Does Higher Risk Require More Rewards? Firm-Level Climate Risk and Top Executives' Compensations

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Abstract

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Keywords: climate risks, executives' compensation, cash-based reward, equity incentive

JEL classifications: E22, G32, H63, G31

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"Rank does not confer privilege or give power. It imposes responsibility"

Peter Ferdinand Drucker

1 Introduction

Climate change poses a compelling threat that compromises the health and well-being of individuals across every nation with a range of potential threats, ranging from global warming, sea level rises, and augmented occurrence of catastrophic natural events such as hurricanes, drought, or heavy rainfall events (Deryugina et al., 2019; Stern, 2008). Its repercussions extend beyond human health, encompassing disruptions to the macroeconomy (Burke et al., 2015; Dell et al., 2012). As forecasted by the Economist Intelligence Unit (EIU), climate change could directly cost the world economy US$ 7.9 trillion or 3% of the global GDP by 2050[1]. Over the past few decades, the issues surrounding climate change and environmental risks have risen to the forefront of global awareness not only from policymakers alone, but also from investors, businesses, and public alike. At the corporate level, businesses contend with explicit costs stemming from climate change, including those linked to natural disasters, extreme temperatures, and the ascent of sea levels. Companies might confront cash flow disruptions arising from tangible harm to their facilities, escalated operational and regulatory expenses, and disturbances within their supply chains (Chang et al., 2016; Peters and Wagner, 2014). Given the improvements in climate awareness and knowledge of the stakeholders, several studies delve into the hostile consequences of climate change on financial markets and corporations regarding corporate valuations, profitability or operations (Choi et al., 2020; Huang et al., 2018; Huynh and Xia, 2020). With the negative impacts of climate risk on corporate activities, a critical question still lingers how climate risk affects the company's most critical staff—the managerial team. Considering their focal roles in resource management, operational oversight, and strategic decision-making for the firm's future trail, it becomes commanding to establish reward guidelines that optimally compensate top-management executives. These policies are instrumental in incentivizing and rewarding their endeavors

[1]See: https://phys.org/news/2019-11-climate-impacts-world-trillion.html

to guide the company toward sustainable operations and strategic approaches.

Motivated by the risk-driven-reward theory (Chen et al., 2022; Miller et al., 2002), there are two plausible reasons to anticipate that top executives might seek compensation increases in response to climbing climate change threats. Firstly, existing literature documents compensation premiums associated with occasions when top executives encounter elevated risks. Previous studies have consistently shown that senior executives are skilled at bargaining for higher pay in response to various forms of increased risk. These risks include the potential for financial distress Chang et al. (2016), unpredictable industry dynamics Peters and Wagner (2014), compromised quality of life or higher costs of living (Deng and Gao, 2013; Francis et al., 2016), and a greater threat of terrorist activities Dai et al. (2020). Specifically, research indicates that executives can effectively secure better compensation packages when their turnover risk is amplified by unstable industry conditions (Peters and Wagner, 2014), when the company faces higher distress risk (Chang et al., 2016), or when personal circumstances such as living conditions or safety concerns become less favorable (Dai et al., 2020; Deng and Gao, 2013; Francis et al., 2016). If climate risk worsens the firm's overall performance and stability, it can translate into tangible losses for top executives. This is particularly significant as a sizable portion of their long-term wealth encompasses pensions, retirement grants, and deferred rewards (Chang et al., 2016). Additionally, Moreover, the net worth of senior executives linked to equity holdings may suffer when the valuation of stocks and options falls in response to the damaging impact of climate change consequences (Mohanram et al., 2020; Ofek and Yermack, 2000).

A second school of thought proposes that climate risk can directly affect the firm's overall risk. Climate change poses a threefold risk, starting with the clear physical risk that interrupts firms' supply chains, obstructs business activities, and increases the variability of operating expenses and profit margins Huynh and Xia (2020); Sautner et al. (2023). Concurrently, the formidable risks associated with climate change opportunities and regulation, such as shifts in consumer green awareness, technological progressions, and evolving regulatory landscapes. In navigating these complicated challenges, top executives are compelled to invest substantial additional effort in steering their firms toward stability and sustainability. Consequently, they may seek to negotiate a pay increase as a means to justly compensate for the heightened demands and complexities posed by climate change.

This study investigates the relationship between firm-level climate change risk (CCR, hereafter) and different kinds of compensation, including total compensation, short-term compensation (cash, salary, and bonus), and long-term compensation (stock and option payment). To address the limitations inherent in self-reported and aggregate metrics of climate change risk, we employ detailed, firm-specific measures of climate change exposure constructed by Sautner et al. (2023). These measures, derived from bigram analysis of signal words within earnings conference call transcripts, offer a comprehensive evaluation of firms' time-varying vulnerability to various climate change-related risks, surrounding physical, opportunities, and regulatory risks. Its application directly addresses the need, as advocated by Engle et al. (2020), for more precise and tailored metrics to gauge firm-level climate change risks. Drawing upon a comprehensive dataset encompassing publicly listed firms in 35 countries from 2001 to 2021, our study unveils a compelling, significant link between climate change exposure and the compensation components of top executives. With the increase in climate risks, top executives receive a higher total compensation package comprising higher short-term and direct compensations and lower long-term or equity-based compensations as a strategic response. In practical terms, a one-standard-deviation uptick in our climate change exposure metric corresponds to an approximate 3.5% upsurge in total pay for these executives. Furthermore, we also explores the links between climate risk exposure and the different elements of senior executives' pay. We find a pronounced trend towards increased cash compensation in reaction to escalating climate-related risks. Our initial results are persistent, withstanding a series of rigorous tests that employ alternate methodologies to mitigate concerns of endogeneity and the bias from omitted variables.

Subsequently, we explore channels through which top executives can obtain higher pay following increased climate change risk. We suggest three channels for the higher pay level: (1) motivation for eco-innovation, (2) managerial bargaining power, and (3) firms' future performance. Utilizing the multivariate connections between firms' eco-innovation, Climate Change Risk (CCR), and compensation, we reinforce that managers can obtain higher compensation in terms of cash and salary payments if they can take the necessary initiatives to reduce firm-level CCR. Employing well-recognized proxies for the internal corporate governance, our study reveals a stronger connection between climate risk and senior executives' remuneration in companies where managerial influence (indicated by age and tenure) is more pronounced and internal governance mechanisms are weaker (evidenced by lower levels of institutional ownership and analysts following). Pay premium in compensation increases with firms' climate risk, especially short-term and direct payments, for managers with higher bargaining power. Further, utilizing the channels of reductions in firms' future profitability and market valuation as firms are exposed to greater climate change, we can have detrimental influences on top executives' equity-based compensations. Additionally, we conduct various sub-sample analyses to provide intense understanding into the pay premium associated with climate risk. Our results indicate that companies with operations spanning multiple countries experience a relatively lower impact from climate risk, attributable to their lower geographic diversification. Conversely, firms equipped with CSR committees may experience greater exposure to climate risk, as it aligns with their required responsibilities. Moreover, our additional results evidence that the effects of CCR on top executives' compensation primarily depend on the firms in highly polluting industries or operating in environments characterized by high corruption levels and weak minority shareholder protection. Our findings provide added proof for the connection between climate risk and the compensation of top executives. Finally, we utilize quasi-experimental analyses within a difference-in-differences framework, focusing on three significant climate events, namely the EPA Emission Legislation in 2007, Doha Climate Summit in 2012, and Paris Agreement in 2015. We specify a notable rise in cash-based compensation (alongside a reduction in equity-based compensation) for firms after these events, implying a causal connection between climate change risk and the overall compensation of top executives. This result further support the notion that environmental awareness influences the rationale for risk-linked compensation demands when especially as executives, along with boards and shareholders, grow increasingly attentive to a firm's vulnerability to climate risk.

This study provides several notable contributions. First, this study contributes to the growing body of literature focused on the repercussions of how climate risk affects the macroeconomy and businesses. At the macroeconomic level, previous studies have shown that climate change significantly reduces economic outputs and productivity (Burke et al., 2015; Fisher et al., 2012; Lobell et al., 2011), impacts labor force effectiveness (Graff Zivin and Neidell, 2014), hinders economic growth (Carleton and Hsiang, 2018; Dell et al., 2012), and influences asset valuations (Bernstein et al., 2019). At the corporate level, companies contend with amplified revenue and earnings volatility (Huang et al., 2018; Pankratz et al., 2023), escalated operating expenses (Hugon and Law, 2019), reduced equity valuation (Choi et al., 2020; Matsumura et al., 2014), diminished bond returns (Huynh and Xia, 2020), and heightened costs of bank financing Huang et al. (2018); Javadi and Masum (2021). Our study presents novel findings that shed light on the plausible causal impacts of climate change risk on different kinds of top executives' compensation. To the best of our knowledge, this is the first firm-level study to comprehensively consider the impacts of climate risk on top-management compensation rather than only focusing on compensation for CEOs. To some extent, our study can extend the U.S study of Hossain et al. (2022) that considers the impacts of firm-level CCR on equity-based compensation of CEOs. More specifically, while Hossain et al. (2022) concentrate on total and equity-based compensation of CEOs of U.S. firms, we provide a more extensive analysis based on a global sample with different forms of compensation for top executives. On the other hand, our findings are strongly aligned with a recent study by Banerjee et al. (2022). The authors confirm that executives of U.S firms with higher exposure to pollution will induce higher direct compensation (cash, salary, and bonus) and lower incentive pay (equity and option grants). Therefore, our study advances the field and ensures a more accurate and insightful examination of the sophisticated relationship between climate risk and corporate outcomes by painting a comprehensive picture of the literature on compensation for key personnel regarding risk management. Further, our study employs an innovative and highly precise approach to gauge firm-level climate risk, utilizing Sautner et al. (2023)

cutting-edge textual search methodology. By doing so, we enhance our ability to capture and comprehend the unique and idiosyncratic climate change risks faced by individual firms. This method provides a distinct advantage over previous research, which often relied on aggregate or indirect measures that may obscure the nuances and intricacies of climate risk at the firm level.

Second, this paper effectively highlights climate change as a pivotal factor influencing compensation dynamics. Previous research has explored an array of determinants shaping top executives' compensation, encompassing factors such as CEO confidence (Otto, 2014), financial obstacles (Chang et al., 2016), corporate governance (Bebchuk and Fried, 2004; Chhaochharia and Grinstein, 2009; Core et al., 1999), turnover risk (Peters and Wagner, 2014), labor unions (Huang et al., 2017), social stigma (Novak and Bilinski, 2018), and political risks (Dai et al., 2020). Our study diverges from prior investigations by demonstrating that, due to the potential deterioration in market valuation, top executives in firms exposed to higher climate risk tend to show a preference for short-term compensation over long-term forms of payment. Moreover, this study not only corroborates a robust connection between firm-level climate change risk (CCR) and executive compensation but also substantiates the presence of three crucial mechanisms elucidating this nexus. These mechanisms encompass the driving forces of eco-innovation motivation, managerial authority, and corporate performance enhancement. In a comprehensive cross-sectional analysis, our research advances the proposition that the intricate interplay between CCR and compensation is profoundly influenced by a spectrum of factors, spanning firm-specific attributes, industry dynamics, and macro-environmental conditions.

Finally, drawing upon our findings, several pragmatic implications emerge for corporate managers, regulators, and policymakers. This study offers a basis for formulating guidelines to monitor climate risk and establish optimal compensation levels for managers in alignment with their business strategies. For instance, utilizing short-term compensation methods such as cash, salary, and bonus payments could empower top managers to implement business strategies that strike a harmonious equilibrium between maximizing firms' profits and minimizing the detrimental impact of climate risk. Regulators can also consider imposing corporate laws and regulations to suspect the pay-for-performance of the executive's team to reduce overcompensation corruption and agency problems (Bushman, 2021; Vergne et al., 2018). Moreover, this study not only paves the way for future research exploring the interplay between environmental finance and corporate governance but also provides a foundation for potential advancements in this domain.

The remainder of the paper proceeds as follows. Section 2 reviews the related literature and develops the hypotheses. We describe the sample and research design for empirical analyses in Section 3. Section 4 reports the baseline results and robustness checks. Section 5 presents the channel analyses and additional tests, and Section 6 concludes the study.

2 Theoretical Background and Literature Review

2.1 Economic significance of Climate Change Risk

Prior studies have indicated the negative economic impacts of climate risk regarding greenhouse warming. Using extreme temperatures as a proxy of climate risks, Dell et al. (2009) uncover that hot climates reduce income per capita. For example, a change in one degree Celsius reduces 8.5% income per capita. Burke et al. (2015) suggest that economic productivity and temperature have a non-linear correlation. After economic productivity achieves the highest value at 13 degrees Celsius of the average annual temperature, economic productivity decreases once average temperatures rise. In addition, prior works have demonstrated the negative influences of extreme temperatures on economic growth. While Dell et al. (2009) show that an increase of 1°C temperature leads to a decline of 1.3% in GDP growth rate for frontier countries, Carleton and Hsiang (2018) point out that hot climates decline global economic growth by 0.28% annually. Other studies have investigated the impacts of low rainfall and tropical hurricanes on national incomes. Barrios et al. (2010) find evidence that the decline reduces the GDP per capita growth rate for African countries in rainfall. Hsiang and Jina (2014) indicate that tropical storms are attributed to slow GDP growth for all countries, and national income reduction continues fifteen years after the disaster. They further point out that between 1970 and 2008, the global annual GDP growth rate declined by 1.27%, coming from realized cyclones. In addition, Lenzen et al. (2019) uncovered that tropical cyclones cause losses of employment and value-added in the northeastern Australian coast. Hurricanes directly contribute to reducing nearly 4,802 full-time-equivalent jobs and AUD 1,544 million value added.

A large body of prior works shows that climate risks cause the mispricing for financial markets due to causing a bubble in the valuation of real estate assets (Gourevitch et al., 2023). Bakkensen and Barrage (2017) report that climate exposure attitudes in coastal regions are substantially heterogeneous and that increasing flood risk caused by climate change is not efficiently added to coastal house prices. Although Bernstein et al. (2019) show evidence that prices of coastal houses damaged by sea-level rise are reduced by 6.6%

compared to similar houses at higher elevations, Murfin and Spiegel (2020) do not find any evidence on the impacts of sea-level rise risk priced in the value of real estate.

The current literature also examines how stock markets react to climate risks. Hong et al. (2019) document that the value of stock markets does not fully reflect the growing drought risk triggered by climate change. However, Guastella et al. (2022) document that stock market investors quickly adapt to new information about climate change. Zhang (2022) shows that stock market prices react negatively to perceived fluctuations in climate risk. They further support that "green" ("brown") companies are compensated (fined) by the stock market if climate risks grow. Gong et al. (2022) add that the negative impacts of climate risk on equity returns are more significant when firms cope with political uncertainty. However, Bolton and Kacperczyk (2021) find that stocks of firms with higher climate risks, indicated by larger carbon dioxide emissions, yield higher returns, supporting the theory that equity investors demand compensation for bearing climate risk.

Similarly, other studies show that climate risks cause lower firm valuation (Choi et al., 2020; Matsumura et al., 2014) and lower corporate bond returns (Huynh and Xia, 2020).Matsumura et al. (2014) indicate that, on average, an increase in one additional thousand metric tons of carbon emissions leads to a reduction in the firm value of about $212,000. They also support that capital markets absorb both information related to carbon emissions and the act of voluntary disclosure, which may also reflect in firm valuation. Berkman et al. (2021) claim that financial markets admit climate risks as idiosyncratic and material risks, and firms with high climate risks will be penalized if major climate events happen. Huynh and Xia (2020) uncover that companies with high climate risk generate smaller bond returns. However, companies with better environmental policies can receive rewards from investors, who are willing to pay premiums for the bonds and equities of such firms (Flammer, 2021; Huynh and Xia, 2020).

Regarding businesses' operation impacts, prior studies indicate that climate risk can substantially lower firm profits and an increase in earnings volatility0 (Huang et al., 2018; Hugon and Law, 2019; Pankratz et al., 2023). The evidence of Huang et al. (2018) shows the likelihood of loss caused by major hurricanes, flooding, and heat waves, resulting in lower cashflows and more considerable volatile earnings. Hugon and Law (2019) document that companies' incomes, on average, are adversely influenced by an unusually warm climate. For example, an increase in 1°C causes a decline of $1.6 million in earnings for a median-sized company. Pankratz et al. (2023) find evidence that the decrease in firm revenues comes from the dropped supply of inputs (productivity of human resources) attributed to climate risk. This is because extreme weather negatively affects employees' cognitive and physical performances and reduces their working hours. Also, companies may cope with troubles in their business models if their shareholders and other stakeholders recognize their climate-related risks and tend to move to sustainable ones (Pankratz et al., 2023). In addition, Hugon and Law (2019) and Pankratz et al. (2023) support that global warming raises operating costs and the frequency of unusual and extraordinary expense items.

Current research highlights that climate risks lead to adjustments in corporate financing policies. Firms facing climate-related concerns may encounter increased costs of financing and more stringent debt covenants, especially if banks scrutinize their environmental profiles for risk management Chava (2014); Javadi and Masum (2021). Consequently, companies potentially affected by climate risks need to adapt their financing strategies to avoid the financial constraints. Huang et al. (2018) show that companies grappling with elevated climate risks tend to favor long-term debt, maintain larger cash reserves, and distribute smaller cash dividends. Such financial strategies may help them deal with liquidity shocks due to extreme weather, and they are helpful solutions for companies to maintain organizational resistance to climate risks. On the other hand, Lemma et al. (2021) do not find any relationship between climate risk and the debt financing policy of companies. However, companies with a higher commitment to solving climate-associated issues may have a positive reputation, higher credit rating, and decreased costs related to agency and information asymmetry problems. As such, they may have easier access to long-term debt markets.

2.2 Top-Management Compensation and Climate Risk

Prior studies indicate different kinds of top-executive compensation. Based on the time horizon, Aggarwal and Samwick (1999) suggest two types of compensation, including short-term and long-term incentives. While salary and bonus are considered as short-term compensation, stock options are long-term compensation. Bushman et al. (1996) divide compensation into two main parts, including a salary-based section and an incentive section. Salary is the "fixed" income of executives' incentive, which does not depend on performance. The incentive section contains bonus and long-term compensation plans based on performance (Bushman et al., 1996). This type of compensation plays a vital role in the arrangement of interests between top managers and shareholders as this incentive is sensitively compensated by performance. Rekker et al. (2014) further explain that a bonus is a reward for the good performance of a CEO within a year, while options will be assigned over time and frequently last 10–15 years, forming the long-term compensation and depending on the company's long-term performance.

The current literature identifies various factors influencing the top-executives' compensation. Gabaix and Landier (2008) provide evidence suggesting a positive correlation between CEO incentive pay and the size of the company they oversee, as well as a positive relationship with the average size of companies in the economy. Regarding corporate governance factors, Core et al. (1999) suggest that poor governance structures contribute to more significant agency problems so that executives in such firms receive greater incentives. Bebchuk and Fried (2004) add that changes in the executives' pay arrangement depend on the power of managers. Chhaochharia and Grinstein (2009) find evidence that executives of companies that are more affected by new requirements of the U.S. stock exchanges to increase board oversight will experience a decrease in compensation. Hubbard and Palia (1995) find evidence of the impact of industry deregulations on the compensation of U.S. CEOs in the banking industry. They point out that top executives of banks in areas where interstate banking is allowed will receive higher compensation. Regarding CEO characteristics and compensation, Otto (2014) finds evidence that top executives whose behavior reveals optimistic beliefs will be compensated by lower equity-option grants, fewer bonus incentives, and small total compensation compared to their peers. Graham et al. (2012) support that CEO's compensation payment relates to their characteristics, including risk-aversion and time preference. They find that while top executives with greater risk aversion receive lower compensation with performance-based pay, those with a greater rate of time preference are paid higher compensation in salary. Muñoz-Bullón (2010) shows that the gender factor impacts executive pay. Of these, female CEOs are rewarded at lower compensation levels than male CEOs.

The existing literature posits that top-management compensation is impacted by uncertainty factors such as dismissal risks, financial distress risks, and threats of terrorist attacks. Regarding dismissal risk, Peters and Wagner (2014) show that top executives of firms in volatile industry conditions are more likely to be terminated from their positions. As such, CEOs with higher turnover risks will receive higher compensation and vice versa. Chang et al. (2016) argue that financial distress risk is an economically significant determinant of new CEO incentive packages. They show that executives in companies with higher financial distress risks receive larger compensation than peers. A premium compensates them for this uncertainty because top managers spend more on personal expenses if their companies later experience financial distress. Dai et al. (2020) uncover that top executives of companies situated in areas that are nearby regions with terrorist attacks receive an average income growth of 12% after the attack. In addition, managers at terrorist attack-proximate companies expect to be paid higher cash-based compensation (such as salary and bonus) than equity-based compensation (such as stocks or options).

Climate risk represents a form of uncertainty, and existing literature offers varied findings regarding its connection with executive compensation. Studies by Coombs and Gilley (2005) and Berrone and Gomez-Mejia (2009) indicate that executives implementing eco-friendly strategies are often rewarded with higher overall compensation. Berrone and Gomez-Mejia (2009) further explain that such strategies can generate intangible values with higher "hard-core" financial performance for firms. Hossain et al. (2022) find that CEOs of companies with higher climate risks are compensated with more significant equity-based incentives. The positive relationship between equity-based compensation and climate exposure is more pronounced for companies with better social responsibility, vulnerable to higher environmental litigation, and belonging to non-high-tech sectors. Wang et al. (2021) report that firms located in cities with elevated levels of air pollution substantially increase financial incentives for employees, as well as safety measures and job training opportunities. Their rationale is that these companies need to motivate their workforce in return for their skills, boost loyalty and productivity, reduce staff turnover, and attract skilled personnel. On the other hand, some studies have discovered the negative impacts of environmental performance (CSR) on top management compensation. Rekker et al. (2014) and Cai et al. (2011) find that companies with higher environmental performance pay lower total compensation. Rekker et al. (2014) explain that firms taking more responsible actions for society and the environment or tending to supply a 'good' output may do so for ethical reasons. As such, CEOs in such companies may feel ethical accountability toward the community and expect fewer incentives. Similarly, while Coombs and Gilley (2005) and Rekker et al. (2014) posit negative impacts of environmental performance on variable short-term incentives, and Rekker et al. (2014) additionally find a negative correlation between performance related to environmental responsibility and cash-based incentive.

To explain the relationship between climate risk and top management compensation, the current literature has widely combined stakeholder, incentive alignment, and compensating wedge differential theories. The stakeholder theory states that top managers are anticipated to consider the benefits of different stakeholders (beyond shareholders) to guarantee the company's long-term growth as companies work in an interactive connection with broad-ranging stakeholders (Edmans, 2012; Tsang et al., 2021). However, top managers play an important role in arranging and executing business strategies for companies in the long term and short term (Nielsen, 2014). If managers put their effort into achieving temporary achievement, they may invest less in the long-term goals (such as reducing funding for innovation, research, and development) (Scuotto et al., 2022). As such, incentives have widely been employed as an efficient solution to maintain the balance between executives and organizations' benefits (Berrone and Gomez-Mejia, 2009). The incentive alignment theory further explains that compensation is a solution to connect the benefits of top managers, stakeholders, and shareholders, so it is necessary to encourage executives to work productively to maintain and enlarge profits for stakeholders and shareholders (Bebchuk and Fried, 2004; Zhou et al., 2021).

The compensating wedge differential theory argues that workers at any ranking level in an organization will look after higher incomes to compensate for their greater demand for risk management Haanwinckel and Soares (2021). This is because the growth of risks will contribute to potential job dismissal for employees or reduce their reputation in the job market so that they require more additional compensation. Prior works show evidence that climate risks may lead to lower performance (Matsumura et al., 2014), which may negatively impact the future job of the CEO and reduce the reputation of the company (Zalewska, 2014), for which the manager may be criticized. Top executives are predisposed to pursue elevated compensation, as substantiated by research such as that of Hossain et al. (2022) and Banerjee et al. (2022). In light of the current body of literature underscoring the formidable risks and uncertainties introduced by climate change in financial markets and corporate domains, the imperative for top-tier leaders to possess expertise and devote substantial efforts to steer their organizations toward sustainability becomes paramount. Hence, it is rational to expect that the incentives aligned with the successful execution of such sustainability strategies serve as a compelling motivator for top executives to invest significant efforts. In this context, we posit our first hypothesis:

Hypothesis 1 (H1): Total compensation for top executives increases with the firm's climate risk.

Banerjee et al. (2022) corroborate that executives from U.S. firms with greater pollution exposure tend to receive higher direct compensation, including cash, salary, and bonuses, while experiencing a reduction in incentive-based pay, such as equity and option grants. In light of the foreseeable scenarios involving potential declines in market valuations and the depreciation of stock options among firms grappling with elevated climate risk, it is reasonable to anticipate a predilection among executives at these organizations for short-term compensation structures over longer-term incentives. Encouraging this rationale, we put forth our second hypothesis:

Hypothesis 2 (H2): Managers of high-climate-risk firms receive lower long-term and higher short-term compensations.

3 Data and method

3.1 Data and variables construction

Our initial sample includes all publicly listed firms across 35 countries from 2001 to 2021. In this study, we utilize the firm-level climate change risk (CCR) measures composed by Sautner et al. (2023) as our key indicator[2]. The dimensions of firm-specific climate exposure are derived from analyzing pairs of signal words (bigrams) in earnings conference call transcripts. Sautner et al. (2023) assess the occurrence of climate-related bigrams, for instance, word pairs like 'risks' and 'uncertainties,' that appear in sentences discussing climate change issues. This frequency is subsequently adjusted relative to the overall length of the transcript. This comprehensive measure can effectively condense a firm's vulnerability to various climate change facets, encompassing physical, opportunity, and regulatory risks. Further, this approach can lighten the concerns of spotting "niche languages" in the climate change theme by portraying language employed by policymakers, journalists, and financial market participants during the conference calls. As stated by Sautner et al. (2023), their proxies extracted from the earnings conference call can exclude the biased information by the management. Therefore, the firm-level climate risk measure can overcome the drawbacks of using self-reported indicators such as carbon emission or corporate disclosures, mainly driven by past performance and corporate strategic settings. This climate risk measure is widely employed by prior climate finance papers, including Gong et al. (2022); Hossain et al. (2022), and Javadi et al. (2023). Following Sautner et al. (2023), we utilize the standardized values for all CCR proxies by deducting the sample mean and dividing by the standard deviation.

We sourced data on top-management compensation from two main sources the Execucomp and S&P Capital IQ databases, which covers both the aggregate and specific elements of total compensation for US and international firms[3]. The term "top executives" in listed firms typically refers to the highest-ranking officers responsible for managing

[2]The data for this variable is publicly available at: https://osf.io/fd6jq/

[3]We further obtain missing data from firms' available financial reports and the cross-check between different data sources are applied to maintain the consistency of our data.

the organization[4]. In line with existing research on compensation (Dai et al., 2020; Focke et al., 2017; Peters and Wagner, 2014), we analyze the five components of total compensation: salary, bonuses, stock awards, option grants, and cash compensations. Our main dependent variable is the total compensation for all senior executives, normalized by the company's total assets. For detailed analysis of each compensation component, we convert all values into their natural logarithm form, following the methodology of prior studies (Dai et al., 2020; Hoi et al., 2019; Otto, 2014).

We obtain the top-management compensation data that includes the total values and specific elements of the total compensation. Following prior literature on compensation (Focke et al., 2017; Peters and Wagner, 2014), we utilize the five components of total compensation, including salary, bonuses, stocks, options, and cash payments. The primary dependent variable is the total compensation paid to all senior executives scaled by the total assets. For the specific elements of the total compensation, all indicators are transformed into the natural logarithm for our empirical analyses as utilized in previous studies. We collect firm-level financial, board-related, and accounting data from Compustat Global, BoardEx, and Refinitiv Eikon (Datastream). Table 1 reports the list of variables' definitions and the data sources. For the board-related variables (excluding Senior executives' age), we created the dummy variables of 1 if the values are higher than the mean of the sample. We also obtain a set of firm-specific, industry-specific, and country-specific variables to control for the potential impacts on the compensation. We also specify the 2007–2008 and 2020 – 2021 periods as the occurrence of the global financial crisis by a dummy variable.

We rely on various sources to construct our sample. Following existing studies, we perform the following steps to filter the sample. First, we exclude firm-year observations for financial institutions, regulated utilities, and industries that are not clearly defined

[4]As classified by the Execucomp and S&P Capital IQ databases, the top executives include, but not limited to: *President & Vice-President; Chief Executives (Chief Executive Officer, Chief Financial Officer, Chief Operating Officer, Chief Information Officer, Chief Technology Officer, Chief Marketing Officer, Chief Legal Officer or General Counsel, Chief Compliance Officer, Chief Investment Officer, Chief Accounting Officer, Chief Credit Officer, Chief Administrative Officer); and Department or Division Heads (Head of Sales, Corporate Development, Human Resources, Corporate Communications, Investor Relations, VP or Exploration).*

(Wei and Zhang, 2008), as those firms tend to have significantly different investment and financial policies. For the industry classification, firms are classified by using the Global Industry Classification Standard (GICS). Such a classification is a joint Standard and Poor's (S&P) and Morgan Stanley Capital International (MSCI) product aimed at standardizing industry definitions worldwide Balachandran and Nguyen (2018). Further, we exclude observations that have negative total assets and a total debt-to-lagged asset ratio of less than 0 or greater than 1. We further winsorize the values of all continuous variables at the 1st and 99th percentiles to reduce the effect of outliers. Finally, we ensure that all variables from our main model are available, ending up with a final sample of non-missing information of 64,601 firm-year observations from 9,871 unique firms in 35 countries[5].

- Insert Table 1 about here -

3.2 Research design

This section presents models to examine how climate change risk might impact executives' compensation. These are premised on the notion that executives aim to maximize their utility, and climate change risk is one facet for which executives might expect higher compensation. Therefore, we propose a baseline model for multivariate analysis to better estimate the impacts of firm-level Climate change risk (CCR) on compensation for top managers by using the following models:

$$PAY_{i,j,c,t} = \alpha_0 + \beta_1 CCR_{i,j,c,t} + \sum \delta_k \text{FirmControls}_{i,j,c,t} + \sum \gamma_k \text{CountryControls}_{i,j,c,t} + \varepsilon_{i,j,c,t} \quad (1)$$

where i, j, c, and t index firm, industry, country, and year, respectively. The compensation (PAY) is proxied by the ratio of total and decomposition of compensation paid to top executives over firms' total assets during the financial year. The firm-level climate change risk measure (CCR) is climate risks proxies constructed by Sautner et al. (2023). Following the extant literature on top-management compensation (Dai et al., 2020; Hoi et al., 2019; Huang et al., 2017; Otto, 2014), we also include firm-specific controls ($FirmControls$)

[5] See Appendix A for the sample distribution.

and country-specific factors (*CountryControls*). The firm-specific controls include two groups of firm-level and corporate governance variables. We employ eight firm-specific controls, including *Firm size, Market to book ratio, Leverage, Profitability, Cash holdings, Sales growth, Annualized stock return*, and *Capital expenditures (Capex).* In addition, corporate governance indicators include *Institutional ownership, Co-opted independence*, and *Senior executives' age.* The detailed descriptions of all variables are reported in Table 1. In specific regressions, we also include fixed effects for country, industry, and year in various specifications, which are modified from the baseline model in each subsection of the empirical analyses. We also utilize the robust standard errors clustered at the firm level to address within-firm serial correlations[6].

[6]In unreported results, we also use standard errors clustered by industry to account for industry-specific and time-varying factors; and replace the industry-fixed effect by firm-fixed effect. This approach addresses concerns that elevated compensation levels might be attributable to evolving industry or product market dynamics. Despite these additional controls, our primary findings remain consistent.

4 Baseline Results

4.1 Descriptive statistics

Table 2 presents the summary statistics and univariate analyses of selected variables in this study. For brevity, we do not report the statistics for the dummy and industry-specific variables in our sample (See Appendix A). All continuous variables are winsorized at the 1st and 99th percentiles. As reported in Panel A of Table 2, the Total Pay is 4.88. By comparison, our statistic for compensation ratio is lower than the U.S sample (5.64) reported by Phung et al. (2023). Overall, the statistics are reasonable for the international sample, which includes lower compensations of firms in some emerging markets. On average, firms in our sample have a positive profitability ratio - ROA (0.01), sales growth (0.05), and stock return (0.04), indicating relatively good performance during the examined period. The average age of CEOs is 44.4 years old, which is relatively lower than the U.S sample of Otto (2014).

- Insert Table 2 about here -

In Panel B, we provide preliminary evidence on the effect of firm-level CCR on each component of executives' compensation. To perform our univariate analyses, we split our sample into High and Low subsamples based on the means of firm-level CCR. Regarding total compensation, we observe that firms with a higher CCR are featured with a lower Total Pay than those with a lower CCR. The mean differences in Total Pay for high and low CCR are all statistically significant at a 1% level, suggesting that high-CCR firms are more likely to increase their compensation than low-CCR firms. Similarly, considering the statistical test-of-difference values for other variables, our results indicate that high-CCR firms, compared to low-CCR firms, will pay (1) comparatively higher Cash pay and Salary and (2) less Stock pay and Stock option grants. Overall, our preliminary results suggest that firms with high CCR have considerably different firm characteristics compared to low-CCR firms, especially the heterogeneous impacts of CCR on each type of compensation.

We also provide several graphical statistics for the firm-level CCR. Figure 1 exhibits the average time-series trend in average CCR for all firms in our sample, and the sub-sample excluded the Chinese, Austrian, and Spanish firms – the top three countries with the highest CCR (See Appendix B). As expected, the whole sample exhibits higher CCR than the sub-sample. The trend implies a significant surge in interest in climate change risk from 2001 to 2010 before experiencing a trivial decline from 2011 to 2016. This downward period can be explained by the unsuccessfulness of the Doha Climate Summit in 2012. Following the 2015 Paris Agreement, the CCR started soaring again to a new height in 2017 before reaching the top in 2021. The data for the three components of CCR are also graphically reported in Figure 1. Further, we provide the graphical data for the country-level CCR in Figure 2. The statistics indicate significant heterogeneity in CCR across countries, varying from 0.04 to 0.21.

- Insert Figure 1 & 2 about here -

4.2 Baseline results: Climate risk and compensation

Initially, we explore whether the firm-level climate risk (CCR) motivates the compensations for top executives. The baseline results for the impacts of CCR and total compensation (Column (1) and five components of compensation (Column (2) to (6) are reported in Table 3. Overall, the CCR coefficients are positively significant in columns (1) to (3), where the dependent variables are Total Pay, Cash pay, and Salary. With all fixed effects in the models, the coefficient (0.217, $p-value < 0.05$) on Total Pay suggests that firms with higher CCR pay relatively more to their top executives. The magnitude of this relation is economically meaningful across all models. In other words, a one-standard-deviation of CCR (0.16) increase in CCR is accompanied by a rise of 3.53% ($e^{(0.16\times0.217)}-1$) in total compensation[7]. Regarding the Cash pay and Salary, we also obtain positive and statistically significant coefficients on CCR, implying that managers of firms exposed to high climate risk can earn higher short-term compensation.

[7] Undisclosed results indicate that within our sample, where the average total compensation stands at \$6.335 million, a slight increase of 3.53% in CCR corresponds to an annual rise of about \$223,625 in total compensation.

Regarding the economic magnitude, coefficients on Cash pay and Salary are significantly higher than those of Total Pay are 0.320 ($p - value < 0.01$) and 0.229 ($p - value < 0.01$), respectively. In other words, Cash pay, and Salary are the main drivers of the higher total compensation in a short time. In Columns (4), we do not find a significant relation between CCR and bonuses. In contrast, our results suggest the significant and negative association between CCR and two equity-based proxies reported in Columns (5) and (6). The estimated coefficients on CCR are -0.188 and -0.252 and are statistically significant at the 1% confidence level.

Collectively, our results presented in Table 3 offer significant understanding into the compensation preferences of senior executives in firms facing high climate risk. The regression analysis reveals a strong and positive correlation between climate change exposure and the total remuneration of top executives. Therefore, these findings conclusively validate Hypothesis 1, suggesting that executives in high-climate-risk companies are compensated more generously than those in low-climate-risk conditions. Notably, top-executives are more inclined towards higher cash-based compensation, primarily driven by increased salary and cash payments. Conversely, their compensation in stocks and stock option grants tends to be lower. As such, these findings corroborate Hypothesis 2, suggesting that top executives favor a higher proportion of short-term cash compensation as a strategic response to mitigate the long-term impact of climate risks. Overall, our results contradict the findings for the U.S firms of Hossain et al. (2022) which confirm the impacts of firm-level CCR on equity-based compensation of CEOs. On the other hand, this is consistent with Banerjee et al. (2022) that that CEOs and non-CEO executives require greater higher fixed compensation (cash and salary), when their firms expose to more environmental issues. Further, it is essential to emphasize that our research provides a unique vantage point by examining top executives' compensation across an international sample. From this diverse perspective, we confidently assert the validity and resilience of our results, which are fortified by a comprehensive examination of underlying mechanisms and a battery of rigorous robustness analyses.

- Insert Table 3 about here -

Regarding the control variables, the estimated coefficient on Firm size is significantly positive, aligning with established research indicating a substantial dependency of management compensation on firm size (Gabaix and Landier, 2008). In line with previous studies supporting the positive associations between corporate performance and managerial compensation, the coefficients on Profitability, Sales growth, and Stock return are all positive and highly significant, indicating that higher compensations are paid when firms become more profitable (Dai et al., 2020; Hoi et al., 2019; Peters and Wagner, 2014). The results of other control variables are also corresponding to those in the findings documented in prior literature. With the significant coefficients of the Financial Crisis, we find that firms reduce their pay ratio when facing the economic downturn.

4.3 Robustness checks: Alternative models and model specifications

- Insert Table 4 about here -

In Table 4, we report the estimation results of the baseline model using alternative model specifications. Across all test specifications, the estimated coefficients of CCR are all significantly positive at 1% and 5% levels, upholding a positive relationship between climate risk and top executives' compensation. We perform a battery of sensitivity tests to verify the reliability of the baseline finding. We use the random sampling method with a replacement of 100,000 replications to calculate the bootstrapping standard error. Bootstrap is a computational resampling technique that mimics random sampling from an assumed infinite population. This method allows us to see whether our baseline results still hold if we use a sample closer to the population. Next, to further alleviate the concern of heteroskedasticity and serial correlation arising from our model specification, Newey-West, and Prais-Winsten estimators are conducted as shown in Columns 2 and 3, respectively. Moreover, as climate risk exerts its impact on some groups of firms in the economy simultaneously due to geographical factors, there might exist a certain degree of cross-sectional dependency in the data. To account for this potential issue, we employ the Driscoll-Kraay estimator. Driscoll-Kraay standard errors are robust to general forms of cross-sectional and temporal dependence. The Driscoll-Kraay estimation is reported in Column 4. The robustness tests' results are generally consistent with the full baseline results, that is, the positive impact of climate risk and compensation for top executives, with only slight changes in the magnitude of the impact. Further, to address the concern that the main results could be driven by countries with a larger sample size caused by the deviation of country-level sample size. We further utilize the Weighted Least Square (WLS) approach to reduce the bias towards countries with more observations Han et al. (2010). We report the WLS results and sub-sample results by excluding the U.S firms in Appendix C1. Overall, our baseline results remain unchanged.

4.4 Robustness checks: Endogeneity concerns

In this section, we rigorously tackle potential endogeneity concerns within the climate change exposure-compensation relationship to establish a causal connection. These endogeneity concerns encompass unobservable factors omitted from our regression models, which could simultaneously influence firm-level climate risk and top executives' compensation. Besides, there is a potential concern that managers might either overstate or understate their firm's true vulnerability to climate change in earnings conference calls. First, the system-GMM is a statistical method widely used to tackle the endogeneity issue of reverse causality in quantitative studies. Leszczensky and Wolbring (2022) emphasize that the system-GMM method produces efficient estimates by employing a wide range of instruments to estimate a set of equations, using both preceding level and first differences of lagged dependent variables Arellano and Bover (1995); Blundell and Bond (1998). We employ a two-step system GMM estimator to re-estimate the model. The estimates are reported in Panel A, Table 6. The coefficient of CCR remains significantly positive, which aligns with our previous results. The outcome of the specification tests (e.g., AR tests, Hansen test of overidentification restrictions) accentuates the validity of our system-GMM estimates, thus confirming our baseline finding.

- Insert Table 5 about here -

Moreover, to tackle potential endogeneity issues in our regression models, we adopt the instrumental variable (IV) approach as a robust method. Drawing on previous research that identified geographic location as a respectable IV for climate risk proxied by carbon risk (Safiullah et al., 2021) and Corporate Social Responsibility (CSR) (Jiraporn et al., 2014), we use the one-year lagged value of a country's average carbon risk. We implement this in a two-stage least squares (2SLS) estimation. The outcomes of this analysis are detailed in Panel B, Table 5. Notably, our results maintain their consistency, even when accounting for possible endogeneity, which highlights the reliability of our findings. Additionally, the results in Table C3 confirm that our model does not exhibit any bias due to omitted variables. We further utilize the 2SLS with the alternative IV in Appendix C2. Following the approach of Huang et al. (2018) and Ding et al. (2021), we adopt the country-level population density (people per square kilometer) as an IV as this factor is significantly correlation with damage from climate risk (i.e., natural disasters) but uncorrelated with the compensations for firms' managers. Overall, the second-stage coefficients are all statistically significant with the predicted signs. Thus, our baseline results are quantitatively unaffected after controlling for potential endogeneity issues.

- Insert Table 6 about here -

5 Additional analyses

5.1 Decomposition analyses

- Insert Table 7 about here -

We further consider the impacts of three distinct components of CCR on compensations in Table 7. The estimated coefficients for CCOR, CCRR, and CCPR remain positive and statistically significant at the 1%, 5%, and 10% levels, respectively. Overall, the impacts of CCR are primarily driven by climate change opportunities and regulatory risk. Given the attention of climate change, higher CCR means that firms experience both inherent expenses (reducing reputation and competitive advantage) and explicit expenses (increased compliance costs, operational or interest expenses) (Kabir et al., 2021; Zhou et al., 2021). As such, firms are more likely to suffer from profitability uncertainties and default on financial obligations. Further, based on the stakeholder theory, top managers would require higher compensations for trading off the increasing levels of risk exposed (Brockman et al., 2015; Cadez et al., 2019).

5.2 Channel analyses

5.2.1 Motivations for firm eco-innovations

In prior sections, we have empirically confirmed the nexus between compensations for top executives and climate risk. In this section, we consider the first channel of firms' eco-innovation engagement, which can be clarified by the following motives. First, prior studies confirm that eco-innovations are essential for firms to reduce the climate change risk (Biggerstaff et al., 2019; Hossain et al., 2022). Given the increasing pressure from various stakeholders (e.g., regulators, policymakers, responsible shareholders, and communities), firms need to engage in innovative and environmental-friendly strategies to reduce their exposure to climate risks by pushing the top management to act and activate their strategic plans (Choi and Luo, 2021; Phung et al., 2023). Second, investments in eco-innovations are relatively less profitable, more costly, and riskier than other types of innovation and sometimes reduce the firms' investment efficiency (Triguero et al., 2013). As such, from the managers' perspective, their risk aversion and preferences for short-term incentives can induce value protection and misaligning benefits (Arena et al., 2018; Haque and Ntim, 2020). Hence, we resist incentive alignment and stakeholder theory to elucidate the nexus between econ-innovation and climate risk-compensation nexus, particularly when we consider that high-CCR firms are facing pressure from a wide range of stakeholders beyond shareholders (Edmans, 2012; Tsang et al., 2021).

To test this conjecture, we utilize two approaches of sub-sample of innovation-compensation correlation and regression models. First, we compute the firm-level correlations between compensation and eco-innovation. The firm-level eco-innovation is measured by the Refinitiv ESG innovation score, which reflects the firms' capacity to alleviate environmental obligations and accompanying expenses by utilizing new eco-friendly technologies, processes, environment-oriented products, and services (Phung et al., 2023; Zaman et al., 2021). We then divide all firms into two sub-groups according to the correlations between compensation in prior periods and eco-innovation. We re-estimate the baseline regression for two sub-groups and report the results in Panels A and B of Table 8. Compared to our baseline results, we only find the consistently significant coefficients on CCR for a group of firms with greater connection between compensation and eco-innovation for Total pay, Salary, and Cash Pay. For other types of compensation, this channel cannot be explained due to insignificant differences between the two groups. Remarkably, the magnitudes of CCR coefficients for a high-correlation group are significantly higher than those of a low-correlation group, which is also signified by the results of Chi-square tests. In the next step, we employ the following regression model to further test the first channel.

$$\begin{aligned} INN_{i,j,c,t} = \alpha_0 + \beta_1 CCR_{i,j,c,t-1} + \beta_2 (CCR_{i,j,c,t-1} \times PAY_{i,j,c,t-1}) + \beta_3 PAY_{i,j,c,t-1} \\ + \sum \delta_k \text{FirmControls}_{i,j,c,t} + \sum \gamma_k \text{CountryControls}_{i,j,c,t} + \varepsilon_{i,j,c,t} \end{aligned} \quad (2)$$

In this model, the dependent variable is firm-level eco-innovation (INN), and other variables are in line with the baseline regression. Our main interest is the coefficients of the interaction terms between compensation and CCR ($CCR_{i,j,c,t-1} \times PAY_{i,j,c,t-1}$), which can further confirm our channel analysis. Consistent with our previous tests, we obtain all consistently positive and significant coefficients for Total pay, Salary, and Cash Pay, and insignificant results for other types of compensation in Panel C of Table 8. In other words, firms' eco-innovation increases with higher traditional and direct rewards (cash and salary) given CCR, which is the driver for executives to implement CCR-mitigation strategies. Overall, we can confirm the first channel for firms to directly compensate more managers, in terms of cash and salary payments if they can take the necessary initiatives to reduce firm-level CCR.

- Insert Table 8 about here -

5.2.2 The channel of managerial bargaining power

With the links between compensation and firm-level climate risk, we continue to dissect another potential channel of managerial bargaining power for this relationship. Existing literature offers valuable insights into potential mechanisms driving a pay increase, such as the top executives' bargaining power (Gabaix and Landier, 2008; Rajgopal et al., 2006; Song and Wan, 2019). According to the managerial power hypothesis, in settings with weak corporate governance, top executives possess greater leverage to negotiate compensation packages that might be deemed inefficiently high (Bebchuk and Fried, 2004; Walls and Berrone, 2017). Conversely, another perspective, posited by Murphy and Zabojnik (2004) and Gabaix and Landier (2008), is that the increase in top executives' compensation is primarily a reaction to heightened demand for skilled and talented managerial leadership. In this study, we therefore test whether more powerful managers who have higher bargaining power can get higher total and direct compensation (cash and salary) when their firms experience higher exposure to climate risks. In other words, powerful executives will use their bargaining supremacy to enhance their payments to trade off for the uncontrollable risk of higher-CCR firms. Following prior literature, we consider two factors of high bargaining power, including managerial power and firms with poor governance. We utilize the two indicators of managerial power, including Senior executives' age (Lewis and Bajari, 2014) and Board tenure (Chen et al., 2019)[8]. Regarding the corporate governance measures, we utilize two indicators of Institutional ownership and Analyst following. Institutional investors play an effective role in mitigating agency problems associated with benefits paid to the top executives Hartzell and Starks (2003). Building upon this notion, Chen et al. (2015) conjecture that professional analysts serve as a crucial external monitoring mechanism, pointing out that compensation tends to rise notably following exogenous decreases in analyst coverage.

First, we split the sample into high versus low sub-groups using the median values of the managerial bargaining power indicators. Then, we create binary variables for each proxy, which takes the value of one for sub-groups with low Institutional Ownership, low Analyst Following, High Senior executives' age, or High Board tenure and zero otherwise. A firm is categorized as having weak corporate governance if their implied variables equal one. We then replicate the baseline model by including the interaction terms between CCR and each of the managerial bargaining power variables indicators, and the results are reported in Table 9.

- Insert Table 9 about here -

In Table 9, we obtain positively (negatively) significant coefficients on interaction terms for Total pay, Salary, and Cash Pay (Stock and Option pay) in most cases of the managerial bargaining power measures, which are consistent with our expectations. For example, the coefficients of$CCR\times$ Analyst following are positive (negatively) significant for Cash Pay (Option Pay), indicating that managers of firms with weak external monitoring can pay higher direct and short-term compensation premiums instead of scheduled or indirect payments when their firms experience higher CCR. Hence, it is reasonable to conclude that the pay premium in compensation increases with firms' climate risk, especially short-term and direct payments, for managers with higher bargaining power.

[8]Senior executives' age (Tenure) is the average number of age (years on board) for each board member.

5.2.3 Firm performance and climate risk-compensation nexus.

Prior studies confirm positive correlations between top-management compensation packages and financial performance and the value of the firms (Brick et al., 2006; Buck et al., 2008; Ozkan, 2011). In this study, we predict that compensation rewards for higher climate risk are driven by firm performance and valuation due to a sizable association between compensation and performance. In other words, firms with higher climate risk insist on higher short-term compensation (salary and cash) rather than equity-based or option payments due to lower future pay in the context of unfavorable performance and valuation Berk et al. (2010)[9]. Similar to our previous analysis in Section 5.2.1, we employ two approaches of sub-sample of performance-compensation correlation and regression models. First, we compute the firm-level correlations between compensation and performance. We utilize two indicators of firm future performance, including Tobin's Q and Return on Assets (ROA). We then divide all firms into two sub-groups according to the correlations between compensation and Tobin's Q and Return on Assets (ROA). We re-estimate the baseline regression for two sub-groups and report the results in Panels A and B of Table 10 for Tobin's Q and Table 11 for ROA. For both indicators, we find the consistently significant coefficients on CCR for a group of firms with greater connection between compensation and performance for all compensation measures (except Bonus). As expected, the levels of CCR coefficients for a high-link group are notably higher than those of a low-link group, which is also signified by the results of Chi-square tests. Next, we utilize the regression approach to further examine this channel as follows.

$$\begin{aligned} PER_{i,j,c,t} = \alpha_0 + \beta_1 CCR_{i,j,c,t} + \beta_2 (CCR_{i,j,c,t} \times PAY_{i,j,c,t}) + \beta_3 PAY_{i,j,c,t} \\ + \sum \delta_k \text{FirmControls}_{i,j,c,t} + \sum \gamma_k \text{CountryControls}_{i,j,c,t} + \varepsilon_{i,j,c,t} \end{aligned} \quad (3)$$

In this model, the dependent variable is firm performance (PER) proxied by *Tobin's Q* and ROA, and other variables are in line with the baseline regression[10]. Our main interest

[9] Mehran (1995) argues that firm performance is positively associated with the proportion of equity held by executives and the percentage of equity-based compensation to total compensation.

[10] In unreported results, we also consider two alternative indicators of firm performance, industry-adjusted Tobin's Q and ROA, for two approaches. Overall, our results are qualitatively similar.

is the coefficients of the interaction terms between compensation and CCR ($CCR_{i,j,c,t} \times PAY_{i,j,c,t}$), which can further confirm our channel analysis. The results are reported in Panel C of Table 10 for Tobin's Q and Table 11 for ROA.

Consistent with the sub-sample analyses, we obtain all consistently positive and significant coefficients for all compensation measures (except for Bonus). In addition, the negative coefficients on CCR indicate that climate risk exerts hostile impacts on corporate performance; therefore, climate risk can alter compensation if the financial performance drives large slices of their rewards. Hence, profitability and valuation increase with higher traditional and short-term compensations such as salary or cash when firms experience a reduction in profitability due to higher climate risk. On the other hand, there are significant reductions in long-term compensation, such as equity-based or option rewards, given to higher firms' CCR. Overall, firm performance can rationalize the variations in top executives' compensation for climate risk.

- Insert Table 10 and 11 about here -

5.3 Additional analyses: Cross-sectional differences

5.3.1 Firm-level heterogeneity

This section embarks on several sub-sample analyses, an essential step to reinforce the established positive relationship between climate risk and compensation. We subdivide the primary sample into distinct sub-samples, focusing on firms that are potentially more vulnerable to the impacts of climate change. To test if the compensation premium for climate risk persists, we hypothesize that this effect will be more pronounced in firms with: (1) high financial constraint (higher KZ index)[11]; (2) high international exposure[12]; and (3) high social responsibility. Firms are classified as high social responsibility if they have a CSR sustainability committee (CSR), which exhibits more significant sustainable and greener policies (Phung et al., 2023). We then create dummy variables for each indicator

[11] Following Baker et al. (2003), the KZ Index is computed as 1.002 × Cashflow - 39.368 × Dividends - 1.315 × Cash + 3.139 × Leverage.

[12] To categorize firms into sub-samples based on their countries of operation, we draw upon the dataset compiled by Dyreng and Lindsey (2009).

equal to one for high Financial Constraints, International Exposure, and CSR. We then re-estimate results using the baseline model and report in Table 12. In Panel A, the coefficients of the interaction terms are statistically insignificant across all compensation measures, which indicates that financial constraints do not modify the CCR-compensation nexus. Regarding the International exposure in Panel B, we find significant results for all compensation measures (except Bonus) – higher (lower) for short-term (long-term) payments. It can be explained that firms with geographically diversified businesses are vulnerable to climate risk due to universal climate-related disruptions to their operations (Ai and Gao, 2023). In Panel C, we find that the CSR committee enhances the positive impacts of total and short-term compensations; however, the modified impacts are invisible for other types. As such, our results are consistent with prior literature that higher CSR initiatives encourage the executives' risk-taking motivations, which induces higher compensations for them (Armstrong and Vashishtha, 2012; Coles et al., 2014; Phung et al., 2023).

- Insert Table 12 about here -

5.3.2 Country-level industry-level heterogeneity

- Insert Table 13 about here -

In our subsequent cross-sectional analysis, we consider the heterogeneity at both the industry and country levels. For the industry aspect, we differentiate between high and low CCR groups. This classification is based on the rankings provided by Sautner et al. (2023), allowing us to create sub-samples of firms operating in industries with high and low climate exposure[13]. For the level of pollution, high-polluting industries are identified by using approaches the Ilhan et al. (2021) (2-digit SIC of 13, 26, 29, 30, 32, 33, 44, 45, 49,

[13] Sautner et al. (2023) posit that the top ten industries that have higher exposure to the climate change risk are *Construction, Electronic & Other Electric Equipment Electric, Gas and Sanitary Services, Except Building, Heavy Construction, Coal Mining, Fabricated Metal Products, Industrial Machinery and equipment, Petroleum Refining, Transportation Equipment, and Engineering & Management Services. The bottom ten climate exposure industries include Miscellaneous, Leather and Leather Products, Tobacco Products, Educational Services, Depository Institutions, Home Furniture, Eating and Drinking Places, Printing and publishing, Motion Pictures, and Apparel and Accessory Stores.*

or 54). We then create dummy variables for the high group and then re-estimate results using the baseline model, which is reported in Panels A and B of Table 13. Overall, we find that climate change's effect on compensation is more visible for more high-polluting and CCR industries.

At the national level, we consider two indicators of corruption and shareholder protection levels. In Panel C, we utilize the country-level *Control of Corruption*[14] to create the dummy of one for the low score group and zero otherwise, using the sample median. Prior studies confirm that managers in countries with a higher level of corruption can obtain higher compensation due to the check-and-balance mechanism[15](Hossain et al., 2021; Smith, 2016). Remarkably, the estimated coefficients are positively (negatively) significant for short-term (long-term) payments. As such, our results indicate that the CCR-compensation nexus is strengthened when executives gain more power in nations with a higher level of corruption. In the final cross-sectional analysis, we consider the national levels of protection for minority shareholders against directors by employing the Antidirector Rights Index (ARI) by Spamann (2010)[16]. We then create a dummy variable equal to one for high ARI using the sample median and zero otherwise. As reported in Panel D of Table 13, we obtain negatively (positively) significant coefficients for short-term (long-term) compensations. Hence, we can argue that the CCR-pay nexus is indeed weaker in firms located in countries with better minority shareholder protection.

[14] *Control of Corruption* captures perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, which is obtained from the Worldwide Governance Indicators database.

[15] Specifically, checks are mechanisms that limit or stop one person or arm of government from becoming too powerful and able to exceed their specific powers.

[16] The "Antidirector Rights Index" has been utilized as a degree of shareholder protection introduced by La Porta et al. (1998) and then revised by Spamann (2010) This index combines such components of shareholder rights and the accessibility of legal procedures for protecting minority shareholders from expropriation by executives.

5.4 Quasi-natural experiments: Differences-in-differences analyses with climate treaties

To further address endogeneity and provide more inclusive analyses, we employ three major climate treaties as exogenous shocks to a firm's climate risk situation to determine a causal link between CCR and executives' compensation. In this study, we consider three major climate policy events, including EPA Emission Legislation in 2007, the Doha Climate Summit in 2012, and the Paris Agreement in 2015, to conduct the quasi-natural experiments using difference-in-differences (DID) analysis. We create a dummy for post-period of those events, that Post denotes the value of one if the observed year is in two years after the event year period and zero otherwise. For instance, the variable of Post EPA 2007 is equal to one if the observations are from 2008 and 2009, and zero otherwise. We then simultaneously include this dummy and the interaction term $CCR_{i,j,c,t} \times \text{Post}$ in our main model and re-estimate the results as in the following model.

$$\begin{aligned} PAY_{i,j,c,t} = \alpha_0 + \beta_1 CCR_{i,j,c,t} + \beta_2 CCR_{i,j,c,t} \times (1 - \text{Post}) + \beta_3 (CCR_{i,j,c,t} \times \text{Post}) \\ + \beta_4 \text{Post} + \sum \delta_k \text{FirmControls}_{i,j,c,t} + \sum \gamma_k \text{CountryControls}_{i,j,c,t} + \varepsilon_{i,j,c,t} \end{aligned} \quad (4)$$

Table 4 presents the results by considering the exogenous shocks from major climate policy events that consider the association between climate risk and top executives' compensation. Our results indicate that the different impacts of CCR intensified during the period post-three examined climate events. This finding is consistent with the proposition that more vulnerable firms are more sensitive to climate risk with the rising climate awareness, which requires higher compensations for their managers. Therefore, our findings are free of potential endogeneity issues and persist when valid through exogenous shocks.

- Insert Table 14 about here -

6 Conclusion

This study is a pioneering contribution, shedding new light on the intricate relationship between climate change and top executives' compensation. Building upon prior research investigating the impact of risk on executive pay packages, our investigation ventures into uncharted territory by positing that top executives in firms confronted with elevated climate change risk command a higher total compensation. Drawing on an extensive dataset spanning international firms across 35 countries over two decades (2001 to 2021), we uncover compelling evidence by establishing a 'climate risk premium' within executive compensation. This premium underscores a marked preference for cash-based compensation over equity-based incentives, aligning with the risk-driven-reward hypothesis.

The link between climate risk and compensation is dissected through the lens of three key channels: eco-innovation, managerial bargaining power, and firms' future performance. Notably, our findings reveal that the influence of climate risk on compensation is most pronounced for firms grappling with financial constraints, extensive international exposure, and a solid commitment to social responsibility. Moreover, we uncover that the effects of climate change risk extend to companies operating in heavily polluting industries and countries plagued by high corruption levels and ineffective minority shareholder protection. To warrant the robustness of our results, we rigorously address the endogeneity problem through a battery of robustness tests and sensitivity analyses. In conclusion, this study's empirical findings not only enhance our understanding of the multifaceted determinants shaping top executives' compensation but also constitute a pivotal and timely addition to the ongoing dialogue concerning the profound implications of climate change across individuals, the broader macroeconomic landscape, and the corporate sphere.

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APPENDIX

Appendix A. List of sample countries and observations

This table presents the years, number of firms, and number of firm-year observations for each country in the sample. The sample consists of 64,601 firm-year observations from 9,871 unique firms across 35 countries from 2001 to 2021.

Countries	No. of Years	No. of Firms	No. of Obs.
Argentina	20	19	112
Australia	21	280	1,356
Austria	19	27	266
Belgium	21	44	412
Bermuda	20	33	255
Brazil	21	161	1,355
Canada	21	749	5,264
Chile	19	18	186
China	20	319	964
Denmark	21	56	512
Finland	21	75	733
France	20	131	1,486
Germany	21	209	1,344
Greece	19	29	188
India	20	243	1,155
Indonesia	18	17	102
Ireland	21	71	659
Israel	21	105	543
Italy	20	75	613
Japan	21	205	1,249
Luxembourg	20	38	212
Mexico	21	95	684
Netherlands	20	89	811
New Zealand	16	42	205
Norway	21	86	472
Portugal	20	9	115
Russian Federation	20	34	212
Singapore	21	33	354
South Africa	20	74	572
Spain	20	43	359
Sweden	21	215	1,566
Switzerland	21	146	1,454
Thailand	16	34	146
United Kingdom	21	435	3,910
United States	21	5,642	34,775
Mean	19.94	282	1,846
Total		9,871	64,601

Appendix B. Climate Change Risk (CCR) data

Countries	CCR (Mean)
Argentina	0.13
Australia	0.09
Austria	0.18
Belgium	0.13
Bermuda	0.11
Brazil	0.14
Canada	0.10
Chile	0.16
China	0.19
Denmark	0.07
Finland	0.12
France	0.10
Germany	0.12
Greece	0.08
India	0.12
Indonesia	0.11
Ireland	0.06
Israel	0.04
Italy	0.09
Japan	0.10
Luxembourg	0.11
Mexico	0.09
Netherlands	0.08
New Zealand	0.07
Norway	0.15
Portugal	0.09
Russian Federation	0.12
Singapore	0.11
South Africa	0.11
Spain	0.21
Sweden	0.10
Switzerland	0.09
Thailand	0.11
United Kingdom	0.11
United States	0.08
Mean	0.11

Appendix C

Table C1. Observation bias: Weighted Least Square (WLS) and Excluded US firms.

Panel A: Weighted Least Square (WLS)						
Dependent variable	Total Pay	Cash pay	Salary	Bonus	Stock pay	Option pay
Variables	(1)	(2)	(3)	(4)	(5)	(6)
CCE	0.312***	0.420***	0.229**	0.085	-0.275***	-0.355***
	(0.004)	(0.001)	(0.006)	(0.035)	(0.004)	(0.004)
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	No
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observation	64,601	64,601	64,601	64,601	64,601	64,601
Adjusted R-squared	0.465	0.654	0.544	0.365	0.397	0.541
Panel B: Excluded US Firms						
Dependent variable	Total Pay	Cash pay	Salary	Bonus	Stock pay	Option pay
Variables	(1)	(2)	(3)	(4)	(5)	(6)
CCE	0.214***	0.287***	0.184**	0.033	-0.153**	-0.201***
	(0.014)	(0.011)	(0.016)	(0.029)	(0.017)	(0.015)
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	No
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observation	28,826	28,826	28,826	28,826	28,826	28,826
Adjusted R-squared	0.397	0.475	0.346	0.325	0.389	0.364

Table C2. 2SLS with the alternative IV – Population Density

Following the approach of Huang et al., (2018) and Ding et al. (2021), we adopt the country-level population density (people per square kilometer) as an IV as this factor are significantly correlation with damage from climate risk (i.e., natural disasters). The approach and model are similar to those in Section 4.4 – Table 5.

2SLS instrumental variables (IV) regressions - Second stage						
Variables	Total Pay	Cash pay	Salary	Bonus	Stock pay	Option pay
	(1)	(2)	(3)	(4)	(5)	(6)
CCR	0.211***	0.198***	0.238*	0.036	-0.207**	-0.165**
	(0.009)	(0.010)	(0.009)	(0.033)	(0.010)	(0.015)
Kleibergen & Paap Unid. (p-value)	0.002	0.004	0.006	0.002	0.004	0.002
Hansen J Overid. (p-value)	0.000	0.000	0.000	0.000	0.000	0.000
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observation	64,601	64,601	64,601	64,601	64,601	64,601
Adjusted R-squared	0.367	0.336	0.320	0.281	0.307	0.295

Table C3. Omitted variable bias – Oster (2019)

To address the concern of omitted variables in our models, we initiate a statistical test proposed by Oster (2019). The author uses the belief that the strength of coefficients associated with R^2 from regressions with and without controls can be utilized to create an identifiable set. We use the Mian and Sufi (2014) assumptions of Oster (2019) to construct the lower and upper bounds of the identified set, using $\delta = 1$ and $R_{\max} = \min(2.2\tilde{R}, 1)$ and the extreme bounds from Oster's study, i.e., $\delta = 1$ and $R_{\mathrm{MAX}} = 1$.

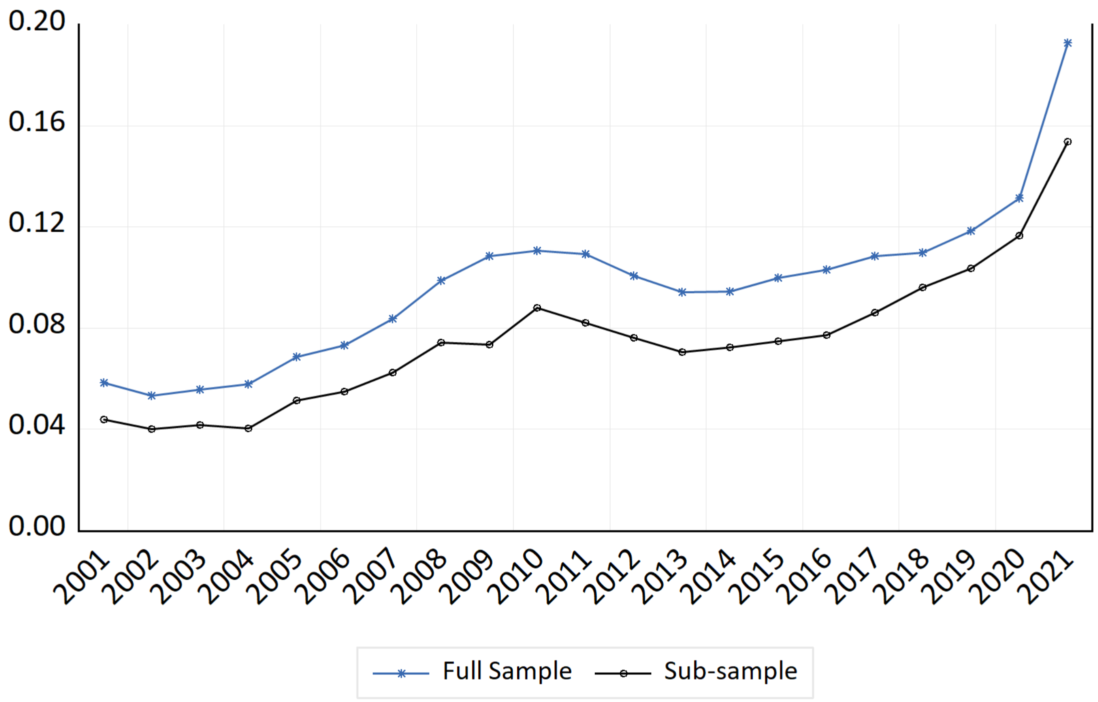
Oster Condition	**Dependent Variables**	**Variable of interest**	**Lower Bound**	**Upper Bound**	**Includes Zero?**
Assume t=1; $\mathrm{R}_{\max} = \min(2.2\tilde{R}, 1)$	Total Pay	CCR	0.0282	0.0620	No
Assume t=1; $\mathrm{R}_{\max} = \min(2.2\tilde{R}, 1)$	Cash pay	CCR	0.0443	0.0895	No
Assume t=1; $\mathrm{R}_{\max} = \min(2.2\tilde{R}, 1)$	Salary	CCR	0.0373	0.0807	No
Assume t=1; $\mathrm{R}_{\max} = \min(2.2\tilde{R}, 1)$	Bonus	CCR	0.0408	0.0784	No
Assume t=1; $\mathrm{R}_{\max} = \min(2.2\tilde{R}, 1)$	Stock pay	CCR	0.0403	0.0885	No
Assume t=1; $\mathrm{R}_{\max} = \min(2.2\tilde{R}, 1)$	Option pay	CCR	0.0533	0.1012	No
Assume t=1;$\mathrm{R}_{\mathrm{MAX}} = 1$	Total Pay	CCR	0.0170	0.0424	No
Assume t=1;$\mathrm{R}_{\mathrm{MAX}} = 1$	Cash pay	CCR	0.0214	0.0427	No
Assume t=1;$\mathrm{R}_{\mathrm{MAX}} = 1$	Salary	CCR	0.0168	0.0443	No
Assume t=1;$\mathrm{R}_{\mathrm{MAX}} = 1$	Bonus	CCR	0.0215	0.0412	No
Assume t=1;$\mathrm{R}_{\mathrm{MAX}} = 1$	Stock pay	CCR	0.0159	0.0405	No
Assume t=1;$\mathrm{R}_{\mathrm{MAX}} = 1$	Option pay	CCR	0.0138	0.0377	No

Tables and Figures

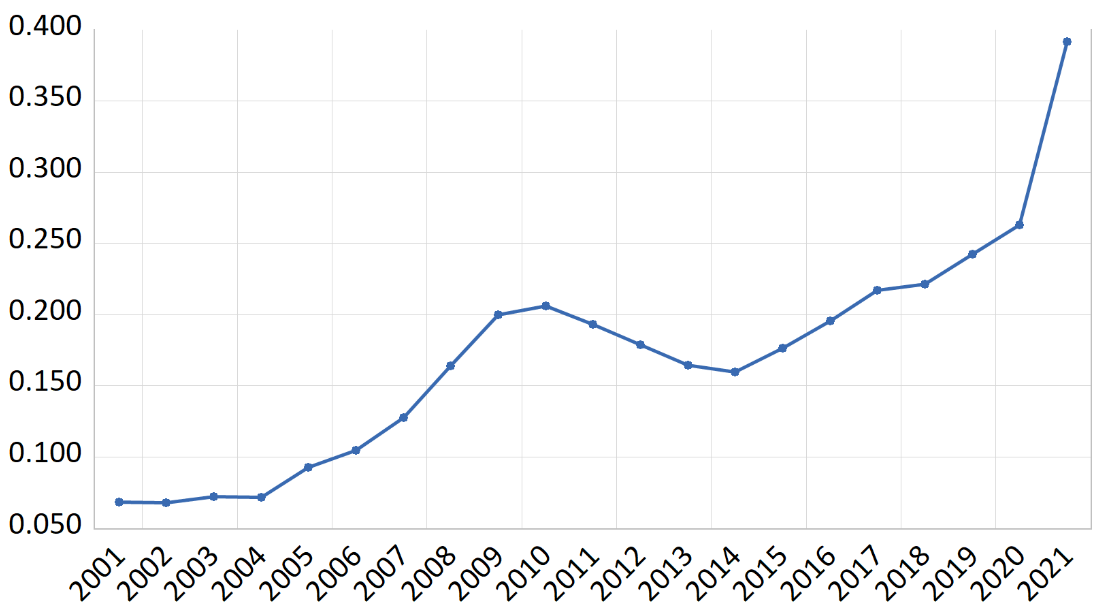
Figure 1. Time-series trend in firm-level climate change risk (CCR)

This figure displays the average time-series trend in firm-level climate change risk for the full sample and sub-sample excluded the Chinese, Austrian, and Spanish firms – top three countries with highest CCR (See Appendix B).

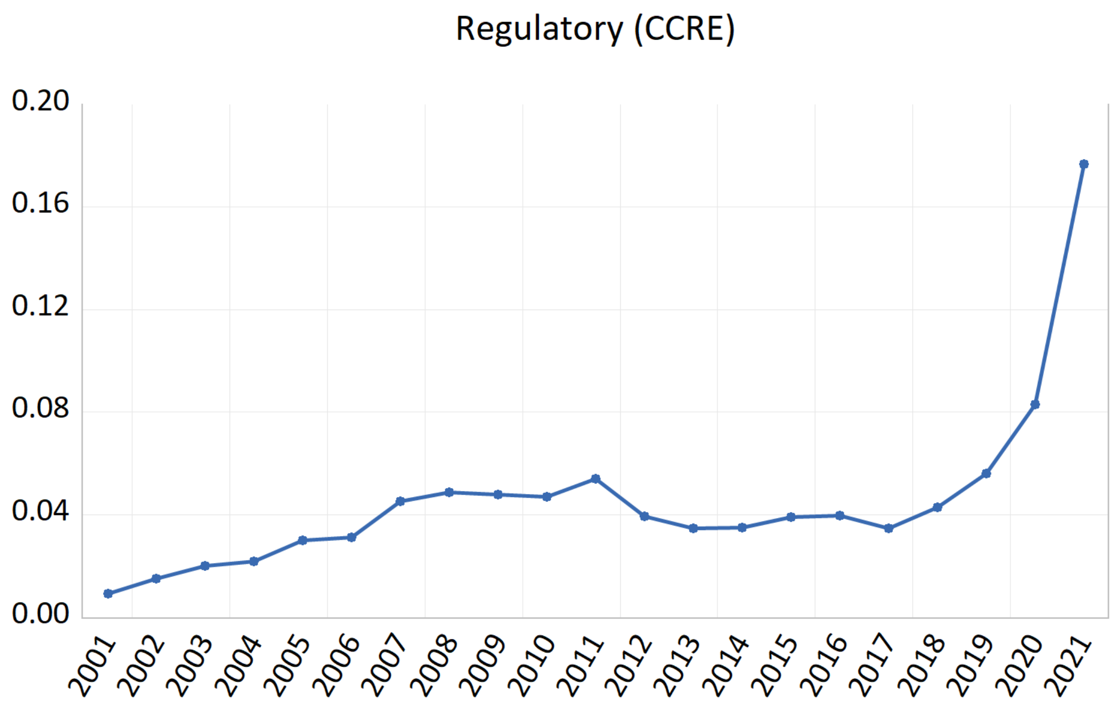
(a) CCR for whole sample and sub-sample (excluded top 3 countries)



(b) Opportunity Risk (CCOR)



(c) Regulatory Risk (CCOR)



(d) Physical Risk (CCOR)

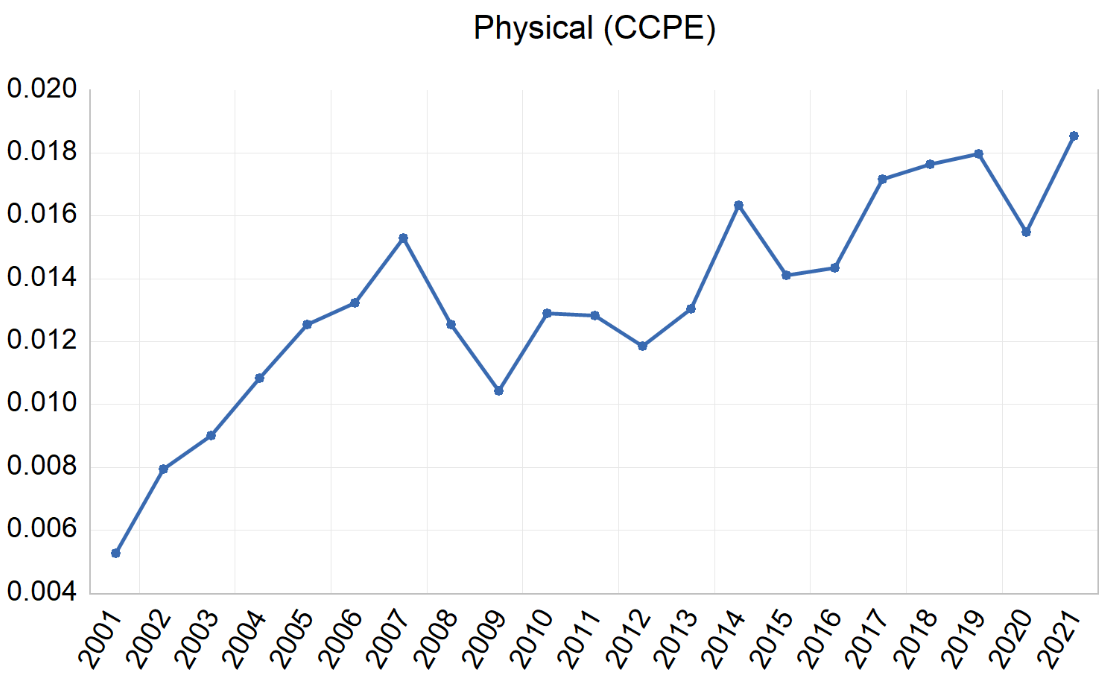


Figure 2. Country-level climate change risk (CCR)

This figure displays the average for country-level climate change risk (See Appendix B).

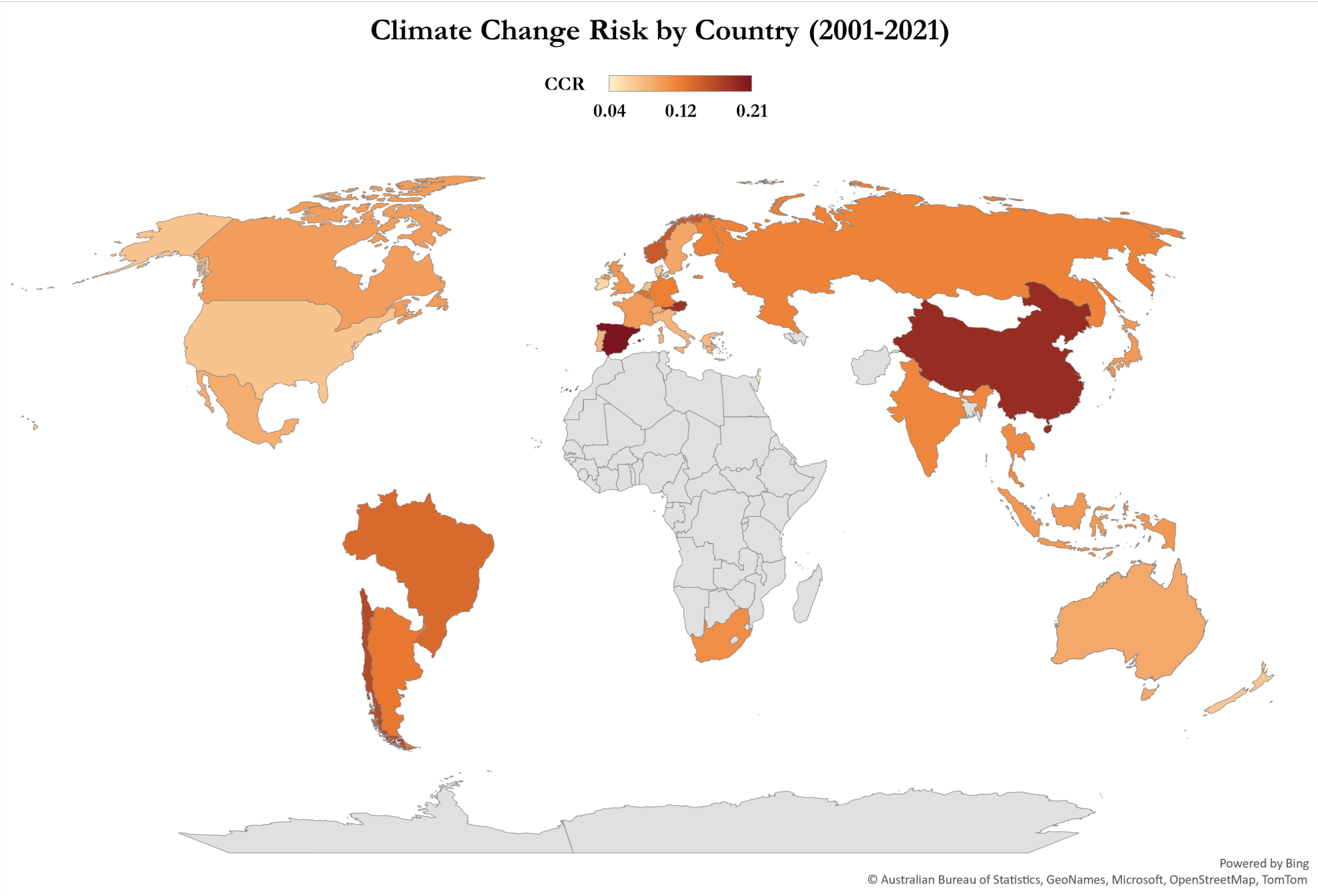


Table 1. Variable definitions

This table describes the definitions of variables used in the analyses with the data sources.

Main Variable	Definition	Source
Top-management compensation		
Total Pay	The total compensation paid to all senior executives scaled by the total assets.	Execucomp and Captial IQ
Decomposition of compensation		
Cash pay	The total cash compensation paid to all top executives scaled by the total assets.	Execucomp and Captial IQ
Salary	The total salary paid to all top executives scaled by the total assets.	
Bonus	The total bonuses paid to all top executives scaled by the total assets.	
Stock pay	The total dollar value of stock grants paid to all top executives scaled by the total assets.	
Option pay	The total dollar value of stock option grants paid to all top executives scaled by the total assets.	
Firm climate risk		
Climate change risk (CCR)	The firm-level climate change risk to climate change extracted from firms' earnings conference calls.	Sautner et al. (2023)
Decomposition of CCR		
Climate change opportunity risk (CCOR)	Relative frequency with bigrams that capture opportunities related to climate change risk occur in the transcripts of earnings conference calls.	Sautner et al. (2023)
Climate change regulatory risk (CCRR)	Relative frequency with which bigrams that capture regulatory shocks related to climate change occur in the transcripts of earnings conference calls	Sautner et al. (2023)
Climate change physical risk (CCPR)	Relative frequency with which bigrams that capture physical risk related to climate change occur in the transcripts of earnings conference calls.	Sautner et al. (2023)
Firm-level controls		
Firm Size	The natural logarithm of total assets.	Compustat Global
Market to Book ratio	The ratio of the market value of the common equity and its balance sheet value of the ordinary equity.	Compustat Global
Leverage	The ratio of total debts to total assets during the financial year.	Compustat Global
Profitability	The ratio of total earnings over total assets during the financial year.	Compustat Global
Cash holdings	The ratio of total cash plus marketable securities during the financial year to lagged total assets.	Compustat Global
Sales growth	The annual growth in total sales revenues during the financial year.	Compustat Global
Stock return	The annualized returns by using buy-and-hold stock monthly return of the financial year.	Refinitiv
Capex	The ratio of capital expenditure over the firm's total assets.	Compustat Global
Corporate governance controls		
Senior executives' age	The average age of the senior executives as of the current financial year	Execucomp and Captial IQ
Institutional ownership	The fraction of shares owned by institutional investors	Refinitiv
Co-opted independence	The fraction of independent directors appointed by the senior executives.	Boardex and Captial IQ
Country-specific controls		
Economic Growth	Country's annual percentage growth rate of GDP at market prices based on constant local currency	WDI
Inflation	Country's annual inflation rate	WDI
Stock market return	Annual changes in national stock market indices	Refinitiv
Financial Crisis	Dummy variable is equal to 1 if financial year is during the Global Financial Crisis (2007 – 2008) and the COVID – 19 pandemic (2020 - 2021)	Authors' calculation

Table 2. Descriptive Statistics

This table displays the summary statistics for the variables used in our analysis. Our sample contains 64,601 firm-year observations from 9,871 firms, spanning from 2001 to 2021. This dataset includes companies with accessible climate change exposure data from Sautner et al. (2023), covering firms across 35 countries. All continuous variables are winsorized at the 1st and 99th percentiles. The descriptions of all variables are reported in Table 1.

Panel A: Descriptive Statistics						
Top-management compensation	**Mean**	**S.D.**	**Min**	**Median**	**Max**	**N**
Total pay	4.88	7.19	0.23	3.24	31.25	64,601
Cash pay	3.72	0.99	0.00	2.88	9.26	64,601
Salary	3.49	0.03	0.13	2.11	7.99	64,601
Bonus	0.89	1.96	0.00	0.82	9.04	64,601
Stock pay	3.53	2.55	0.00	3.88	10.53	64,601
Option pay	1.46	1.65	0.00	1.22	9.89	64,601
Firm-level climate risk						
Climate change risk (CCR)	0.11	0.16	0.00	0.12	0.68	64,601
Climate change opportunity risk (CCOR)	0.37	0.65	0.00	0.22	0.71	64,601
Climate change regulatory risk (CCRR)	0.08	0.12	0.00	0.10	0.43	64,601
Climate change physical risk (CCPR)	0.25	0.22	0.00	0.26	0.68	64,601
Firm-level controls						
Firm Size	6.18	2.42	3.21	6.03	11.60	64,601
Market to Book ratio	1.82	2.38	12.56	1.21	13.10	64,601
Leverage	0.21	0.21	0.00	0.17	0.99	64,601
Profitability	0.01	0.20	1.05	0.05	0.36	64,601
Cash holdings	0.17	0.11	0.00	0.17	0.44	64,601
Sales growth	0.05	0.20	-0.03	0.04	0.14	64,601
Stock return	0.04	0.26	-0.15	0.03	0.73	64,601
Capex	0.08	0.05	0.00	0.07	0.44	64,601
Corporate governance controls						
Senior executives' age	44.42	8.37	38.00	47.66	68.00	64,601
Institutional ownership	0.53	0.27	0.00	0.43	1.00	64,601
Co-opted independence	0.66	0.37	0.12	0.55	0.96	64,601
Country-specific variables						
Economic Growth	0.03	0.03	0.03	-0.09	0.13	64,601
Inflation	0.04	0.05	0.02	-0.05	0.58	64,601
Stock market return	0.07	0.25	0.07	-0.61	1.05	64,601

Panel B. Univariate analyses						
Top-management compensation	**High CCR**		**Low CCR**		**Difference**	
	Mean	N	Mean	N	H-L	t-stat
Total pay	7.23	27,132	3.25	37,469	3.97	7.49***
Cash pay	4.33	27,132	2.38	37,469	1.95	4.01***
Salary	3.83	27,132	2.97	37,469	0.86	1.98*
Bonus	0.99	27,132	0.94	37,469	0.05	0.15
Stock pay	3.12	27,132	3.75	37,469	-0.62	3.24***
Option pay	1.03	27,132	1.58	37,469	-0.55	2.18**

Table 3. Baseline results: Climate risk and top executives' compensation

This table presents the results of regression models that examine the relation between climate change risk and top-executives' compensation. The sample consists of 64,601 firm-year observations from 9,871 unique firms between 2001 and 2021. The top-management compensation is approximated through the ratio of total compensation and its various components to Total Assets. The Climate Change Risk (CCR) variable, which gauges the firm-level risk associated with climate change, is derived from the analysis of word combinations in earnings conference calls, as established by Sautner et al. (2023). We control the country, industry, and year fixed effects in specific specifications from (1) to (6). Standard errors are clustered at the firm level and are presented in parentheses under the associated coefficients. ***, **, and *indicate significance at the 10%, 5% and 1% levels, respectively. The descriptions of all variables are reported in Table 1.

Dependent variable	**Total Pay**	**Cash pay**	**Salary**	**Bonus**	**Stock pay**	**Option pay**
Variables	(1)	(2)	(3)	(4)	(5)	(6)
CCR	**0.217****	**0.320*****	**0.229****	**0.010**	**-0.188****	**-0.252*****
	(0.022)	**(0.012)**	**(0.021)**	**(0.025)**	**(0.010)**	**(0.015)**
Firm Size	0.025***	0.331***	0.329***	0.272***	0.209***	0.189**
	(0.008)	(0.016)	(0.015)	(0.021)	(0.014)	(0.005)
Market to Book	0.010	0.034**	0.023*	0.004	0.010	0.008
	(0.034)	(0.001)	(0.001)	(0.001)	(0.009)	(0.010)
Leverage	0.278	-0.357***	-0.331***	-0.358***	-0.211***	-0.225**
	(0.254)	(0.053)	(0.051)	(0.073)	(0.011)	(0.037)
Profitability	0.209***	0.207***	0.244***	0.261**	0.149**	0.184***
	(0.031)	(0.069)	(0.068)	(0.031)	(0.020)	(0.011)
Cash holdings	0.118**	0.138**	0.119***	0.190***	0.113**	0.096*
	(0.010)	(0.066)	(0.017)	(0.013)	(0.012)	(0.011)
Sales growth	0.112*	0.125***	0.113***	0.195***	0.132**	0.118*
	(0.011)	(0.022)	(0.021)	(0.030)	(0.064)	(0.043)
Stock return	0.071***	0.075***	0.079***	0.086***	0.094***	0.056**
	(0.018)	(0.009)	(0.009)	(0.012)	(0.009)	(0.013)
Capex	0.125**	0.155***	0.126**	0.090*	0.079	0.085*
	(0.015)	(0.009)	(0.015)	(0.021)	(0.028)	(0.022)
Senior executives' age	0.009	0.001	0.001	-0.001	0.011	0.009
	(0.037)	(0.001)	(0.001)	(0.002)	(0.009)	(0.027)
Institutional ownership	0.241***	0.115**	0.122**	0.104***	0.019	0.021**
	(0.031)	(0.047)	(0.045)	(0.031)	(0.012)	(0.010)
Co-opted independence	0.375***	0.133***	0.111*	0.179***	0.245***	0.265***
	(0.008)	(0.031)	(0.039)	(0.033)	(0.009)	(0.006)
Economic Growth	0.111	0.110	0.211*	0.102	0.122*	0.136*
	(0.033)	(0.025)	0.011)	(0.245)	(0.011)	(0.023)
Inflation	0.066*	0.027	0.084*	0.052*	0.009	-0.002
	(0.018)	(0.045)	(0.019)	(0.028)	(0.027)	(0.003)
Stock market return	0.019**	0.021**	0.024**	0.042***	0.055***	0.027**
	(0.009)	(0.008)	(0.009)	(0.008)	(0.009)	(0.009)
Financial Crisis	0.253	0.769	0.181***	0.133**	0.149**	-0.122***
	(0.198)	(0.121)	(0.009)	(0.011)	(0.010)	(0.011)
Constant	0.162***	0.187***	0.432***	0.240***	0.509***	0.251***
	(0.121)	(0.113)	(0.021)	(0.089)	(0.013)	(0.097)
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	No
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Cluster	Firm	Firm	Firm	Firm	Firm	Firm
Observation	64,601	64,601	64,601	64,601	64,601	64,601
Adjusted R-squared	0.411	0.499	0.385	0.301	0.305	0.371

Table 4. Robustness checks: Alternative models and model specifications

This table presents the results of regression models that examine the relation between climate change risk and top-executives' compensation. The sample consists of 64,601 firm-year observations from 9,871 unique firms between 2001 and 2021. The top-management compensation is approximated through the ratio of total compensation and its various components to Total Assets. The Climate Change Risk (CCR) variable, which gauges the firm-level risk associated with climate change, is derived from the analysis of word combinations in earnings conference calls, as established by Sautner et al. (2023). The results from using alternative estimation techniques are reported in Panel A to C. Panel D reports the results with modified specifications regarding fixed effects. Standard errors are clustered at the firm level and are presented in parentheses under the associated coefficients. ***, **, and *indicate significance at the 10%, 5% and 1% levels, respectively. The descriptions of all variables are reported in Table 1.

Panel A: Bootstrap standard errors						
Dependent variable	**Total Pay**	**Cash pay**	**Salary**	**Bonus**	**Stock pay**	**Option pay**
Variables	(1)	(2)	(3)	(4)	(5)	(6)
CCR	0.163***	0.375***	0.073*	0.016	-0.118**	0.253***
	(0.023)	(0.008)	(0.018)	(0.057)	(0.025)	(0.011)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observation	64,601	64,601	64,601	64,601	64,601	64,601
Adjusted R-squared	0.510	0.511	0.477	0.373	0.465	0.460
Panel B: Newey-West estimation						
Dependent variable	**Total Pay**	**Cash pay**	**Salary**	**Bonus**	**Stock pay**	**Option pay**
Variables	(1)	(2)	(3)	(4)	(5)	(6)
CCR	0.169***	0.424***	0.051*	0.021	-0.136***	-0.243***
	(0.022)	(0.023)	(0.093)	(0.013)	(0.011)	(0.007)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observation	64,601	64,601	64,601	64,601	64,601	64,601
Adjusted R-squared	0.522	0.511	0.488	0.382	0.507	0.470
Panel C: Driscoll-Kraay estimation						
Dependent variable	**Total Pay**	**Cash pay**	**Salary**	**Bonus**	**Stock pay**	**Option pay**
Variables	(1)	(2)	(3)	(4)	(5)	(6)
CCR	0.199***	0.435***	0.116**	0.010	-0.192***	-0.352***
	(0.009)	(0.006)	(0.017)	(0.034)	(0.023)	(0.008)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observation	64,601	64,601	64,601	64,601	64,601	64,601
Adjusted R-squared	0.519	0.511	0.485	0.380	0.496	0.468
Panel D: Alternative model specifications						
Dependent variable	**Total Pay**	**Cash pay**	**Salary**	**Bonus**	**Stock pay**	**Option pay**
Variables	(1)	(2)	(3)	(4)	(5)	(6)
CCR	0.189***	0.485***	0.185**	0.069	-0.266***	-0.429***
	(0.008)	(0.027)	(0.007)	(0.012)	(0.076)	(0.009)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observation	64,601	64,601	64,601	64,601	64,601	64,601
Adjusted R-squared	0.551	0.624	0.515	0.403	0.444	0.496

Table 5. Robustness checks: S-GMM & 2SLS

This table reports the results for the robustness tests that uses the Generalized Method of Moments (GMM) and the two-stage least squares (2SLS) instrumental variables (IV) regressions in Panel A and B, respectively. We use the one-year lagged value of the country's average carbon risk as the instrumental variable. The top-management compensation is approximated through the ratio of total compensation and its various components to Total Assets. The Climate Change Risk (CCR) variable, which gauges the firm-level risk associated with climate change, is derived from the analysis of word combinations in earnings conference calls, as established by Sautner et al. (2023). Standard errors are clustered at the firm level and are presented in parentheses under the associated coefficients. ***, **, and *indicate significance at the 10%, 5% and 1% levels, respectively. The descriptions of all variables are reported in Table 1.

Panel A: Two-step system GMM regressions						
Variables	**Total Pay**	**Cash pay**	**Salary**	**Bonus**	**Stock pay**	**Option pay**
	(1)	(2)	(3)	(4)	(5)	(6)
CCR	0.298***	0.443***	0.162**	0.003	-0.224***	-0.365***
	(0.012)	(0.007)	(0.013)	(0.017)	(0.023)	(0.015)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
AR(1) (p-value)	0.000	0.000	0.000	0.000	0.000	0.000
AR(2) (p-value)	0.316	0.509	0.702	0.895	1.088	1.281
Hansen Test (p-value)	0.367	0.416	0.465	0.414	0.363	0.312
Sargan test (p-value)	0.208	0.312	0.416	0.120	0.324	0.528
Observation	64,601	64,601	64,601	64,601	64,601	64,601
Adjusted R-squared	0.438	0.452	0.466	0.479	0.493	0.506
Panel B: 2SLS instrumental variables (IV) regressions - Second stage						
Variables	**Total Pay**	**Cash pay**	**Salary**	**Bonus**	**Stock pay**	**Option pay**
	(1)	(2)	(3)	(4)	(5)	(6)
CCR	0.189***	0.375***	0.098*	0.013	-0.134**	-0.251***
	(0.008)	(0.008)	(0.032)	(0.020)	(0.052)	(0.017)
Kleibergen & Paap Unid.(p-value)	0.001	0.001	0.003	0.001	0.003	0.002
Hansen J Overid.(p-value)	0.000	0.000	0.000	0.000	0.000	0.000
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observation	64,601	64,601	64,601	64,601	64,601	64,601
Adjusted R-squared	0.411	0.352	0.339	0.326	0.312	0.299

Table 6. Shocks to CCR and top-executive compensation

This table presents the results of regression models that examine the relation between climate change risk and top-executives' compensation by considering the impacts of CCR shocks. CCR Shock is a dummy variable identifying firms with change in CCR in a given financial year which is greater than two time (1), three times (2) and five times (5), the average change in CCR of the whole sample. The top-management compensation is approximated through the ratio of total compensation and its various components to Total Assets. The Climate Change Risk (CCR) variable, which gauges the firm-level risk associated with climate change, is derived from the analysis of word combinations in earnings conference calls, as established by Sautner et al. (2023). Standard errors are clustered at the firm level and are presented in parentheses under the associated coefficients. ***, **, and *indicate significance at the 10%, 5% and 1% levels, respectively. The descriptions of all variables are reported in Table 1.

Variables	$\Delta CCR{>}2times$	$\Delta CCR{>}3times$	$\Delta CCR{>}5times$	**PSM**
	(1)	(2)	(3)	(4)
CCR Shocks	0.016	0.104**	0.154***	
	(0.257)	(0.020)	(0.006)	
CCR				0.176***
				(0.001)
Constant	0.164	0.084**	0.025	0.327
	(0.009)	(0.031)	(0.023)	(0.365)
Controls	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Observation	64,601	64,601	64,601	25,377
Adjusted R-squared	0.484	0.760	0.640	0.855

Table 7. Decomposition of Climate risk and Compensation

This table presents the results by examining the impacts of three components of climate change exposure on total top-management. The results for Opportunity (CCOR), Regulatory (CCRR), and Physical risk (CCPR) are reported in Panel A, B, and C, respectively. The top-management compensation is approximated through the ratio of total compensation and its various components to Total Assets. The Climate Change Risk (CCR) variables, which gauges the firm-level risk associated with climate change, is derived from the analysis of word combinations in earnings conference calls, as established by Sautner et al. (2023). Standard errors are clustered at the firm level and are presented in parentheses under the associated coefficients. ***, **, and *indicate significance at the 10%, 5% and 1% levels, respectively. The descriptions of all variables are reported in Table 1.

Panel A: Opportunity Risk (CCOR)						
Dependent variable	**Total Pay**	**Cash pay**	**Salary**	**Bonus**	**Stock pay**	**Option pay**
Variables	(1)	(2)	(3)	(4)	(5)	(6)
CCOR	0.126***	0.253**	0.113*	0.012	-0.196***	-0.275***
	(0.011)	(0.032)	(0.044)	(0.027)	(0.015)	(0.010)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observation	64,601	64,601	64,601	64,601	64,601	64,601
Adjusted R-squared	0.426	0.423	0.399	0.312	0.401	0.384
Panel B: Regulatory Risk (CCRR)						
Dependent variable	**Total Pay**	**Cash pay**	**Salary**	**Bonus**	**Stock pay**	**Option pay**
Variables	(1)	(2)	(3)	(4)	(5)	(6)
CCRR	0.125**	0.189***	0.082*	-0.018	-0.232**	-0.126*
	(0.013)	(0.008)	(0.009)	(0.016)	(0.022)	(0.052)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observation	64,601	64,601	64,601	64,601	64,601	64,601
Adjusted R-squared	0.384	0.385	0.360	0.281	0.351	0.346
Panel C: Physical Risk (CCPR)						
Dependent variable	**Total Pay**	**Cash pay**	**Salary**	**Bonus**	**Stock pay**	**Option pay**
Variables	(1)	(2)	(3)	(4)	(5)	(6)
CCPR	0.071	0.184**	0.066	-0.015	-0.132**	-0.105*
	(0.126)	(0.022)	(0.027)	(0.022)	(0.029)	(0.048)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observation	64,601	64,601	64,601	64,601	64,601	64,601
Adjusted R-squared	0.323	0.320	0.302	0.236	0.302	0.291

Table 8. Channel analysis: Motivations for firm eco-innovations

This table presents the results of regression models that investigate the relation between climate change risk, eco-innovation and compensation using Eq. (2). The sample consists of 64,601 firm-year observations from 9,871 unique firms between 2001 and 2021. The top-management compensation is approximated through the ratio of total compensation and its various components to Total Assets. The Climate Change Risk (CCR) variable, which gauges the firm-level risk associated with climate change, is derived from the analysis of word combinations in earnings conference calls, as established by Sautner et al. (2023). The firm-level eco-innovation is measure by the Refinitiv ESG innovation score. The results for sub-groups of high and low Compensation-Innovation nexus are reported in Panel A and B, respectively. The results for Eq. (2) are reported in Panel C. Standard errors are clustered at the firm level and are presented in parentheses under the associated coefficients. ***, **, and *indicate significance at the 10%, 5% and 1% levels, respectively. The descriptions of all variables are reported in Table 1.

Panel A: High Compensation-Innovation nexus						
Dependent variable: PAY	**Total Pay**	**Cash pay**	**Salary**	**Bonus**	**Stock pay**	**Option pay**
Variables	(1)	(2)	(3)	(4)	(5)	(6)
CCR	0.224***	0.385***	0.095**	0.012	-0.190***	-0.192***
	(0.025)	(0.011)	(0.021)	(0.027)	(0.015)	(0.024)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observation	19,378	19,378	19,378	19,378	19,378	19,378
Adjusted R-squared	0.398	0.398	0.372	0.291	0.363	0.358
Panel B: Low Compensation-Innovation nexus						
Dependent variable: PAY	**Total Pay**	**Cash pay**	**Salary**	**Bonus**	**Stock pay**	**Option pay**
Variables	(1)	(2)	(3)	(4)	(5)	(6)
CCR	0.089*	0.210**	0.044	0.011	-0.196***	-0.188***
	(0.029)	(0.018)	(0.031)	(0.013)	(0.022)	(0.017)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observation	23,905	23,905	23,905	23,905	23,905	23,905
Adjusted R-squared	0.459	0.460	0.429	0.336	0.418	0.414
Chi-square p-value	0.000***	0.000***	0.003***	0.423	0.562	0.521
Panel C: Regression approach - Equation (2)						
Dependent variable: INN	**Total Pay**	**Cash pay**	**Salary**	**Bonus**	**Stock pay**	**Option pay**
Variables	(1)	(2)	(3)	(4)	(5)	(6)
CCR×PAY	**0.196*** **	**0.345*** **	**0.176** **	**0.054**	**0.038**	**0.029**
	(0.011)	**(0.006)**	**(0.013)**	**(0.021)**	**(0.026)**	**(0.019)**
PAY	0.242***	0.194**	0.153**	0.016	0.043	0.053
	(0.007)	(0.009)	(0.005)	(0.022)	(0.025)	(0.021)
CCR	0.154**	0.092*	0.187**	0.199**	0.112*	0.142**
	(0.015)	(0.035)	(0.015)	(0.014)	(0.026)	(0.021)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observation	43,283	43,283	43,283	43,283	43,283	43,283
Adjusted R-squared	0.512	0.513	0.478	0.374	0.466	0.461

Table 9. Channel analysis: The roles of Managerial Bargaining Power

This table presents the results of regression models that investigate the relation between climate change risk, managerial bargaining power and compensation. The sample consists of 64,601 firm-year observations from 9,871 unique firms between 2001 and 2021. The top-management compensation is approximated through the ratio of total compensation and its various components to Total Assets. The Climate Change Risk (CCR) variable, which gauges the firm-level risk associated with climate change, is derived from the analysis of word combinations in earnings conference calls, as established by Sautner et al. (2023). The results for each indicator of managerial bargaining power are reported in Panel A to D, respectively. Standard errors are clustered at the firm level and are presented in parentheses under the associated coefficients. ***, **, and *indicate significance at the 10%, 5% and 1% levels, respectively. The descriptions of all variables are reported in Table 1.

Panel A: Institutional Ownership (Low)						
Dependent variable: PAY	**Total Pay**	**Cash pay**	**Salary**	**Bonus**	**Stock pay**	**Option pay**
Variables	(1)	(2)	(3)	(4)	(5)	(6)
CCR×Institutional Ownership	0.204***	0.218***	0.129***	0.004	-0.113**	-0.109**
	(0.019)	(0.016)	(0.023)	(0.035)	(0.029)	(0.029)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observation	40,687	40,687	40,687	40,687	40,687	40,687
Adjusted R-squared	0.437	0.438	0.409	0.320	0.399	0.394
Panel B: Analyst following (Low)						
Dependent variable: PAY	**Total Pay**	**Cash pay**	**Salary**	**Bonus**	**Stock pay**	**Option pay**
Variables	(1)	(2)	(3)	(4)	(5)	(6)
CCR×Analyst following	0.146**	0.153***	0.112**	0.001	-0.099**	-0.035
	(0.022)	(0.018)	(0.026)	(0.041)	(0.026)	(0.029)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observation	39,060	39,060	39,060	39,060	39,060	39,060
Adjusted R-squared	0.324	0.324	0.303	0.237	0.295	0.292
Panel C: Senior executives' age (High)						
Dependent variable: PAY	**Total Pay**	**Cash pay**	**Salary**	**Bonus**	**Stock pay**	**Option pay**
Variables	(1)	(2)	(3)	(4)	(5)	(6)
CCR×Age	0.105**	0.121***	0.109**	0.003	-0.086**	-0.091**
	(0.024)	(0.019)	(0.023)	(0.034)	(0.029)	(0.025)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observation	64,601	64,601	64,601	64,601	64,601	64,601
Adjusted R-squared	0.412	0.413	0.393	0.349	0.465	0.430
Panel D: Board tenure (High)						
Dependent variable: PAY	**Total Pay**	**Cash pay**	**Salary**	**Bonus**	**Stock pay**	**Option pay**
Variables	(1)	(2)	(3)	(4)	(5)	(6)
CCR×Board tenure	0.209***	0.265***	0.217***	0.005	-0.155***	-0.172***
	(0.012)	(0.009)	(0.016)	(0.031)	(0.016)	(0.012)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observation	64,601	64,601	64,601	64,601	64,601	64,601
Adjusted R-squared	0.465	0.526	0.404	0.401	0.491	0.493

Table 10. Channel analysis: Firm performance – Tobin's Q

This table presents the results of regression models that investigate the relation between climate change risk, firm performance (Tobin's Q) and compensation using Eq. (3). The sample consists of 64,601 firm-year observations from 9,871 unique firms between 2001 and 2021. The top-management compensation is approximated through the ratio of total compensation and its various components to Total Assets. The Climate Change Risk (CCR) variable, which gauges the firm-level risk associated with climate change, is derived from the analysis of word combinations in earnings conference calls, as established by Sautner et al. (2023). The results for sub-groups of high and low Compensation-Tobin's Q nexus are reported in Panel A and B. The results for Eq. (3) are reported in Panel C. Standard errors are clustered at the firm level and are presented in parentheses under the associated coefficients. ***, **, and *indicate significance at the 10%, 5% and 1% levels, respectively. The descriptions of all variables are reported in Table 1.

Panel A: High Compensation-Tobin's Q nexus						
Dependent variable	**Total Pay**	**Cash pay**	**Salary**	**Bonus**	**Stock pay**	**Option pay**
Variables	(1)	(2)	(3)	(4)	(5)	(6)
CCR	0.154***	0.278***	0.082**	0.015	-0.131***	-0.137***
	(0.019)	(0.012)	(0.032)	(0.021)	(0.022)	(0.022)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observation	31,905	31,905	31,905	31,905	31,905	31,905
Adjusted R-squared	0.495	0.497	0.463	0.363	0.491	0.485
Panel B: Low Compensation-Tobin's Q nexus						
Dependent variable	**Total Pay**	**Cash pay**	**Salary**	**Bonus**	**Stock pay**	**Option pay**
Variables	(1)	(2)	(3)	(4)	(5)	(6)
CCR	0.080**	0.177***	0.055*	0.012	-0.088**	-0.104***
	(0.024	(0.018)	(0.037)	(0.023)	(0.027)	(0.024)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observation	32,696	32,696	32,696	32,696	32,696	32,696
Adjusted R-squared	0.435	0.436	0.407	0.318	0.431	0.426
Chi-square p-value	**0.002**	**0.002**	**0.066**	**0.437**	**0.047**	**0.004**
Panel C: Regression approach - Equation (3) for Tobin's Q						
Dependent variable: PER	**Total Pay**	**Cash pay**	**Salary**	**Bonus**	**Stock pay**	**Option pay**
Variables	(1)	(2)	(3)	(4)	(5)	(6)
CCR×PAY	0.250***	0.556***	0.284***	0.002	-0.242***	-0.137***
	(0.003)	(0.001)	(0.003)	(0.018)	(0.009)	(0.025)
PAY	0.211***	0.266***	0.133**	0.139**	0.213***	0.147***
	(0.008)	(0.007)	(0.015)	(0.015)	(0.008)	(0.012)
CCR	-0.327***	-0.325***	-0.306**	-0.314***	-0.324***	-0.320***
	(0.022)	(0.022)	(0.025)	(0.023)	(0.022)	(0.024)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observation	64,601	64,601	64,601	64,601	64,601	64,601
Adjusted R-squared	0.637	0.469	0.596	0.466	0.631	0.624

Table 11. Channel analysis: Firm performance – Return on Asset (ROA)

This table presents the results of regression models that investigate the relation between climate change risk, firm performance (ROA) and compensation using Eq. (3). The sample consists of 64,601 firm-year observations from 9,871 unique firms between 2001 and 2021. The top-management compensation is approximated through the ratio of total compensation and its various components to Total Assets. The Climate Change Risk (CCR) variable, which gauges the firm-level risk associated with climate change, is derived from the analysis of word combinations in earnings conference calls, as established by Sautner et al. (2023). The results for sub-groups of high and low performance-Innovation nexus are reported in Panel A and B. The results for Eq. (3) are reported in Panel C. Standard errors are clustered at the firm level and are presented in parentheses under the associated coefficients. ***, **, and *indicate significance at the 10%, 5% and 1% levels, respectively. The descriptions of all variables are reported in Table 1.

Panel A: High Compensation-ROA nexus						
Dependent variable	**Total Pay**	**Cash pay**	**Salary**	**Bonus**	**Stock pay**	**Option pay**
Variables	(1)	(2)	(3)	(4)	(5)	(6)
CCR	0.203***	0.365***	0.107**	0.020	-0.196***	-0.140***
	(0.011)	(0.004)	(0.021)	(0.037)	(0.005)	(0.009)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observation	35,148	35,148	35,148	35,148	35,148	35,148
Adjusted R-squared	0.572	0.573	0.535	0.419	0.567	0.560
Panel B: Low Compensation-ROA nexus						
Dependent variable	**Total Pay**	**Cash pay**	**Salary**	**Bonus**	**Stock pay**	**Option pay**
Variables	(1)	(2)	(3)	(4)	(5)	(6)
CCR	0.152***	0.169***	0.074*	0.007	-0.089**	-0.081**
	(0.023)	(0.013)	(0.036)	(0.039)	(0.018)	(0.021)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observation	29,453	29,453	29,453	29,453	29,453	29,453
Adjusted R-squared	0.516	0.517	0.483	0.378	0.511	0.505
Chi-square p-value	**0.002**	**0.001**	**0.035**	**0.181**	**0.014**	**0.023**
Panel C: Regression approach - Equation (3) for ROA						
Dependent variable: PER	**Total Pay**	**Cash pay**	**Salary**	**Bonus**	**Stock pay**	**Option pay**
Variables	(1)	(2)	(3)	(4)	(5)	(6)
CCR×PAY	0.326***	0.426***	0.187***	0.019	-0.335***	-0.172**
	(0.002)	(0.001)	(0.004)	(0.013)	(0.002)	(0.005)
PAY	0.538***	0.640***	0.451***	0.226**	0.431***	0.355**
	(0.001)	(0.001)	(0.001)	(0.006)	(0.001)	(0.001)
CCR	-0.582**	-0.751***	-0.601**	-0.622**	-0.688**	-0.629**
	(0.010)	(0.008)	(0.010)	(0.009)	(0.009)	(0.009)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observation	64,601	64,601	64,601	64,601	64,601	64,601
Adjusted R-squared	0.641	0.580	0.599	0.549	0.635	0.679

Table 12. Additional analyses: Firm-level heterogeneity

This table presents the results of regression models that investigate the relation between climate change risk and compensation by considering the cross-sectional heterogeneity. The sample consists of 64,601 firm-year observations from 9,871 unique firms between 2001 and 2021. The top-management compensation is approximated through the ratio of total compensation and its various components to Total Assets. The Climate Change Risk (CCR) variable, which gauges the firm-level risk associated with climate change, is derived from the analysis of word combinations in earnings conference calls, as established by Sautner et al. (2023). The results for KZ index, international exposure, and CSR committee are reported in Panel A, B and C, respectively. Standard errors are clustered at the firm level and are presented in parentheses under the associated coefficients. ***, **, and *indicate significance at the 10%, 5% and 1% levels, respectively. The descriptions of all variables are reported in Table 1.

Panel A: Financial Constraints - KZ Index						
Dependent variable	**Total Pay**	**Cash pay**	**Salary**	**Bonus**	**Stock pay**	**Option pay**
Variables	(1)	(2)	(3)	(4)	(5)	(6)
CCR×Financial Constraints	0.161	0.138	0.136	0.110	0.183	0.150
	(0.038)	(0.045)	(0.046)	(0.052)	(0.032)	(0.039)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observation	58,622	58,622	58,622	58,622	58,622	58,622
Adjusted R-squared	0.373	0.319	0.313	0.254	0.421	0.347
Panel B: International exposure						
Dependent variable	**Total Pay**	**Cash pay**	**Salary**	**Bonus**	**Stock pay**	**Option pay**
Variables	(1)	(2)	(3)	(4)	(5)	(6)
CCR×International Exposure	0.339***	0.457***	0.240**	0.084	-0.213**	-0.252**
	(0.016)	(0.010)	(0.019)	(0.043)	(0.038)	(0.026)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observation	52,364	52,364	52,364	52,364	52,364	52,364
Adjusted R-squared	0.534	0.457	0.449	0.364	0.604	0.498
Panel C: CSR sustainability committee						
Dependent variable	**Total Pay**	**Cash pay**	**Salary**	**Bonus**	**Stock pay**	**Option pay**
Variables	(1)	(2)	(3)	(4)	(5)	(6)
CCR×CSR	0.174**	0.206**	0.228**	0.012	0.054	0.061
	(0.009)	(0.006)	(0.006)	(0.029)	(0.038)	(0.027)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observation	50,553	50,553	50,553	50,553	50,553	50,553
Adjusted R-squared	0.588	0.503	0.494	0.401	0.650	0.548

Table 13. Additional analyses: Country-level industry-level heterogeneity

This table presents the results of regression models that investigate the relation between climate change risk and compensation by considering the cross-sectional heterogeneity. The sample consists of 64,601 firm-year observations from 9,871 unique firms between 2001 and 2021. The top-management compensation is approximated through the ratio of total compensation and its various components to Total Assets. The Climate Change Risk (CCR) variable, which gauges the firm-level risk associated with climate change, is derived from the analysis of word combinations in earnings conference calls, as established by Sautner et al. (2023). The results for industry-ranked CCR by Sautner et al. (2023), polluting industries by Ilhan et al. (2021), and CSR committee are reported in Panel A, B and C, respectively. Standard errors are clustered at the firm level and are presented in parentheses under the associated coefficients. ***, **, and *indicate significance at the 10%, 5% and 1% levels, respectively. The descriptions of all variables are reported in Table 1.

Panel A: High-CCR Industries						
Dependent variable	**Total Pay**	**Cash pay**	**Salary**	**Bonus**	**Stock pay**	**Option pay**
Variables	(1)	(2)	(3)	(4)	(5)	(6)
CCR×HighCCR	0.449***	0.609***	0.795***	0.117*	-0.359***	-0.511***
	(0.005)	(0.002)	(0.002)	(0.029)	(0.008)	(0.005)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observation	64,601	64,601	64,601	64,601	64,601	64,601
Adjusted R-squared	0.406	0.468	0.408	0.415	0.456	0.528
Panel B: High-Polluting Industries						
Dependent variable	**Total Pay**	**Cash pay**	**Salary**	**Bonus**	**Stock pay**	**Option pay**
Variables	(1)	(2)	(3)	(4)	(5)	(6)
CCR×Polluting	0.337**	0.576***	0.308**	0.016	-0.207**	-0.183**
	(0.010)	(0.005)	(0.011)	(0.023)	(0.015)	(0.018)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observation	64,601	64,601	64,601	64,601	64,601	64,601
Adjusted R-squared	0.412	0.377	0.360	0.309	0.463	0.414
Panel C: High-corruption countries						
Dependent variable	**Total Pay**	**Cash pay**	**Salary**	**Bonus**	**Stock pay**	**Option pay**
Variables	(1)	(2)	(3)	(4)	(5)	(6)
CCR×Corruption	0.253**	0.267**	0.243**	0.167	-0.240**	-0.175**
	(0.012)	(0.012)	(0.013)	(0.026)	(0.015)	(0.021)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observation	64,601	64,601	64,601	64,601	64,601	64,601
Adjusted R-squared	0.414	0.437	0.472	0.375	0.464	0.442
Panel D: High Anti-director Rights Index (ARI)						
Dependent variable	**Total Pay**	**Cash pay**	**Salary**	**Bonus**	**Stock pay**	**Option pay**
Variables	(1)	(2)	(3)	(4)	(5)	(6)
CCR×ARI	-0.120**	-0.154**	-0.182**	-0.013	0.162**	0.091**
	(0.024)	(0.021)	(0.016)	(0.036)	(0.031)	(0.027)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observation	64,601	64,601	64,601	64,601	64,601	64,601
Adjusted R-squared	0.323	0.353	0.386	0.307	0.359	0.354

Table 14. Differences-in-differences analyses with major climate events on CCR-compensation nexus.

TThis table presents the results by considering the impacts of major climate policy events, that investigate the relation between climate change exposure and total compensation in the sample from 2001 to 2021. The top-management compensation is approximated through the ratio of total compensation and its various components to Total Assets. The Climate Change Risk (CCR) variable, which gauges the firm-level risk associated with climate change, is derived from the analysis of word combinations in earnings conference calls, as established by Sautner et al. (2023). We control for country, industry, and year fixed effects in all specifications. Post is a dummy variable with a value of one capturing a period post the major climate events period and zero otherwise. Standard errors are clustered at the firm level and are presented in parentheses under the associated coefficients. ***, **, and *indicate significance at the 10%, 5% and 1% levels, respectively. The descriptions of all variables are reported in Table 1.

Panel A: EPA Emission Legislation 2007						
Dependent variable	**Total Pay**	**Cash pay**	**Salary**	**Bonus**	**Stock pay**	**Option pay**
Variables	(1)	(2)	(3)	(4)	(5)	(6)
CCR	0.098**	0.119**	0.128**	0.071	-0.077	-0.092*
	(0.057)	(0.041)	(0.040)	(0.085)	(0.058)	(0.047)
CCR×Post	0.121**	0.148***	0.158***	0.066	-0.096**	-0.114***
	(0.035)	(0.033)	(0.032)	(0.058)	(0.043)	(0.036)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observation	64,601	64,601	64,601	64,601	64,601	64,601
Adjusted R-squared	0.235	0.313	0.318	0.285	0.271	0.322
Panel B: Doha Climate Summit 2012						
Dependent variable	**Total Pay**	**Cash pay**	**Salary**	**Bonus**	**Stock pay**	**Option pay**
Variables	(1)	(2)	(3)	(4)	(5)	(6)
CCR	0.074*	0.111**	0.141**	0.065	-0.087*	-0.106**
	(0.032)	(0.031)	(0.030)	(0.067)	(0.048)	(0.037)
CCR×Post	0.143***	0.155***	0.142***	0.060	-0.108**	-0.131***
	(0.022)	(0.013)	(0.015)	(0.058)	(0.032)	(0.030)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observation	64,601	64,601	64,601	64,601	64,601	64,601
Adjusted R-squared	0.347	0.372	0.445	0.362	0.394	0.327
Panel C: Paris Agreement 2015						
Dependent variable	**Total Pay**	**Cash pay**	**Salary**	**Bonus**	**Stock pay**	**Option pay**
Variables	(1)	(2)	(3)	(4)	(5)	(6)
CCR	0.111**	0.152***	0.138***	-0.059	-0.098**	-0.122***
	(0.025)	(0.022)	(0.023)	(0.046)	(0.045)	(0.031)
CCR×Post	0.329***	0.518***	0.416***	0.114*	-0.318***	-0.415***
	(0.005)	(0.002)	(0.002)	(0.026)	(0.005)	(0.003)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observation	64,601	64,601	64,601	64,601	64,601	64,601
Adjusted R-squared	0.495	0.493	0.530	0.420	0.494	0.473