our sample for pure stock. So, payment methods play a vital role in deciding the performance of M&A (as implied by Faccio & Masulis, 2005). Overall, our results are consistent with the initial findings, and it supports Hypothesis 2.

3.5 | Additional deal-related results

In this section, we test whether CCR has any impact on deal completion, cross-border acquisition, deal value and M&As when acquirers are in environmentally exposed industry (such as chemical,

TABLE 7 Cross-border deals.

	(1)	(2)	(3)
Dependent variable:	**CAR (−2, +2)**		
Physical risk	−0.0025		
	(0.0026)		
Regulatory risk		−0.0105*	
		(0.0063)	
Reputational risk			−0.0042*
			(0.0024)
Log (language distance)	0.008*	0.0078*	0.0087*
	(0.0047)	(0.0046)	(0.0047)
Log (legal enforcement of contracts)	0.0082	0.0068	0.0073
	(0.0124)	(0.0122)	(0.0122)
Capital control	−0.0001	0.0002	0.0000
	(0.0012)	(0.0012)	(0.0012)
GDP growth	0.0011	0.0012	0.001
	(0.001)	(0.001)	(0.001)
Similar	−0.0027	−0.0026	−0.003
	(0.0052)	(0.0052)	(0.0052)
Environment-sensitive industry	0.0014	0.0000	0.0025
	(0.0089)	(0.0089)	(0.0089)
Constant	0.0233	0.0115	0.0228
	(0.0544)	(0.0545)	(0.0541)
Observations	225	225	225
R-squared	0.0403	0.0487	0.0494

Note: This table presents the coefficient estimates OLS regressions in which the dependent variable is CAR (−2, +2). The main independent variables are risks related to physical, regulation and reputation due to climate change. Additional macro-economic variables are included—Language distance, Legal enforcement, Capital Control and GDP growth. Detailed definitions of all variables can be found in Appendix A. The specification of Models 1–4 includes year fixed effects. Standard errors are in parentheses and clustered at the industry level.
***$p < .01$, **$p < .05$, and *$p < 0.1$.

construction materials, petroleum and natural gas, utilities and non-metallic and industrial metal mining).

3.5.1 | CCR and deal completion

We begin with the impact of CCR on deal completion. We test it with two sub-samples positive and negative CAR following Brooks et al. (2018). The results are reported in Table 6. The dependent variable is a binary variable equal to 1 if the deal is completed, and 0 if withdrawn.[15] We use a probit regression model and Columns 1–6 report the marginal effects. However, we see a negative and statistically significant coefficient for reputational risk in Column 3 ($\beta = -.159$, $p < .05$) when the CAR (−2, +2) is positive. This shows with the increase of reputational risk, the firms are less likely complete the deal despite a positive CAR (−2, +2). This could be due to two reasons. Firstly, the positive market reaction attracts competition, and these firms are unable to compete effectively due to the barrier placed on them by higher CCR, they must preserve resources to address those risks and thus cannot outbid the competition. Secondly, acquirers with higher CCR are, ceteris paribus, less attractive to targets as the latter may wish to avoid merging with a risky firm. Hence, as the M&A due diligence process progresses post announcement, the target firm may pull out resulting in a withdrawn deal. The coefficients for CCR are not statistically significant at any traditional level for the negative CAR (−2, +2).

3.5.2 | CCR and cross-border deals

Cross border M&As tend to be more risky than domestic ones due to additional informational asymmetry, the difference in the culture, transparency and governance. Previous studies have highlighted the additional uncertainty that acquirers face while evaluating foreign

[15]We consider all the deals of the sample firms that are reported as completed or withdrawn in Thomson Reuter Eikon and Bloomberg database until January 2022.

targets (Rossi & Volpin, 2004; Kang & Kim, 2010; Lim & Lee, 2016). However, a recent study found that firms with higher sea level rise risk (physical risk arising from climate change) tend to acquire firms that are not exposed to the same risk in order to diversify and reduce their overall risk from sea level rise (Bai et al., 2022). Li et al. (2021) find that firms may go for cross border M&A when there is economic policy uncertainty in the firm's home country. Irwin et al. (2022) find that country level factors such as GDP, Inflation, Regulations, Technology and Culture play an important role in firms going for cross border M&As. Chen et al. (2022) find that Chinese acquirers may use cross border M&A transactions to signal their commitment towards CSR (Corporate Social Responsibility) and boost their image. Thus, cross border M&As may provide firms with an opportunity to diversify and reduce their overall CCR. However, if the M&A activity was actually reducing risk then that should reflect in the announcement returns in terms of positive CAR as the market would reward the same; instead, we find that CAR is negative.

Our sample consists of both domestic and cross-boarder M&A. To make the analysis clearer, we analyse a subsample of only cross-border M&A. The results are presented in Table 7. We use ordinary least square (OLS) regression where the dependent variable is CAR (−2, +2) as before. However, the target firms in our sample are a mix of private and public firms and if we choose only public targets for financial variables as control variables, our sample for analysis becomes even smaller. To deal with this, following prior literature we use a few macroeconomic variables of the target country (Bose et al., 2021). Pan and Zhang (2022) and Zhu et al. (2015) show that common language between acquirer and target countries play an important role. The data are obtained from CEPII GeoDist Database (see Todtenhaupt et al., 2020). La Porta et al. (1998) argue that the stronger legal enforcement can effectively resolve disputes between corporate constituencies. So, we use the language distance and legal enforcement along with capital control and GDP growth of the countries of target firms. The other control variables are included as usual. Our results are consistent with the initial findings.

3.5.3 | CCR and deal values

In this analysis, we want to understand if there is any role of deal values in the relationship between CCR and CAR (−2, +2). M&A can be a highly competitive activity with numerous bidders for one target. This leads to the winner's curse where the acquirer ends up paying too high a price for the target due to the presence of competition (Díaz et al., 2009; Ismail, 2011; Varaiya & Ferris, 1987). Previous studies find that competition tends to reduce the acquirers' post M&A returns (Banerjee et al., 2014; Moeller et al., 2004). Thus, an acquirer that pays a higher price for the target due to increased competition (more bidders for the same target), will have lesser resources available for other activities, such as, investing in larger facilities, product development, regulatory compliance and managing other risks. For firms with higher CCR, this issue is further amplified due to the additional risk that arises from physical, regulatory and reputational factors connected with climate change. This argument also extends to the deal value or size of the M&A transaction; firms with higher CCR need resources to address those risks and thus in order to conserve resources are less likely to engage in large sized M&A transactions as measured using deal value.

TABLE 8a Effect of CCR on CAR (−2, +2): Subsample test for high deal values.

	(1)	(2)	(3)	(4)	(5)	(6)
	High deal value			Low deal value		
Dependent variable	Positive CAR (−2, +2)			Negative CAR (−2, +2)		
Physical risk	−0.1034*			0.0203		
	(0.0606)			(0.0619)		
Regulatory risk		−0.2581**			−0.1904	
		(0.1271)			(0.1233)	
Reputational risk			−0.0354			0.0693
			(.0701)			(.0928)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes
Observations	524	544	487	476	490	445
Pseudo R^2	0.1146	0.1146	0.1147	0.0937	0.0902	0.0955

Note: This table presents the coefficient estimates probit regressions in which the dependent variable is CAR (−2, +2). The main independent variables are risks related to physical, regulation and reputation due to climate change. Marginal effects are reported. Columns 1–3 are for the subsample where the deal values are above the median deal value in the sample, and Columns 4–6 are for the subsample where the deal values below the median in 1372 sample deals. Detailed definitions of all variables can be found in Appendix A. Robust standard errors are in parentheses and clustered at the industry level.
***$p < .01$, **$p < .05$, and *$p < 0.1$.

TABLE 8b Effect of CCR on CAR (−2, +2): Subsample test for environmentally sensitive industries.

	(1)	(2)	(3)	(4)	(5)	(6)
	Environmentally sensitive = 1			Environmentally non-sensitive = 0		
Dependent variable	CAR (−2, +2)			CAR (−2, +2)		
Physical risk	−0.0014			−0.0004		
	(0.0031)			(0.0014)		
Regulatory risk		−0.0027			−0.0075***	
		(0.0078)			(0.0027)	
Reputational risk			−0.0101*			0.0022
			(0.0057)			(0.0016)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes
Constant	−.01278	−0.0798	−0.3094**	0.0493*	0.0141	0.0216
	(0.1449)	(0.1153)	(0.1442)	(0.0277)	(0.0275)	(0.028)
Observations	101	115	93	899	919	839
R-squared	0.5631	0.5228	0.5802	0.0647	0.0772	0.0757
Industry dummy	Yes	Yes	Yes	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes

Note: This table presents the coefficient estimates OLS regressions in which the dependent variable is CAR (−2, +2). The main independent variables are risks related to physical, regulation and reputation due to climate change. Columns 1–3 are for the subsample for environmentally sensitive industries 9 such as chemical, construction materials, petroleum and natural gas, utilities and non-metallic and industrial metal mining), and Columns 4–6 are environmentally non-sensitive industries. Note that the number of deals in environmentally sensitive industries are 120 while the number of deals in non-sensitive industries are 1,252. Detailed definitions of all variables can be found in Appendix A. Robust standard errors are in parentheses and clustered at the industry level.
***$p < .01$, **$p < .05$, and *$p < 0.1$.

So, we divided the sample into two subsamples—high and low deal values calculated as above and below the median deal value of the sample of 1372 deals. Our results, presented in Table 8a, show that for a higher deal, the CAR (−2, +2) is more sensitive for increasing CCR, compared to the lower deal values. This also support the risk vulnerability theory and consistent with our above-mentioned argument.

3.5.4 | CCR and environmentally exposed industry deals

To ensure the robustness of our results, we run a sub-sample test to see if our results continue to hold. In Table 8b, we separately regress the climate change risks (CCR) on CAR (−2, +2) for firms in environmentally sensitive and non-sensitive industries. Column 3 shows that our Hypothesis 2 continues to hold for reputational risk for acquirers belonging to environmentally sensitive industries. On the other hand, the coefficient of regulatory risk is negative and statistically significant when the acquirer belongs to the environmentally non-sensitive industries (Column 5). In other words, firms that have higher CCR continue to avoid engaging in M&A activities, though it varies in terms of types of CCR and whether the acquirer is in environmentally sensitive industry.

4 | CONCLUSION

This study aims to investigate the relationship between CCR and firms' M&A decisions and performance. Using a sample of 1372 deals from 296 US acquirers during the period 2010–2020, we find that there exists a negative relationship between CCR (i.e., physical, regulatory and reputational risk) and M&A engagement. Our findings show that the presence of CCR decreases the likelihood of M&A activity. Consistent with the risk vulnerability theory, due to the presence of high CCR, firms anticipate an adverse effect of taking on additional risk arising from the M&A activity. Our findings also indicate that if firms facing high climate change risks choose to engage in M&A activity, the market reaction to the same is significantly negative. Hence, the implication of this study for managers is that they need to integrate CCR into corporate decision-making, particularly when it comes to M&A activities.

This study contributes to the growing body of literature on CCR and corporate activities. To the best of our knowledge, no prior study examines the relationship between CCR and M&A engagement and performance in such detail with special focus on deal characteristics. The evidence presented in our paper is consistent with the view that different aspects of CCR (i.e., physical, regulatory and reputational risks) together can make the firms cautious about the externalities. To our knowledge, this study is the first to capture CCR as indicated by

the participating firms in the CDP survey. Thus, our paper uses a more direct and comprehensive measure of CCR as compared to previous studies.

Our study has a few limitations. Similar to prior studies we only include those deals that are made public. This is partly related to the acquirer's capacity to manage the risk. A similar justification is true for the firms that are not taking part in CDP survey. We do not observe these firms. In addition, our sample is between 2010 and 2020. A longer time period is not possible as the CDP questionnaire keep changing and it is difficult to idenify the same questions over a long time. Lastly, the choice of external variables as an instrument is always a challenge, especially when the data is restricted by certain criteria. In our final sample, we have 296 firms that have participated in CDP survey. So, we created an instrument using median value of CCR. Future study can overcome this limitation.

We propose two extensions for future research. Firstly, to investigate the impact of high CCR on various stakeholders (this paper focussed only on shareholders) and their attitude and reactions to the firms' decision to engage in M&A.[16] Secondly, future studies can explore the impact of CCR on corporate decision-making in areas other than M&A; such investigations would give us a better understanding of the firms' attitudes towards CCR and the extent to which they plan to reduce those risks.

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

ORCID

Suman Lodh https://orcid.org/0000-0002-4513-1480

Alireza Rohani https://orcid.org/0000-0003-0996-9937

REFERENCES

Abd Rahman, N. R., Rasid, S. Z. A., & Basiruddin, R. (2014). Exploring the relationship between carbon performance, carbon reporting and firm performance: A conceptual paper. *Procedia-Social and Behavioral Sciences*, *164*, 118–125. https://doi.org/10.1016/j.sbspro.2014.11.059

Ahuja, G., & Katila, R. (2001). Technological acquisitions and the innovation performance of acquiring firms: A longitudinal study. *Strategic Management Journal*, *22*(3), 197–220. https://doi.org/10.1002/smj.157

Akbaş, H. E., & Canikli, S. (2019). Determinants of voluntary greenhouse gas emission disclosure: An empirical investigation on Turkish firms. *Sustainability*, *11*(1), 1–24.

Alexandridis, G., Hoepner, A. G. F., Huang, Z., & Oikonomou, I. (2021). Corporate social responsibility culture and International M&As. *The British Accounting Review*, *54*(1), 101035. https://doi.org/10.1016/j.bar.2021.101035

Arouri, M., Gomes, M., & Pukthuanthong, K. (2019). Corporate social responsibility and M&A uncertainty. *Journal of Corporate Finance*, *56*, 176–198. https://doi.org/10.1016/j.jcorpfin.2019.02.002

Bai, John and Chu, Yongqiang and Shen, Chen and Wan, Chi (2022). *Managing climate change risks: Sea level rise and mergers and acquisitions*. Available at SSRN: https://ssrn.com/abstract=3739599

Banerjee, P., Pri, B., De, S., Jindra, J., & Mukhopadhyay, J. (2014). Acquisition pricing in India during 1995–2011: Have Indian acquirers really beaten the odds? *Journal of Banking & Finance*, *38*, 14–30. https://doi.org/10.1016/j.jbankfin.2013.09.011

Batten, Sandra, Sowerbutts Rhiannon, and Tanaka Misa (2016). *Let's talk about the weather: The impact of climate change on central banks*. https://doi.org/10.2139/ssrn.2783753

Bena, J., & Li, K. (2014). Corporate innovations and mergers and acquisitions. *The Journal of Finance*, *69*(5), 1923–1960. https://doi.org/10.1111/jofi.12059

Boone, A., & Uysal, V. B. (2020). Reputational concerns in the market for corporate control. *Journal of Corporate Finance*, *61*, 101399. https://doi.org/10.1016/j.jcorpfin.2018.08.010

Bose, S., Minnick, K., & Shams, S. (2021). Does carbon risk matter for corporate acquisition decisions? *Journal of Corporate Finance*, *70*, 102058. https://doi.org/10.1016/j.jcorpfin.2021.102058

Broadstock, D. C., Collins, A., Hunt, L. C., & Vergos, K. (2018). Voluntary disclosure, greenhouse gas emissions and business performance: Assessing the first decade of reporting. *The British Accounting Review*, *50*(1), 48–59. https://doi.org/10.1016/j.bar.2017.02.002

Brooks, C., Chen, Z., & Zeng, Y. (2018). Institutional cross-ownership and corporate strategy: The case of mergers and acquisitions. *Journal of Corporate Finance*, *48*, 187–216. https://doi.org/10.1016/j.jcorpfin.2017.11.003

Cameron, A. C., & Trivedi, P. K. (2005). *Microeconometrics: Methods and applications*. Cambridge University Press. https://doi.org/10.1017/CBO9780511811241

Cassiman, B., Colombo, M. G., Garrone, P., & Veugelers, R. (2005). The impact of M&A on the R&D process: An empirical analysis of the role of technological-and market-relatedness. *Research Policy*, *34*(2), 195–220. https://doi.org/10.1016/j.respol.2005.01.002

Chen, X., Liang, X., & Wu, H. (2022). Cross-border mergers and acquisitions and CSR performance: Evidence from China. *Journal of Business Ethics*, *183*, 255–288. https://doi.org/10.1007/s10551-021-05025-6

Chui, B. S. (2011). A risk management model for merger and acquisition. *International Journal of Engineering Business Management*, *3*, 11. https://doi.org/10.5772/50935

Clarkson, P. M., Li, Y., Pinnuck, M., & Richardson, G. (2015). The valuation relevance of greenhouse gas emissions under the European Union carbon emissions trading scheme. *The European Accounting Review*, *24*(3), 551–580. https://doi.org/10.1080/09638180.2014.927782

Cornaggia, J., & Li, J. Y. (2019). The value of access to finance: Evidence from M&As. *Journal of Financial Economics*, *131*(1), 232–250. https://doi.org/10.1016/j.jfineco.2018.09.003

Cui, H., & Leung, S. C.-M. (2020). The long-run performance of acquiring firms in mergers and acquisitions: Does managerial ability matter? *Journal of Contemporary Accounting and Economics*, *16*(1), 100185. https://doi.org/10.1016/j.jcae.2020.100185

Dawkins, C. E., & Fraas, J. W. (2011). Erratum to: Beyond acclamations and excuses: Environmental performance, voluntary environmental disclosure and the role of visibility. *Journal of Business Ethics*, *99*(3), 383–397. https://doi.org/10.1007/s10551-010-0659-y

De Villiers, C., Naiker, V., & Van Staden, C. J. (2011). The effect of board characteristics on firm environmental performance. *Journal of Management*, *37*(6), 1636–1663.

Delis, M. D., Iosifidi, M., Kazakis, P., Ongena, S., & Tsionas, M. G. (2022). Management practices and M&A success. *Journal of Banking & Finance*, *134*, 106355.

Deloitte, (2020). *The risks and rewards of cross-border M&A*. Retrieved October 1, 2020, from https://www2.deloitte.com/us/en/pages/mergers-and-acquisitions/articles/cross-border-m-and-a-risks-rewards.html

Deng, X., Kang, J.-K., & Low, B. S. (2013). Corporate social responsibility and stakeholder value maximization: Evidence from mergers. *Journal of Financial Economics*, *110*(1), 87–109. https://doi.org/10.1016/j.jfineco.2013.04.014

[16]We thank an anonymous referee for this suggestion

Díaz, K., Azofra, S., & Gutiérrez, C. (2009). Are M&A Premiums too High? Analysis of a quadratic relationship between premiums and returns. *Quarterly Journal of Finance and Accounting*, *48*(3), 5–21.

Dietz, S., Bowen, A., Dixon, C., & Gradwell, P. (2016). 'Climate value at risk' of global financial assets. *Nature Climate Change*, *6*(7), 676–679. https://doi.org/10.1038/nclimate2972

Dong, Y., Li, C., & Li, H. (2021). Customer concentration and M&A performance. *Journal of Corporate Finance*, *69*, 102021. https://doi.org/10.1016/j.jcorpfin.2021.102021

Doukas, J. A., & Zhang, R. (2020). Corporate managerial ability, earnings smoothing, and acquisitions. *Journal of Corporate Finance*, *65*, 101756. https://doi.org/10.1016/j.jcorpfin.2020.101756

Elijido-Ten, E. O., & Clarkson, P. (2019). Going beyond climate change risk management: Insights from the world's largest most sustainable corporations. *Journal of Business Ethics*, *157*(4), 1067–1089. https://doi.org/10.1007/s10551-017-3611-6

Faccio, M., & Masulis, R. W. (2005). The choice of payment method in European mergers and acquisitions. *The Journal of Finance*, *60*(3), 1345–1388. https://doi.org/10.1111/j.1540-6261.2005.00764.x

Ferguson, M. J., Lam, K. C. K., & Lee, G. M. (2002). Voluntary disclosure by state-owned enterprises listed on the stock exchange of Hong Kong. *Journal of International Financial Management and Accounting*, *13*(2), 125–152. https://doi.org/10.1111/1467-646X.00081

Fiordelisi, F., Soana, M. G., & Schwizer, P. (2013). The determinants of reputational risk in the banking sector. *Journal of Banking & Finance*, *37*(5), 1359–1371. https://doi.org/10.1016/j.jbankfin.2012.04.021

Gallego-Álvarez, I., Rodríguez-Domínguez, L., & García-Sánchez, I.-M. (2011). Study of some explanatory factors in the opportunities arising from climate change. *Journal of Cleaner Production*, *19*, 912–926. https://doi.org/10.1016/j.jclepro.2011.02.012

Glambosky, M., Jory, S. R., & Ngo, T. N. (2020). The wealth effects of mergers and acquisitions by dividend payers. *The Quarterly Review of Economics and Finance*, *78*, 154–165. https://doi.org/10.1016/j.qref.2020.01.013

Gollier, C., & Pratt, J. (1996). Risk vulnerability and the tempering effect of background risk. *Econometrica*, *64*(5), 1109–1123. https://doi.org/10.2307/2171958

Heckman, J. J. (1979). Sample selection bias as a specification error. *Econometrica: Journal of the Econometric Society*, *47*, 153–161. https://doi.org/10.2307/1912352

Heidinger, D., & Gatzert, N. (2018). Awareness, determinants and value of reputation risk management: Empirical evidence from the banking and insurance industry. *Journal of Banking & Finance*, *91*, 106–118. https://doi.org/10.1016/j.jbankfin.2018.04.004

Heinemann, A. (2012). Government control of cross-border M&A: Legitimate regulation or protectionism? *Journal of International Economic Law*, *15*(3), 843–870. https://doi.org/10.1093/jiel/jgs030

Heinle, M. S., & Smith, K. C. (2017). A theory of risk disclosure. *Review of Accounting Studies*, *22*(4), 1459–1491. https://doi.org/10.1007/s11142-017-9414-2

Hoffmann, V. H., & Busch, T. (2008). Corporate carbon performance indicators. *Journal of Industrial Ecology*, *12*(4), 505–520. https://doi.org/10.1111/j.1530-9290.2008.00066.x

Hong, H., Karolyi, G. A., & Scheinkman, J. (2020). Climate finance. *The Review of Financial Studies*, *23*(3), 1011–1023. https://doi.org/10.1093/rfs/hhz146

Huang, C., Ozkan, N., & Xu, F. (2023). Shareholder litigation risk and Firms' choice of external growth. *Journal of Financial and Quantitative Analysis*, *58*(2), 574–614.

Humphery-Jenner, M., & Powell, R. (2014). Firm size, sovereign governance, and value creation: Evidence from the acquirer size effect. *Journal of Corporate Finance*, *26*, 57–77. https://doi.org/10.1016/j.jcorpfin.2014.02.009

Hussaini, M., Rigoni, U., & Perego, P. (2023). The strategic choice of payment method in takeovers: The role of environmental, social and governance performance. *Business Strategy and the Environment*, *32*(1), 200–219. https://doi.org/10.1002/bse.3125

Irwin, K., Gilstrap, C., McDowell, W., Drnevich, P., & Gorbett, A. (2022). How knowledge and uncertainty affect strategic international business investment decisions: Implications for cross-border mergers and acquisitions. *Journal of Business Research*, *139*, 831–842. https://doi.org/10.1016/j.jbusres.2021.10.001

Ismail, A. (2011). Does the Management's forecast of merger synergies explain the premium paid, the method of payment, and merger motives? *Financial Management*, *40*, 879–910. https://doi.org/10.1111/j.1755-053X.2011.01165.x

Jorgensen, B. N., & Kirschenheiter, M. T. (2003). Discretionary risk disclosures. *The Accounting Review*, *78*(2), 449–469. https://doi.org/10.2308/accr.2003.78.2.449

Jung, J., Herbohn, K., & Clarkson, P. (2018). Carbon risk, carbon risk awareness and the cost of debt financing. *Journal of Business Ethics*, *150*(4), 1151–1171. https://doi.org/10.1007/s10551-016-3207-6

Kai, L., & Prabhala, N. R. (2007). Self-selection models in corporate finance. In *Handbook of empirical corporate finance* (pp. 37–86). Elsevier. https://doi.org/10.1016/B978-0-444-53265-7.50016-0

Kang, J. K., & Kim, J. M. (2010). Do foreign investors exhibit a corporate governance disadvantage? An information asymmetry perspective. *Journal of International Business Studies*, *41*(8), 1415–1438. https://doi.org/10.1057/jibs.2010.18

Kim, E. H., & Lyon, T. (2011). When does institutional investor activism increase shareholder value? The carbon disclosure project. *The BE Journal of Economic Analysis & Policy*, *11*(1). https://doi.org/10.2202/1935-1682.2676

King, D. R., Dalton, D. R., Daily, C. M., & Covin, J. G. (2004). Meta-analyses of postacquisition performance: Indications of unidentified moderators. *Strategic Management Journal*, *25*(2), 187–200. https://doi.org/10.1002/smj.371

Klitzka, M., He, J., & Schiereck, D. (2021). The rationality of M&A targets in the choice of payment methods. *Review of Managerial Science*, *16*, 933–967. https://doi.org/10.1007/s11846-021-00469-6

La Porta, L., Lopez-de-Silanes, F., Shleifer, A., & Vishny, R. W. (1998). Law and finance. *Journal of Political Economy*, *106*(6), 1113–1155. https://doi.org/10.1086/250042

Lechner, P., & Gatzert, N. (2018). Determinants and value of enterprise risk management: Empirical evidence from Germany. *The European Journal of Finance*, *24*(10), 867–887. https://doi.org/10.1080/1351847X.2017.1347100

Lehmann, E. E., Braun, T. V., & Krispin, S. (2012). Entrepreneurial human capital, complementary assets, and takeover probability. *The Journal of Technology Transfer*, *37*(5), 589–608. https://doi.org/10.1007/s10961-011-9225-8

Lemma, T. T., Lulseged, A., & Tavakolifar, M. (2021). Corporate commitment to climate change action, carbon risk exposure, and a firm's debt financing policy. *Business Society and Environment*, *30*, 3919–3936. https://doi.org/10.1002/bse.2849

Lennox, C. S., Francis, J. R., & Wang, Z. (2012). Selection models in accounting research. *The Accounting Review*, *87*(2), 589–616. https://doi.org/10.2308/accr-10195

Li, F., Ting Liang, T., & Zhang, H. (2021). Does economic policy uncertainty affect cross-border M&As? — A data analysis based on Chinese multinational enterprises. *International Review of Financial Analysis*, *73*, 101631. https://doi.org/10.1016/j.irfa.2020.101631

Lim, M. H., & Lee, J. H. (2016). The effects of industry relatedness and takeover motives on cross-border acquisition completion. *Journal of Business Research*, *69*(11), 4787–4792.

Lodh, S., & Battaggion, M. R. (2015). Technological breadth and depth of knowledge in innovation: The role of mergers and acquisitions in biotech. *Industrial and Corporate Change*, *24*(2), 383–415.

Luo, L., Lan, Y. C., & Tang, Q. (2012). Corporate incentives to disclose carbon information: Evidence from the CDP global 500 report. *Journal of*

International Financial Management & Accounting, *23*(2), 93–120. https://doi.org/10.1111/j.1467-646X.2012.01055.x

Mantecon, T. (2009). Mitigating risks in cross-border acquisitions. *Journal of Banking and Finance*, *33*(4), 640–651. https://doi.org/10.1016/j.jbankfin.2008.12.001

McFadden, D. (1973). Conditional logit analysis of qualitative choice behavior. In P. Zarembka (Ed.), *Frontiers in econometrics*. Academic Press.

McKinsey. (2012). *Taking a longer-term look at M&A value creation*. Retrieved October 1, 2020, from https://www.mckinsey.com/business-functions/strategy-and-corporate-finance/our-insights/taking-a-longer-term-look-at-m-and-a-value-creation

Moeller, S. B., & Schlingemann, F. P. (2005). Global diversification and bidder gains: A comparison between cross-border and domestic acquisitions. *Journal of Banking and Finance*, *29*, 533–564. https://doi.org/10.1016/S0378-4266(04)00047-0

Moeller, S. B., Schlingemann, F. P., & Stulz, R. M. (2004). Firm size and the gains from acquisitions. *Journal of Financial Economics*, *73*(2), 201–228. https://doi.org/10.1016/j.jfineco.2003.07.002

Mohana-Neill, I. S. (1995). The influence of firm's age and size on its environmental scanning activities. *Journal of Small Business Management*, *33*, 10–12.

Nguyen, J. H. (2018). Carbon risk and firm performance: Evidence from a quasi-natural experiment. *Australian Journal of Management*, *43*(1), 65–90. https://doi.org/10.1177/0312896217709328

Nikolaou, I., Evangelinos, K., & Leal Filho, W. (2015). A system dynamic approach for exploring the effects of climate change risks on firms' economic performance. *Journal of Cleaner Production*, *103*, 499–506. https://doi.org/10.1016/j.jclepro.2014.09.086

Nordhaus, W. (2019). Climate change: The ultimate challenge for economics. *American Economic Review*, *109*(6), 1991–2014. https://doi.org/10.1257/aer.109.6.1991

Pan, X., & Zhang, J. (2022). Language similarity and M&A Transactions. *The European Accounting Review*, 1–30. https://doi.org/10.1080/09638180.2022.2117221

Pineiro-Chousa, J., Vizcaíno-González, M., López-Cabarcos, M. Á., & Romero-Castro, N. (2017). Managing reputational risk through environmental management and reporting: An options theory approach. *Sustainability*, *9*(3), 376. https://doi.org/10.3390/su9030376

Pinner, D., and Sneader, K. (2019). *Earth to CEO: Your company is already at risk from climate change*. (https://www.mckinsey.com/business-functions/sustainability/our-insights/earth-to-ceo-your-company-is-already-at-risk-from-climate-change).

Pratt, J. W. (1964). Risk aversion in the small and in the large. *Econometrica*, *32*, 122–136. https://doi.org/10.2307/1913738

Qian, W., & Schaltegger, S. (2017). Revisiting carbon disclosure and performance: Legitimacy and management views. *The British Accounting Review*, *49*(4), 365–379. https://doi.org/10.1016/j.bar.2017.05.005

Renneboog, L., & Vansteenkiste, C. (2019). Failure and success in mergers and acquisitions. *Journal of Corporate Finance*, *58*, 650–699. https://doi.org/10.1016/j.jcorpfin.2019.07.010

Rossi, S., & Volpin, P. (2004). Cross-country determinants of mergers and acquisitions. *Journal of Financial Economics*, *74*(2), 277–304. https://doi.org/10.1016/j.jfineco.2003.10.001

Shaari, M. S., Abdul Karim, Z., & Zainol Abidin, N. (2020). The effects of energy consumption and national output on CO2 emissions: New evidence from OIC countries using a panel ARDL analysis. *Sustainability*, *12*(8), 3312. https://doi.org/10.3390/su12083312

Shaw, D., Cumbers, A., McMaster, R., & Crossan, J. (2018). Scaling up community action for tackling climate change. *British Journal of Management*, *29*(2), 266–278. https://doi.org/10.1111/1467-8551.12274

Shecter, H. (1996). *Selected risk issues in merger and acquisition transactions* (Vol. 719). University of Miami Law Review.

Skjærseth, J. B., & Skodvin, T. (2001). Climate change and the oil industry: Common problems, different strategies. *Global Environmental Politics*, *1*(4), 43–64. https://doi.org/10.1162/152638001317146363

Smith, C. W., & Watts, R. L. (1992). The investment opportunity set and corporate financing, dividend, and compensation policies. *Journal of Financial Economics*, *32*, 263–292. https://doi.org/10.1016/0304-405X(92)90029-W

Stanny, E., & Ely, K. (2008). Corporate environmental disclosures about the effects of climate change. *Corporate Social Responsibility and Environmental Management*, *15*, 338–348. https://doi.org/10.1002/csr.175

Suk, I., & Wang, M. (2021). Does target firm insider trading signal the target's synergy potential in mergers and acquisitions? *Journal of Financial Economics*, *142*(3), 1155–1185. https://doi.org/10.1016/j.jfineco.2021.05.038

Sun, Y., Yang, Y., Huang, N., & Zou, X. (2020). The impacts of climate change risks on financial performance of mining industry: Evidence from listed companies in China. *Resources Policy*, *69*, 1–9. https://doi.org/10.1016/j.resourpol.2020.101828

Tanna, S., & Yousef, I. (2019). Mergers and acquisitions: Implications for acquirers' market risk. *Managerial Finance*, *45*(4), 545–562.

TCFD. (2017). Recommendations of the Task Force on Climate-related Financial Disclosures. Basel: Task Force on Climate-related Financial Disclosures. https://assets.bbhub.io/company/sites/60/2021/10/FINAL-2017-TCFD-Report.pdf

Todtenhaupt, M., Voget, J., Feld, L. P., Ruf, M., & Schreiber, U. (2020). Taxing away M&A: Capital gains taxation and acquisition activity. *European Economic Review*, *128*, 103505. https://doi.org/10.1016/j.euroecorev.2020.103505

Tzouvanas, P., Kizys, R., Chatziantoniou, I., & Sagitova, R. (2020). Environmental and financial performance in the European manufacturing sector: An analysis of extreme tail dependency. *The British Accounting Review*, *52*(6), 100863. https://doi.org/10.1016/j.bar.2019.100863

Uysal, V. B. (2011). Deviation from the target capital structure and acquisition choices. *Journal of Financial Economics*, *102*(3), 602–620. https://doi.org/10.1016/j.jfineco.2010.11.007

Varaiya, N., & Ferris, K. (1987). Overpaying in corporate takeovers: The Winner's curse. *Financial Analysts Journal*, *43*, 64–70. https://doi.org/10.2469/faj.v43.n3.64

Yang, J., Guariglia, A., & Guo, J. M. (2019). To what extent does corporate liquidity affect M&A decisions, method of payment and performance? Evidence from China. *Journal of Corporate Finance*, *54*, 128–152. https://doi.org/10.1016/j.jcorpfin.2017.09.012

Zhu, H., Xia, J., & Makino, S. (2015). How do high-technology firms create value in international M&A? Integration, autonomy and cross-border contingencies. *Journal of World Business*, *50*(4), 718–728. https://doi.org/10.1016/j.jwb.2015.01.001

Zollo, M., & Singh, H. (2004). Deliberate learning in corporate acquisitions: Post-acquisition strategies and integration capability in US bank mergers. *Strategic Management Journal*, *25*(13), 1233–1256. https://doi.org/10.1002/smj.426

How to cite this article: Lodh, S., Deshmukh, N., & Rohani, A. (2023). Stemming the tide: Does climate risk affect M&A performance? *Business Strategy and the Environment*, 1–24. https://doi.org/10.1002/bse.3518

APPENDIX A: VARIABLE DEFINITION

Variables	Definition	Source
MA	A dummy variable equals 1 if sample firms have an M&A in the following year of participating in the CDP survey, 0 otherwise	Eikon, Bloomberg
CAR (−2, +2)	Cumulative abnormal return for the 5-day event window, estimated using a market model with at least 30 non-missing daily return for 200-day of estimation period and value-weighted market return as benchmark.	
Climate change risk		
Physical risk	Score calculated by principal component analysis	CDP and authors' calculation As described in Section 3.1
Regulatory risk	Score calculated by principal component analysis	
Reputational risk	Score calculated by principal component analysis	
Firm level characteristics		
Capital intensity	Capital expenditure divided by total sales	DataStream
Firm size	The logarithm of total assets	DataStream
Liquidity	Net cash flow from operations divided by the beginning period total assets	DataStream
Profitability	Ratio of EBIT to total assets	DataStream
Asset newness	The ratio of annual net property, plant and equipment (PPE) to gross annual PPE	DataStream
Leverage	Ratio of total debt to total assets	DataStream
Book to market	(Total assets - preferred stock + deferred taxes + convertible debt) divided by market capitalization	DataStream
Acquirer age	The logarithm of difference between the current year and incorporation year	DataStream
CEO duality	A dummy variable equals 1 when the CEO is also a chairman of the firm, 0 otherwise	Capital IQ
Deal level characteristics		
Deal competition	Dummy equal 1 if more than one firm bidding for target, 0 otherwise	Eikon, Bloomberg
Toehold	Dummy variable equals 1 if the acquirer already holds a certain percentage of shares of target firms at the announcement, 0 otherwise	Eikon, Bloomberg
Cash only	Dummy equal 1 if the deals are financed by only cash, 0 otherwise	Eikon, Bloomberg
Stock only	Dummy equals 1 if the deals are financed by only stock, 0 otherwise	Eikon, Bloomberg
Macro-economic variable		
Language distance	Dummy equals 1 if the firm is in a country that primarily speaks English, and zero otherwise.	CEPII GeoDist
Legal enforcement	Impartial and effective enforcement of the law score	Fraser institute
Capital control	Controlling capital allocation score	Fraser institute
GDP growth	GDP growth	World Bank

APPENDIX B

The keywords and phrases are extracted from the comments or description related to each category of physical, regulatory and reputational risks.	
Risk driven by physical climate change	'change in precipitation', 'change in temperature', 'change in extreme precipitation', 'change in drought pattern', 'sea level rise', 'induced changes', 'natural resources pattern', 'frequency of extreme weather', 'temperature extremes', 'snow and ice', 'tropical cyclones', 'hurricanes and typhoons', 'uncertainty of physical risks', 'induced change human', 'change human nature', 'pricing risk', 'supply chain', 'uncertain*', 'change of*' 'change in*', 'physical', 'prolong*', 'severity'
Risk driven by regulation	'air pollution', 'new regulation', 'voluntary agreements', 'indirect exposure', 'renewable energy', 'product labeling', 'product efficiency', 'regulatory drivers', 'lack of regulation', 'international agreements', 'cap and trade' 'carbon taxes', 'environmental regulations', 'emission reporting', 'fuel taxes', 'energy taxes', 'energy consumption', 'pollution', 'emission reporting', 'Fuel energy', 'exposure suppliers', 'international agreement', 'lack of regulation', 'regulatory driver', 'interrupt*', 'product efficiency', 'product labelling', 'renewal energy' 'uncertain regulation', 'voluntary', 'risk', 'change of policy', 'compliance', 'assessment', 'schemes', 'negative impact', 'limit', 'regulat*', 'lack of *', 'protection', 'suspension'
Risk driven by reputation	'media', 'client', 'external reputation', 'loyalty', 'brand', 'image', 'pressure', 'expectation', 'market share', 'competition', 'reputation', 'disadvantage' 'damage', 'confidence', 'mandatory', 'fail to enact', 'climate policy', 'regulatory requirement', 'proactive', 'impact', 'shifting', 'meet customer need', 'consumer attitude', 'compliance', 'fail to identify', 'induced change', 'uncertainty', 'reputation', 'loss of', 'satisfaction', 'trust'

APPENDIX C

Here we report a sample of some of the descriptions or comments given by the respondent acquirers (in 2010–2020) in our sample against each of the risk categories. The phrases in italics are extracted using text analysis method and coded accordingly for the principal component analysis (PCA). We use the PCA scores above the eigen vector 1 to contract the physical, regulatory and reputation risks for each sample acquirer firm in each year.

Comments on risks driven by physical climate change.

'Climate change presents a *business-continuity risk* for the increased *occurrence of prolonged droughts* in the regions throughout the world where A&F sources its materials. *Precipitation extremes and droughts* can result in increased costs of goods sold for A&F due to disruptions in its cotton supply chain and garment manufacturing … Abercrombie & Fitch Co".

'… shifts have the potential to increase the *severity of the catastrophic events* (described in "acute physical" above) in the future-- High degree of *uncertainty around scope*, magnitude and timing of *physical climate impacts* can make physical risks difficult to adequately address and plan for Claims risks arising from increased frequency and overlap of extreme weather events … *Pricing risks arising* from changing risk profiles due to climate-related weather patterns and events impacting insured assets and property (potentially creating uninsurability of property).-- The Hartford'.

Comments on risks driven by regulation change.

'As part of Boeing's Enterprise Risk Management (ERM) processes, we assess all climate change related risks and opportunities … *Non-compliance with regulations* would cause fines and *operation interruption*. We are subject to the US EPA mandatory GHG reporting rule, … and other various US federal, state …, local and non-U.S. laws and *regulations relating to environmental protection*, discharges, treatment, storage, disposal and remediation of hazardous substances and wastes. We continually *assess our compliance* status and management of environmental matters … Boeing'.

'ADP evaluates a number of climate-change *current regulations* including carbon taxes, pollution limits and *emission reporting obligations* that could pose a risk of potential measurable risk of fines … *Failure to comply* with existing laws and regulations applicable to our operations or client solutions and services, which include *climate-related regulations*, may result in the *suspension or revocation of licenses* or registrations, the limitation, suspension or termination of ADP's services … ADP'.

'Concern over climate change has led to *legislative and regulatory* initiatives directed at limiting greenhouse gas ("GHG") emissions. … Laws *enacted that directly or indirectly* affect our production, distribution, packaging, cost of raw materials, fuel, ingredients and water could all negatively impact our business and financial results, … *Risks relating to current regulation* are relevant and always included in that process … Keurig Dr Pepper'.

Comments on risks driven by reputation change.

'Edwards seriously considers its *reputation and public image* especially with regards to the quality and efficacy of our products, trust with our employees and overall satisfaction and *trust with our stakeholders*. We publicly report … to remain *transparent and develop trust* with our key stakeholders … Edwards Lifesciences Corp'.

'Assurant's 2017 materiality assessment identified Customer Relations as one of our top five ESG topics. A *failure to meet customer needs*, *preferences or timeframes* could compromise Assurant's position as a market leader -Assurant'.

'… We have considered *reputation in our climate-related risk* assessments because our reputation is directly tied to producing products that reduce product energy usage and greenhouse gas emissions. … considered risks from climate change and how they would *affect customer satisfaction* and our *external reputation* … CREE Inc'.

'… considers our *reputation and public image* to be highly relevant, especially with regard to our products and patient safety. … *to strengthen our reputation* as a steward to the environment and local community by pursuing green construction strategies … Edwards Lifesciences Corp'.

APPENDIX D

Year	Number of sample acquirer	Number of matched acquire	Total number of acquirers
2010	21	15	36
2011	56	40	96
2012	59	41	100
2013	46	44	90
2014	60	51	111
2015	78	44	122
2016	62	47	109
2017	59	45	104
2018	65	50	115
2019	61	58	119
2020	0	55	55

Note: The table shows the number of sample acquirer and the matched acquirer.