It’s on the rise: Climate change and CEO compensation

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Statement of Original Authorship

I certify that the work in this thesis has not previously been submitted for a degree, nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text. I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

Signature of Student

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Abstract

I examine whether climate change risk affects CEO compensation. Using a sample of U.S firms over the period of 2001-2020, I find that CEOs of firms with higher climate change exposure earn significantly higher total pay. Using natural disasters as exogenous shocks, I show that the uncovered effect is likely causal. CEO bargaining power plays an important role in explaining the effect. As climate change risk lowers firms’ future performance in profitability and firm value, CEOs prefer cash-based compensation to equity-based compensation. My findings suggest that there is a climate risk pay premium in CEO compensation.

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1. Introduction

Climate change is one of the pressing threats of our time that affects every person's health and well-being in every country around the world. Not only has impacts on human health, but climate change also disrupts the macroeconomy (Litterman et al., 2020). From 2018 to 2020, there have been 50 extreme climate and weather events in the United States, with losses exceeding $1 billion.[1] By 2050, weather and climate disasters are expected to cost the world economy $7.9 trillion.[2] Climate change risks can vary from extreme temperatures, a rise in precipitation levels or the increased frequency of natural disaster events such as hurricanes, storms, earthquakes, or heavy rainfalls (Stern, 2008). At the corporate level, firms face direct costs of climate change, from natural disasters, extreme temperatures to rising sea levels. Specifically, firms may face cash flow shocks due to physical damages to their facilities, higher operating and regulatory costs, as well as supply chain disruptions. Firms may also face disruptions in their business models as stakeholders become aware of climate risk and demand a move to more sustainable approaches. A series of recent studies by Huang, Kerstein, and Wang (2018), Choi, Gao, and Jiang (2020), Huynh and Xia (2020) examine the climate change's influences on financial markets and corporations. They document significant and adverse effects of climate risk on equity and bond valuations as well as earnings and cash flow volatility. While there is growing evidence on the effects of climate change on firm value and performance, it remains unclear how climate risk affects the most important personnel of the firm – the chief executive offer (CEO).

CEO is the highest-ranking executive of the firm whose responsibilities include managing resources and operations and making decisions about the future directions of the firm. The role of the CEO will be even more important in a changing economy with significant uncertainties caused by climate change. Therefore, it is essential to set optimal remuneration policies that effectively compensate the CEO in her efforts to lead the firm to more sustainable operations and approaches. In this thesis, I investigate the research questions: How does CEO compensation change following the increased risk of climate change? How do compositions of CEO compensation change?

There are two potential reasons to believe CEOs may seek pay rise following increased climate change threats. First, the literature documents the compensation premium when CEOs face higher risks or non-monetary factors that adversely affect the CEOs' well-being or living arrangements. Specifically, CEOs are able to negotiate for higher pay when facing higher turnover risk due to volatile industry conditions (Peters and Wager, 2014), higher financial distress risk (Chang, Hayes, and Hillegeist, 2016), low quality of life (Deng and Gao, 2013), higher costs of living in metropolitan areas (Francis, Hasan, John, and Waisman, 2016), or higher risk of terrorist attacks (Dai, Rau, Stouraitis, and Tan, 2020). If climate risk exacerbates the firm's overall financial distress risk, CEOs may suffer personal losses as a significant fraction of their long-term wealth tied to corporate performance, e.g.,

[1] https://coast.noaa.gov/states/fast-facts/hurricane-costs.html
[2] https://phys.org/news/2019-11-climate-impacts-world-trillion.html

pensions, retirement benefits, and deferred compensation (Chang, Hayes, and Hillegeist, 2016). CEO's wealth in equity-based holdings is also affected as stock and option values are lower due to the negative impact of climate risk on equity valuation. Second, climate change affects the firm's business risk substantially. Climate change has the obvious physical risk that disrupts the firm's supply chains and business operations while increasing operating costs and performance volatility. Also, the firm needs to factor in transition risk arising from changes in consumer awareness, technologies, and regulations. The associated costs are estimated to be in trillion of dollars.[3] These issues will make the CEO spend considerable extra effort to right the ship. Hence, she may negotiate for a pay rise to compensate for the increased effort.

In this thesis, I investigate the relation between climate change risk and CEO total compensation. I rely on the firm-specific climate change exposure measure from Sautner et al. (2021). This firm-specific and time-varying climate change exposure measure is created by counting signal word combinations (bigrams) from earnings conference call transcripts. The measure captures firms' exposure to various aspects of climate change, including physical climate shocks, carbon emissions, and regulatory risk. The use of this measure directly answers the call by Engle, Giglio, Kelly, Lee, and Stroebel (2020) to use more appropriate measures of firm-level climate change risks.

Using a sample of 28,585 firm-year observations of U.S firms from fiscal years 2001 to 2020, I document a robust and significantly positive relation between climate change exposure and CEO total compensation. In terms of economic significance, a one-standard-deviation increase in the measure of climate change exposure is associated with a 2% increase in CEO total pay. My findings are robust to controlling for known determinants of CEO compensation in the literature, firm fixed effects, year fixed effects, industry conditions, and corporate governance of the firm.

In further analysis, I establish causal interpretations by exploiting natural disaster events, including earthquakes, wildfires, hurricanes, storms, and more, as a source of exogenous shocks to climate change exposure. Natural disasters are clean, unpredictable, and exogenous events to firms and managers that exacerbate climate risks of firms headquartered in the affected areas (Cortes and Strahan, 2017; Dessaint and Matray, 2017). I collect Presidential Disaster Declaration events from SHELDUS database. Employing a difference-in-differences framework, I find that firms that experience natural disasters significantly increase their CEO total compensation relative to firms without major disaster events. The evidence suggests a causal effect of climate change risk on CEO total compensation.

Next, I explore possible channels through which CEOs are able to negotiate higher pay following increased climate change risk. The literature suggests two channels for the high CEO pay level: CEO bargaining power and competitive market forces (Frydman and Jenter, 2010). Using popular corporate governance proxies, I document a stronger relation between climate change exposure and CEO compensation on firms with CEO/Chairman duality, older CEO, low institutional ownership, fewer

[3] https://www.nytimes.com/2019/06/04/climate/companies-climate-change-financial-impact.html

number of analysts following, and lower shareholder rights. These findings are consistent with prior evidence suggesting that powerful CEOs can exert power over the board and extract higher compensation (Bebchuk and Fried, 2004). I do not find a stronger relation when measuring competitive market forces using managerial ability, industry competition, industry product similarity, or local labor market mobility. Taken together, I find that CEO bargaining power is important in explaining the CEO pay premium for climate change risk.

I then investigate the relation between climate change exposure and CEO pay components. Following increased climate risks, CEOs prefer higher pay in cash. The higher salary mainly drives the relation. I also document a significant reduction in the value of annual option grants when climate change exposure is high. As firms with higher climate change risk suffer lower equity valuation (Matsumura, Prakash, and Vera-Munoz, 2014; Choi, Gao and Jiang, 2020; Berkman, Jona, and Sodestrom, 2021), it can have negative impacts on CEOs' equity-based holdings of firms with high exposure to climate change. I also find collaborative evidence on the significantly negative relations between climate change exposure and firms' future performance in return on assets and Tobin's Q. Taken together, it is reasonable for CEOs of high climate risk firms to lower their demand for long-term incentives and increase their preference for cash-based compensation.

Last, I conduct a sub-sample analysis to further my understanding of the climate risk pay premium. I conjecture that firms operating in multiple countries are less affected by climate change thanks to more geographically diversified operations. Firms with more tangible assets may also be more affected by climate risk as they face a higher physical risk of asset damages following climate events. I find that the effect of climate change exposure on CEO compensation mainly concentrates in the sub-samples of firms in high climate exposure industries, operations in the U.S only, and high asset tangibility. These findings further lend support to the positive relation between climate risk and CEO compensation.

The contributions of this thesis are two folds. First, I add to the rapid growing literature on the impacts of climate change on the macroeconomy and corporations. At the macroeconomic level, prior evidence shows that climate change significantly lowers agricultural outputs (Lobell, Schlenker, and Costa-Roberts, 2011; Fisher, Hanemann, Roberts, and Schlenker, 2012), labour productivity (Graff-Zivin and Neidell, 2014), income per capita (Dell, Jones, and Olken, 2012), economic productivity (Burke, Hsiang, and Miguel, 2015), global economic growth rate (Carleton and Hsiang, 2018), and real estate prices in coastal cities (Bernstein, Gustafson, and Lewis, 2019). At the corporate level, firms suffer higher revenue and earnings volatility (Huang, Kerstein, and Wang, 2018; Pankratz, Bauer, and Derwall, 2021), higher operating costs (Hugon and Law, 2021), lower equity valuation (Matsumura, Prakash, and Vera-Munoz, 2014; Choi, Gao, and Jiang, 2020; Berkman, Jona, and Sodestrom, 2021), lower bond returns (Huynh and Xia, 2020), higher cost of bank financing (Jiang, Li, and Qian, 2020). In this thesis, I uncover new evidence on the likely causal effect of climate change on CEO compensation.

Second, I add to the literature on CEO compensation. Prior studies have shown a range of determinants of CEO compensation, including firm size (Gabaix and Landier, 2008), corporate governance (Core, Holthausen, and Larcker, 1999; Bebchuk and Fried, 2004; Chhaochharia and Grinstein, 2009), industry deregulations (Hubbard and Palia, 1995), import penetration (Cunat and Guadalupe, 2009), turnover risk (Peters and Wagner, 2014), financial distress risk (Chang, Hayes, and Hillegeist, 2016), CEO optimism (Otto, 2014), quality of life (Deng and Gao, 2013), labor unions (Huang, Jiang, Lie, and Que, 2017), social stigma (Novak and Bilinkski, 2018), social capital (Hoi, Wu, and Zhang, 2019), and threats of terrorist attacks (Dai et al., 2020). My research contributes to the literature by showing that climate change is an important driver of CEO compensation.

The remainder of the paper proceeds as follows. Section 2 reviews the related literature, and Section 3 develops my hypotheses. I describe the sample and variable constructions in Section 4. Section 5 details research design for empirical analyses. Section 6 presents the main results and supporting evidence. Section 7 concludes the thesis. Detailed variable definitions are in the Appendix.

2. Literature review

2.1. Climate change and the macroeconomy

Climate risk can vary from climate disasters, extreme temperatures to a rise in precipitation levels. While disasters such as hurricane strikes pose direct costs to firms in the affected regions, extreme temperatures or a rise in precipitation levels are less obvious. There is burgeoning literature that documents the influences of global warming on the macroeconomy. Cross-sectional empirical studies such as Gallup et al. (1999), Nordhaus (2006), and Dell et al. (2009) use cross-country and within-country data to investigate the relation between temperature and income. These studies find that income per capita is negatively related to hot climates. For example, Dell et al. (2009) reveal that an increase of one degree Celsius is related to a decline of eight and a half percent in income per capita. Recent panel data studies (e.g., Barrios, Bertinelli, and Strobl, 2010; Hsiang, 2010; Dell, Jones, and Olken, 2012) examining both time-series and cross-sectional variations in temperature document consistent results. For instance, Dell et al. (2012) find that a rise of one degree Celsius is significantly related to a decrease of 1.4% in income per capita in a given year. Burke, Hsiang, and Miguel (2015) document a non-linear association between economic productivity and temperature. The authors suggest that economic productivity peaks when the average annual temperature is 13 degrees Celsius. However, economic productivity declines when temperatures increase. Carleton and Hsiang (2018) show that climate warming depresses the global economic growth rate by 0.28% per year.

The literature suggests two primary channels in which hot climates adversely affect economic productivity. First, there is a negative and significant link between agricultural outputs and temperature. Schlenker and Roberts (2009) show that soybeans and corn output peaks at the temperatures of 29 degrees Celsius and 30 degrees Celsius, respectively. However, temperatures above these thresholds are significantly harmful to production. Lobell et al. (2011) and Fisher et al. (2012) find consistent results by documenting a robust and negative relation between hot temperatures and crop, maize, and wheat productions. Second, hot temperatures can affect aggregate economic outputs through declines in labor productivity and supply. According to Graff-Zivin and Neidell (2014), there are large reductions in labour hours when temperatures are above 85 degrees Fahrenheit. Somanathan et al. (2021) suggest that heat stress causes workers to produce less at work or even take a leave of absence from work. The authors find a 2% reduction in annual outputs for an increase of 1 degree Celsius. These findings are consistent with earlier studies showing reductions in exports and outputs due to extreme temperatures (e.g., Jones and Olken, 2010; Hsiang, 2010).

Another type of climate mate risk is flooding risk. The increased frequency of heavy precipitation results in more severe flooding events (The United States Environmental Protection Agency, 2021).[4] Frequent floods result in disruptions in business transactions, losses of sales, and damages to firms' facilities. In accordance with the National Oceanic and Atmospheric Administration (NOAA, 2021), there have been 35 flooding events where losses exceed one billion dollars in the U.S.[5] Evidence in the literature shows that flood losses cost coastal cities approximately $6 billion a year (Hallegatte, Green, Nicholls and Corfee-Morlot, 2013), reduce real estate prices in coastal cities (Bernstein, Gustafson and Lewis, 2019), and increases issuance costs of municipal bonds in coastal counties (Painter, 2018).

2.2. Climate change and corporations

I turn to discuss the impacts of climate change on corporations as they are one of the major drivers of aggregate economic outputs. In the previous discussion, I highlight how climate change risk can adversely affect corporations through lower labor productivity, losses of sales, and physical damages to their facilities. At the corporate level, firms may face cash flow shocks due to physical damages to their facilities, higher operating and regulatory costs, as well as supply chain disruptions. Empirical studies by Hugon and Law (2019), and Pankratz, Bauer and Derwall, (2021) show that climate change risk leads to significant reductions in revenues and earnings of affected firms. Pankratz, Bauer, and Derwall (2021) attribute the revenue reductions to the decreased supply of inputs as extreme temperatures have adverse effects on workers' cognitive and physical performances and the number of hours worked. Both studies also show that the reductions in earnings are caused by significantly higher selling, general, and administrative expenses, higher cost of goods sold, and higher production costs.

Firms may also face disruptions in their business models as stakeholders become aware of climate risk and demand a move to more sustainable approaches. For instance, firms experience financial risk when investors become more aware of threats of climate risk. Recent studies show that investors factor climate risk into their investment decisions. Matsumura, Prakash, and Vera-Munoz (2014), Choi, Gao,

[4] https://www.epa.gov/climate-indicators/climate-change-indicators-heavy-precipitation
[5] https://www.ncdc.noaa.gov/billions/events.

and Jiang (2020), and Berkman, Jona, and Sodestrom (2021) find that firms with high climate risk suffer lower equity valuations. Choi, Gao, and Jiang (2020) find that as the weather becomes warmer, retail investors pay more attention to climate issues and sell shares of firms with high climate exposure. Berkman, Jona, and Sodestrom (2021) argue that the market recognises climate change as material and idiosyncratic risks and penalizes high climate risk firms when major climate events occur. Huynh and Xia (2020) present evidence that firms with high climate exposure suffer lower bond returns, and Chava (2014) document the higher implied cost of equity for firms with more climate change concerns. On the contrary, investors reward firms with better environmental practices as they pay premiums for the stocks and bonds of these firms (Huynh and Xia, 2020; Flammer, 2021). In terms of bank financing, Chava (2014) and Jiang, Li, and Qian (2020) show that firms having climate concerns experience a higher cost of bank financing and more debt covenants as lenders screen borrowers' environmental profiles to manage risk. While there are many studies on the effects of climate risk on firms' performance and financial markets, the impact of climate change on CEO compensation remains unclear. My study contributes to the literature related to climate risk and corporations by examining the relation between climate exposure and CEO compensation.

Climate-related literature generally divides climate risk into physical risk, regulatory risk, and transition risk. Physical climate risk directly increases the costs, financial losses, and damages stemming from natural disasters and extreme climate events (Hugon and Law, 2019). Regulatory risk is from government regulations and policies to reduce carbon emission and address climate change (Bartram, Hou, and Kim, 2021), while transition risk is when climate-related shifts could negatively affect certain industries (e.g., according to Statista (2020), the market value of US coal mining industry sharply reduced from 2010 to 2020). Each firm is exposed to different types of climate risks. Prior studies examine the effects of each type of climate risk on firms separately. For example, sea level rise risk causes firms to have the higher cost of bank financing (Jiang, Li, and Qian, 2020), while localized policies lead financially constrained firms in California to shift emissions and output to other states (Bartram, Hou, and Kim, 2021). In terms of carbon emission, Bolton and Kacperczyk (2020) reveal that firms that have higher carbon intensities are valued at a discount. Analyzing global stock market data, Choi et al. (2020) show that firms having higher carbon emissions underperform in abnormally hot weather. My study contributes to climate-related literature using a firm-level climate exposure measure that comprehensively captures physical, transition, and regulatory risks (Sautner et al., 2020).

2.3. Climate risk measure

Empirical studies in the literature generally follow three approaches to investigate how climate change affects various economic productivity measures. The first approach involves using cross-country differences in mean temperatures or flood frequencies to relate to aggregate outputs (e.g., Barrios, Bertinelli, and Strobl, 2010; Hsiang, 2010; Dell et al., 2012). In the second approach, researchers focus on specific industries that are more affected by changes in climate, such as agriculture (e.g., Schlenker and Roberts, 2009; Lobell, Schlenker, and Costa-Roberts, 2011; Fisher et al., 2012). The third approach relies on location-specific climate risks to examine the effect on firms (e.g., Hugon and Law, 2019; Jiang, Li, and Qian, 2020).

There are several limitations to these approaches. The previous discussion highlights the severe and pervasive climate change's impacts on the macroeconomy. Focusing on the agricultural sector, which does not account for a large fraction of the economy, may not paint the whole picture. More importantly, firm policy responses towards climate change are heterogeneous across firms, both inter- and intra-industries. There are many firm-specific factors that influence the firm's ability to adjust, including product diversifications, asset structure, capital structure, and financial constraints. The use of location-specific climate change exposures may also be problematic. Studies using location-specific temperatures or sea-level rise may overlook heterogeneities across firms in the same region. Also, some locations are more sensitive to climate change risk than others. For example, coastal cities are more exposed to sea-level rise risk than other cities. However, some of the largest companies in the world are located on the West Coast and the East Coast. In this thesis, I use a firm-level climate change exposure measure constructed by Sautner et al. (2020) to investigate the relation between CEO pay and climate change exposure. This climate exposure is mentioned in the recent climate finance survey by Giglio, Kelly, and Stroebel (2020), which uses the proportion of climate change bigrams in the conference call transcript.

2.4. Risk and executive compensation

My study is also related to the literature on executive compensation. The literature suggests a positive linkage between risk and CEO compensation. Peters and Wagner (2014) describe a pay premium to CEOs who are exposed to higher turnover risk in changing industry conditions. The authors document a positive linkage between turnover risk and CEO pay. They argue that the turnover risk premium exists to compensate the considerable personal costs after being let go. Fee and Hadlock (2004) find that fired CEOs have difficulty getting new jobs. Even if they are lucky, the new jobs are at significantly smaller firms with lower pay. Chang, Hayes, and Hillegeist (2016) show that new CEOs of financially distressed firms earn significantly more. They demonstrate that when firms become financially distressed, CEOs bear large potential financial losses through decreases in the value of equity compensation as stock and option values decrease. CEOs also bear consequences to their reputation if the firms eventually declare bankruptcy (Chang, Hayes, and Hillegeist, 2016). These findings are consistent with earlier theoretical predictions that financially distressed firms pay employees more to compensate for the probability of not finding alternative jobs or lower future pays in the event of bankruptcy (Rose, 1992; Berkovitch, Israel, and Spiegel, 2002; Berk, Stanton, and Zechner, 2010).

Empirical evidence by Gormley and Matsa (2013) indicates that boards modify the manager compensation to be less sensitive to both stock price and volatility when left tail risk increases. Dai et al., (2020) show that terrorism risk increases CEO pay to compensate for potential adversity to personal safety. Regarding climate change, when firms face significant climate risk, they suffer higher operational costs, losses of sales, or asset damages. If these adverse effects exacerbate the risk of financial distress, climate risk may increase the risks and uncertainties CEOs face. Also, as climate change adversely affect macroeconomic conditions and stock prices of firms with high climate risk (e.g., Matsumura, Prakash and Vera-Munoz, 2014; Choi, Gao and Jiang, 2020; Berkman, Jona, and Sodestrom, 2021), CEOs may suffer personal losses in their stock and option holdings of the firms.

Even in the unlikely event that climate risk does not affect CEOs at the corporate level, changing economic conditions may increase CEOs' personal risk. Quality of life is adversely affected by climate change. In particular, it is evident that climate change has severe impacts on the mental health of individuals and communities (Fitze et al., 2008; Berry, Bowen, and Kjellstrom, 2009). Also, CEOs may suffer personal losses in home value discounts if the headquarters are located in coastal areas (Bernstein, Gustafson, and Lewis, 2019). Using quality-of-life measures provided by Morgan Quitno Press, Deng and Gao (2013) reveal that quality of life at the firm's headquarter has significant impacts on overall CEO compensation. More specifically, they document that firms pay CEOs higher if they are in areas with high crime rates, more hazardous waste sites, and a less efficient transportation system. Francis et al. (2016) present evidence that CEOs in major metropolitan areas earn more than CEOs in smaller cities to compensate for lower quality-of-life in congested urban areas and higher living expenses. Wang, Dai, and Kong (2021) find that air pollution significantly increases employee monetary compensation, safety security, and career training.

To the best of my knowledge, there are no existing studies investigating the effect of climate change on executive compensation. My research adds to the compensation literature by investigating the relation between climate risk and CEO compensation. Thus, if executive pay indeed responds to climate change risk, we should see an increase in CEO total pay of firms with high climate change exposure.

3. Hypothesis development

Ashenfelter, Abowd, and Ashenfelter (1981) argue that a compensation package must reflect an agent's efforts and risks associated with the job. The literature suggests that financial risk is an important determinant of executive compensation (Rose, 1992; Berkovitch, Israel, and Spiegel, 2002; Berk, Stanton, and Zechner, 2010; Peters and Wagner, 2014; Chang, Hayes, and Hillegeist, 2016). The general consensus is that compensation is higher when turnover risk increases. The compensation premium reflects the time and personal costs the CEO faces when finding new employment after being dismissed (Gilson,1989; Fee and Hadlock, 2004). As discussed above, climate change risk leads to significant reductions in revenues and earnings (Hugon and Law, 2019; Pankratz, Bauer, and Derwall, 2021), higher earnings and cash flow volatility (Huang, Kerstein, and Wang, 2017), and lower equity valuation of affected firms (Matsumura, Prakash and Vera-Munoz, 2014; Choi, Gao and Jiang, 2020; Berkman, Jona, and Sodestrom, 2021). The evidence suggests that climate change risk may increase financial distress risk. The higher risk of financial distress affects CEOs directly as a significant fraction of their long-term wealth is tied to firm performance, e.g., pensions, retirement benefits, and deferred compensation (Chang, Hayes, and Hillegeist, 2016). CEO's wealth in equity-based holdings is also affected as stock and option values are lower as climate risk is associated with lower equity valuation. Furthermore, if climate risk increases the likelihood of financial distress[6], CEOs face potential reputation losses by having their firms become financially distressed. A reduction in managerial reputation negatively affects the outside job opportunities of the CEOs, thus lowering their expected future remuneration. According to Gilson and Vetsuypens (1993), CEOs who keep their employment at financially distressed firms typically experience a significant reduction in salary and bonus.

Aside from the obvious physical risk of climate change, firms also need to factor in transition risk arising from changes in consumer awareness, technologies, and regulations. The associated costs are estimated to be in trillion of dollars. These issues will make the CEO spend considerable extra effort to right the ship. Hence, she may negotiate for a pay rise to compensate for the increased effort. According to Frydman and Jenter (2010), changes in corporations' technologies, characteristics, and product markets in the last 30 years have enhanced the influence of CEO talent and effort on the value of corporations, which results in greater optimal levels of CEO pay. As climate change poses significant threats and uncertainty to financial markets and businesses, CEOs are expected to have appropriate skills and exert significant effort in transit their firms to more sustainable practices. In turn, the reward for success must induce the CEO to put in enough effort to implement change.

Overall, I expect CEOs of high climate risk firms demand higher pay to compensate for their increased turnover risk, reductions in their personal wealth, and their increased effort. I form my first hypothesis as follows:

H1: CEO total compensation is positively associated with the firm's climate change exposure.

The literature shows that climate change can have adverse effects on macroeconomic conditions (e.g., Gallup, Sachs, and Mellinger, 1999; Dell et al., 2009) and the performance of financial markets (Choi, Gao, and Jiang, 2020; Engle et al., 2020). More specifically, firms that have high climate risk suffer lower equity valuation (Matsumura, Prakash, and Vera-Munoz, 2014; Choi, Gao, and Jiang, 2020; Berkman, Jona, and Sodestrom, 2021). Choi et al. (2020) find evidence that firms with higher carbon emissions underperform when the weather is abnormally hot. These changes in the equity market are because investors become aware of climate change threats and factor climate risk into their investment decisions. As a result, it can negatively impact CEOs' equity-based holdings of firms with high climate risk. Due to the potential decreases in stock returns and values of stock options, CEOs of these firms may prefer short-term compensation to long-term incentives. Based on this idea, I form my second hypothesis is as follows:

H2: CEOs of high climate risk firms receive lower equity-based compensation and higher cash compensation.

[6] The case of the major Californian utility PG&E - "the first climate-change bankruptcy".

CEO compensation is the result of negotiation between CEOs and boards. The literature generally suggests the managerial power hypothesis as an explanation for high CEO compensation (Frydman and Jenter, 2010). Murphy (1999, 2013) suggest that even though CEOs are not explicitly involved in the pay-setting process, they can still influence the compensation committee through different means. The managerial power hypothesis posits that when monitoring is insufficient and ineffective, CEOs have more bargaining power to negotiate for an inefficiently high level of total pays (Bebchuk and Fried, 2004). Core, Holthausen, and Larcker (1999) argue that CEO compensation is higher if the CEO has interlocking relations with directors or is involved in the new directors' nomination process. Cyert, Kang, and Kumar (2002) find that CEOs who also serve as chairman of the board receive higher compensation. Bertrand and Mullainathan (1999) show a significant increase in CEO compensation following antitakeover legislations, which reduce threats of hostile takeovers from outside raiders. Chhaochharia and Grinstein (2009) study the Sarbanes-Oxley Act and find that CEO compensation decreases significantly following more stringent board oversight. Dai et al. (2020) suggest that CEO bargaining power helps explain the pay premium to CEOs for threats of terrorist attacks. Regarding climate risk, CEOs may be able to negotiate for a larger pay premium if they have more bargaining power due to weak corporate governance.

H3a: The pay premium in CEO compensation at high climate exposure firm increases with CEO power.

Another possible explanation for the pay premium is competitive pay. Murphy and Zabojnik (2004, 2007) and Frydman (2007) argue that the rise in CEO compensation results from the increased demand for skilled and talented CEOs. Also, Frydman and Jenter (2010) suggest that managerial mobility has increased markedly over the past three decades. Gao, Luo, and Tang (2015) find that firms significantly increase their incumbent executives’ compensation after losing executives to other firms. The increase is larger when labor market mobility is greater. Deng and Gao (2013) argue that competitive labor market forces help explain the documented pay premium for the low quality of life. When the firm has high climate risks that expose the CEO to future losses and require considerable additional effort, it may need to increase the CEO’s pay or risk losing her to other firms. The likelihood of losing the CEO may be higher if the firm is in a competitive industry or high labor mobility markets.

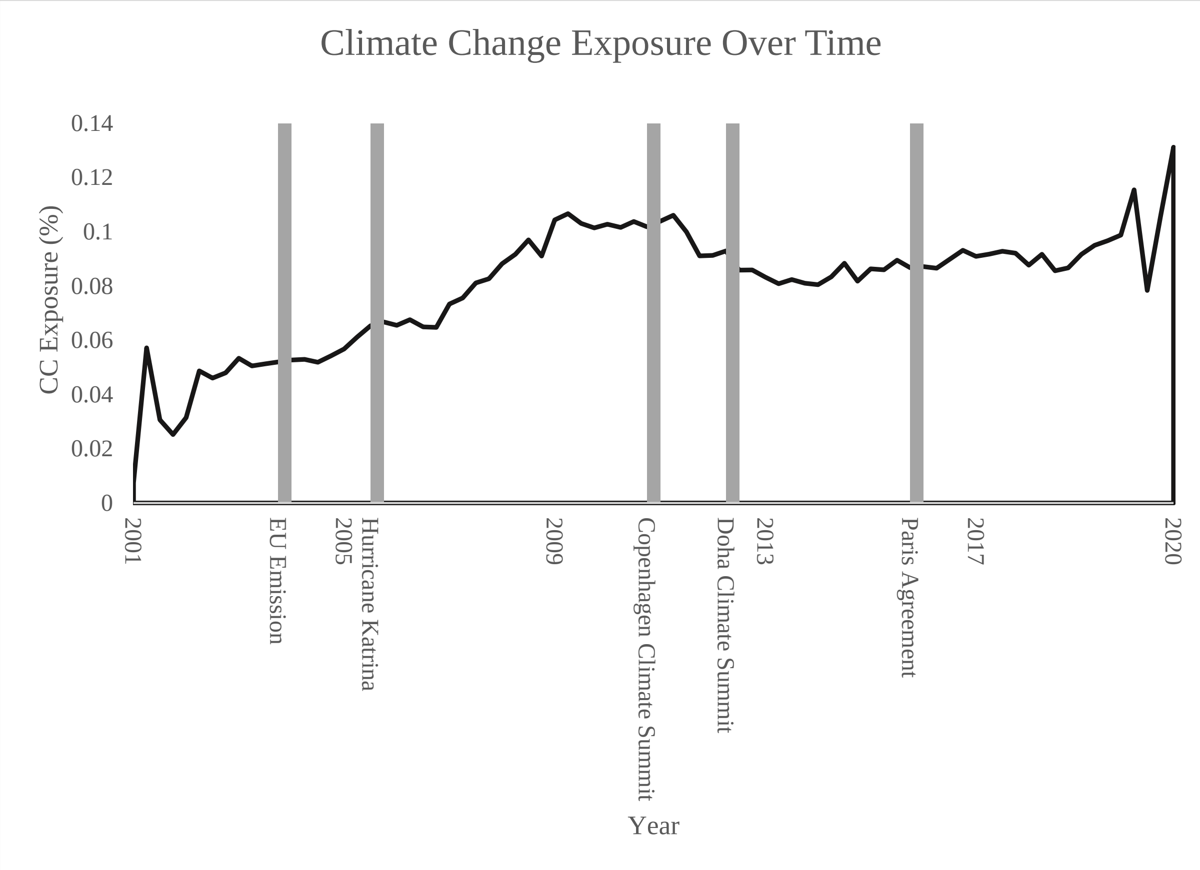
H3b: The effect of climate risk on CEO compensation is stronger on firms with a more competitive labor market.

4. Data and variable constructions

My sample consists of U.S firm-year observations from 2001 to 2020. I obtain stock price data from the Center for Research in Security Prices (CRSP). Annual firm financial data are retrieved from Compustat. I obtain the compensation data from Execucomp. Firm-year climate change exposure is from Sautner, van Lent, Wilkov, and Zhang (2021). The final sample includes 28,585 firm-year observations with non-missing information from CRSP, Compustat, Execucomp, and climate change exposure data.

Figure 1. Climate change exposure over time

This figure plots the annual averages of climate change exposure of all firms from 2001 to 2020. CC Exposure (in percentage points) is the climate change exposure measure from Sautner et al. (2021).



4.1. Climate exposure measure

My proxy for firm-level climate exposure is constructed by Sautner et al. (2021). The firm-specific and time-varying climate exposure measure is created by counting signal word combinations (bigrams) from earnings conference call transcripts. In particular, the climate change exposure is measured using the frequency with which a set of climate change bigrams occurs in an earnings call transcript, divided by the transcript length. The measure captures firms' exposure to various aspects associated with climate change, including physical climate shocks, carbon emissions, and regulatory risk

Figure 1 displays the average time-series trend in firm-level climate change exposure. The trend suggests that there was a substantial increase in attention to climate risk from 2001 to 2011. There was a downward trend from 2011 to 2016. The period covers the unsuccessful Doha Climate Summit 2012. Firm-level climate exposure started rising again, to a new height, following the Paris Agreement in 2015.

Sautner et al. (2021) argue that the benefits of using earnings conference calls include less information manipulation by the management. Bingler, Kraus, and Leippold (2021) argue that annual reports or press releases do not offer meaningful climate-related discussion at the firm level as they are

Table 1. Summary statistics

This table presents the summary statistics for the variables in my analyses. The sample consists of 28,582 firm-year observations between 2001 and 2020 from the merged Compustat/CRSP/ExecuComp dataset with available climate change exposure data from Sautner, van Lent, Vilkov, and Zhang (2021). *Total pay* is the total compensation variable TDC1 from Execucomp. *CC Exposure* is the measure that identifies the firm-level exposure to climate change using word combinations for earnings conference calls (Sautner, van Lent, Vilkov, and Zhang, 2021). *Size* is the natural logarithm of total assets. *M/B* is the ratio of market value of equity to book value of equity. *Leverage* is the ratio of total debts to total assets. *ROA* is the ratio of total earnings to total assets. *Cash* is the ratio of total cash reserves to total assets. *Sales growth* is the annual growth in total sales. *Stock return* is the buy-and-hold stock return of the financial year. *Stock return volatility* is the stock return volatility of the financial year. *Tangibility* is the ratio of net property, plant, and equipment to total assets. *CEO age* is the current age of the CEO in a financial year. All continuous variables are winsorized at the 1st and 99th percentiles.

Variable	Mean	SD	10th percentile	Median	90th percentile	Observation
Total pay (in $000)	5,934.87	7,907.65	974.698	3,924.30	12,768.70	28,585
ln(Total pay)	8.208	0.999	6.883	8.275	9.455	28,585
CC Exposure (%)	0.084	0.180	0.000	0.027	0.189	28,585
Size	7.876	1.735	5.722	7.754	10.244	28,585
M/B	3.061	5.450	0.864	2.159	6.281	28,585
Leverage	0.239	0.200	0.000	0.217	0.505	28,585
ROA	0.033	0.105	-0.044	0.041	0.125	28,585
Cash	0.155	0.167	0.012	0.092	0.405	28,585
Sales growth	0.083	0.224	-0.127	0.061	0.304	28,585
Stock return	0.137	0.465	-0.360	0.097	0.629	28,585
Stock return volatility	0.410	0.219	0.202	0.354	0.687	28,585
Tangibility	0.240	0.236	0.016	0.155	0.637	28,585
CEO age	56.142	7.101	47	56	65	28,585

mostly cheap talks with cherry-picking information disclosures. Earnings calls, on the other hand, are key and official corporate events where analysts are able to ask probing questions to press the issues.

4.2. Compensation data

I collect CEO compensation data from Execucomp, including the total pay and individual components of compensation. I follow the literature and measure the total compensation of the CEO by utilizing Execucomp item *TDC1* (Chhaochharia and Grinstein, 2009; Peters and Wagner, 2014; Focke, Maug, and Niessen-Ruenzi, 2017; Dai et al., 2020). The total compensation includes salary, bonus, stock grants, option grants, and other forms of compensations. The primary dependent variable is the natural logarithm of TDC1, *ln(Total Pay)*. To test the effect of climate exposure on each CEO pay component, I further obtain the total cash pay, salary, bonuses, and fair values of options and stocks granted from Execucomp. I then study the relation between climate change exposure and the natural logarithm of the pay components following prior studies (e.g., Otto, 2014; Hoi, Wu, and Zhang, 2019; Dai, Rau, Stouraitis, and Tan 2020).

4.3. Firm data

I collect firm-specific data from 2001 to 2020 to construct dependent and control variables from Compustat and CRSP. I follow important studies on CEO compensation in the literature to form a set of control variables in my regression models (e.g., Otto, 2014; Huang, Jiang, Lie, and Que, 2017; Hoi, Wu, and Zhang, 2019; Dai et al., 2020). The control variables include: natural logarithm of total assets (*Size*), the ratio of the market value of equity to the book value of equity (*M/B*), the ratio of total debts to total assets (*Leverage*), the ratio of total earnings to total assets (*ROA*), the ratio of total cash reserves to total assets (*Cash*), the annual growth in total sales (*Sales growth*), the buy-and-hold stock return of the financial year *(Stock return*), the stock return volatility of the financial year (*Stock return volatility*), the ratio of net property, plant, and equipment to total assets (*Tangibility*), and age of the CEO (*CEO age*).

Table 1 presents the summary statistics of the variables in my sample. All continuous variables are winsorized at the 1^{st} and 99^{th} percentiles. I show that the mean total compensation is 5,934.87 (in $ thousands). By comparison, Otto (2014) reports the mean of total compensation of 5,664 (in $ thousands). On average, firms in my sample have a positive return on assets (0.033), annual sales growth (0.083), and annual stock return (0.137). The average CEO age is 56 years old.

5. Research design

To evaluate the effect of climate risk on CEO total pay, I estimate the following firm-panel Ordinary Least Square regression model:

$$ln(Total\ pay)_{i,t} = \beta_0 + \beta_1 CC\ Exposure_{i,t} + \beta\ Control_{i,t} + Fixed\ Effects + \epsilon_{i,t} \quad (1),$$

where $ln(Total\ pay)_{i,t}$ refers to the natural logarithm of CEO total compensation of firm *i* in year *t*. I follow previous empirical research to use the natural logarithm of this measure to minimize the effect of outliers (Chhaochharia and Grinstein, 2009; Peters and Wagner, 2014; Focke et al., 2017; Dai et al., 2020). $Climate\ Exposure_{i,t}$ is a proxy of climate risk measure of firm *i* in year *t* from Sautner et al. (2021). I employ the set of control variables discussed in section 4.3. I add firm fixed effects to capture time-invariant differences across firms (Gormley and Matsa, 2016). Year fixed effects are employed to control for nationwide shocks in each year (Gormley and Matsa, 2016). Regression standard errors are adjusted for clustering at the firm level to address within-firm serial correlations (Woolridge, 2015). A positive and statistically significant coefficient on $Climate\ Exposure_{i,t}$ will suggest that CEO of firms that face high climate change exposure earn higher total pay.

6. Results

6.1. Climate risk and CEO compensation

I first investigate whether climate risk influences CEO total pay in this section. Table 2 reports the baseline estimation results of the relation between climate change exposure and CEO total compensation. I find that climate change exposure is significantly and positively associated with CEO total pay in all regression models. Model 1 is the univariate analysis of the relation. Without controlling for firm or CEO characteristics, or any fixed effects, I show that climate change exposure is positively associated with CEO total pay at the 1% confidence level. In Model (2), I include firm fixed effects and year fixed effects. With firm fixed effects removing any fixed differences across firms, the coefficient (0.117) on $CC\ Exposure_{i,t}$ suggests that within each firm, climate change exposure and CEO total pay are positively correlated.

Model (3) includes firm-specific and CEO-specific control variables as well as firm and year fixed effects. The coefficient on $CC\ Exposure_{i,t}$ is 0.119 and statistically significant at the 1% confidence level. The magnitude of the relation is economically meaningful. A one-standard-deviation (0.18) increase in *CC Exposure* is associated with an increase of 2.16% ($e^{0.18 \times 0.119} - 1$) in CEO total compensation. With the sample average dollar values of CEO total compensation of $5.934 million, the 2.16% increase corresponds to an annual increase of approximately $128,477 in total pay.

The coefficient on *Size* is significantly positive, which is consistent with empirical evidence in prior research, documenting that CEO compensation depends on firm size (Rosen, 1981; Himmelberg and Hubbard, 2000; Gabaix and Landier, 2008). Consistent with prior studies documenting a positive relation between firm performance and CEO compensation, the coefficients on *ROA*, *Sales growth*, and *Stock return* are positive and highly significant at the 1% confidence level. The negative and significant correlation between *Stock return volatility* and CEO pay is also found in prior studies, e.g., Peters and Wagner (2014) and Hoi, Wu, and Zhang (2019). In general, the control variables' coefficients are consistent with those in prior literature (e.g., Core et al., 1999; Peters and Wagner, 2014; Focke, Maug, and Niessen-Ruenzi, 2017; Dai et al., 2020). The adjusted R-squared of Model (3) is 71.3%, indicating that the model explains the variations in *ln(Total pay)* reasonably well.

I further control for industry time-varying factors for the concern that the higher CEO pay may be a product of changing industry or product market landscapes. I control for industry factors such as performance, growth opportunities, competition, concentration, or product similarity. I measure industry performance and growth opportunities as the industry (two-digit SIC codes) averages of return on assets, sales growth, and Tobin's Q. Industry competition (*Fluidity*) and product similarity (*Product Similarity*) are from Hoberg, Phillips, and Prabhala (2013) and Hoberg and Phillips (2016), respectively.[7] Industry concentration is measured using the Herfindahl-Hirschman Index of market

[7] I thank Gehard Hoberg for sharing the fluidity and similarity data.

Table 2. Climate change and CEO total compensation

This table presents the results of OLS regression models that investigate the relation between climate change exposure and CEO total compensation in the sample from 2001 to 2020. The dependent variable is the natural logarithm of CEO total compensation, *ln(Total Pay)*. The key independent variable is *CC Exposure*, which is the measure that identifies the firm-level exposure to climate change using word combinations for earnings conference calls (Sautner, van Lent, Vilkov, and Zhang, 2021). The firm and CEO control variables include: natural logarithm of total assets (*Size*), the ratio of market value of equity to book value of equity (*M/B*), the ratio of total debts to total assets (*Leverage*), the ratio of total earnings to total assets (*ROA*), the ratio of total cash reserves to total assets (*Cash*), the annual growth in total sales (*Sales growth*), the buy-and-hold stock return of the financial year (*Stock return*), the stock return volatility of the financial year (*Stock return volatility*), the ratio of net property, plant, and equipment to total assets (*Tangibility*), and age of the CEO (*CEO age*). I include firm fixed effects to account for time-invariance differences across firms and year fixed effects to account for time trends. Heteroskedasticity-robust standard errors (in parentheses) are adjusted for clustering at the firm level. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% confidence levels, respectively.

	ln(Total Pay)				
	(1)	(2)	(3)	(4)	(5)
CC Exposure	0.101***	0.117**	0.119***	0.120***	0.190***
	(0.033)	(0.045)	(0.043)	(0.045)	(0.052)
Size			0.329***	0.331***	0.272***
			(0.015)	(0.016)	(0.021)
M/B			0.003***	0.004***	0.004***
			(0.001)	(0.001)	(0.001)
Leverage			-0.331***	-0.357***	-0.358***
			(0.051)	(0.053)	(0.073)
ROA			0.244***	0.207***	0.261**
			(0.068)	(0.069)	(0.101)
Cash			0.132**	0.138**	0.032
			(0.064)	(0.066)	(0.088)
Sales growth			0.113***	0.125***	0.195***
			(0.021)	(0.022)	(0.030)
Stock return			0.079***	0.075***	0.086***
			(0.009)	(0.009)	(0.012)
Stock return volatility			-0.209***	-0.211***	-0.182***
			(0.040)	(0.043)	(0.058)
Tangibility			0.103	0.062	-0.060
			(0.097)	(0.098)	(0.132)
CEO age			0.001	0.001	-0.001
			(0.001)	(0.001)	(0.002)
Industry sales growth				0.004***	
				(0.001)	
Industry ROA				-0.026	
				(0.052)	
Industry Tobin's Q				0.000	
				(0.001)	
Fluidity				-0.002	
				(0.003)	
Product similarity				-0.001	
				(0.001)	
HHI				0.102	
				(0.245)	
Duality					0.045*
					(0.025)
Institutional ownership					0.115**
					(0.047)
Co-opted independence					0.133***
					(0.031)
Analyst following					0.002
					(0.002)
Firm Fixed Effects	No	Yes	Yes	Yes	Yes
Year Fixed Effects	No	Yes	Yes	Yes	Yes
Observation	30785	30728	28585	26623	18075
Adjusted R-squared	0.000	0.683	0.713	0.714	0.717

share (Gao, Luo, and Tang, 2015). Column (4) of Table 2 reports the results. The coefficient on *CC Exposure* remains significant at the 1% confidence level and qualitatively similar.

Core et al. (1999), Cyert et al. (2002), Bebchuck and Fried (2004), and Chhaochharia and Grinstein (2009) present evidence that corporate governance is an important determinant of CEO compensation. To assess the robustness of the relation between climate exposure and CEO compensation, I further control for corporate governance of firms in my sample. The proxies of corporate governance are CEO/Chairman duality (*Duality*), the percentage of institutional ownership in the firm (*Institutional ownership*), the fraction of independent directors appointed after the CEO assumed office (*Co-opted independence*), and the number of analysts following (*Analyst following*). Cyert, Kang, and Kumar (2002) find that CEO total compensation is higher when also serving as chairman of the board, while Coles, Daniel, and Naveen (2014) show the higher pay for CEOs at firms with a higher fraction of directors appointed to the board after the CEO assumed office, which indicates weak monitoring.[8] Hartzell and Starks (2003) find that institutional investors are effective monitors in reducing agency problems in CEO compensation. Chen, Harford, and Lin (2015) argue that analysts serve a role in external monitoring. Their findings are that CEO compensation increases significantly after exogenous decreases in analyst following. Column (5) of Table 2 reports the estimation results of the regression models with the corporate governance proxies as additional control variables. The coefficient on CC Exposure is 0.190 and statistically significant at the 1% confidence level.

To summarize, the regression results in this section show the positive relation between climate change exposure and CEO total compensation after controlling for firm and year fixed effects, firm-level characteristics, industry conditions, and corporate governance. These findings lend robust support to Hypothesis 1 that CEOs of firms with higher climate risk earn higher total compensation than CEOs of firms with lower climate risk.

6.2. Identifications

In this section, I address endogeneity concerns in the relation between climate change exposure and CEO compensation to establish causality. The possible endogeneity concerns include unobservable factors omitted in the regression models. These factors may lead to changes in both climate change exposure and CEO compensation, which renders the documented position relation spurious. There may also be concerns that CEOs may overstate or understate the level of actual sensitivity to climate change in their earnings conference calls.

I exploit natural disasters, including earthquakes, wildfires, hurricanes, storms, and more, as a source of exogenous shocks to climate change exposure. Natural disasters are clean and exogenous events to firms and managers that exacerbate climate risks of firms headquartered in the affected areas (Cortes and Strahan, 2017; Dessaint and Matray, 2017). Li, Lin, and Lin (2021) also use natural disasters to

[8] I thank Latitha Naveen for sharing the data.

Table 3. Difference-in-differences analysis

This table presents the results of a difference-in-differences analysis that investigate the impact of natural disaster events on CEO total compensation in the sample from 2001 to 2020. The dependent variable is the natural logarithm of CEO total compensation, *ln(Total Pay)*. Panel A presents the comparison of firm characteristics of treated and control firms after propensity score matching. Panel B presents the difference-in-differences results using natural disaster events. The firm and CEO control variables include: natural logarithm of total assets (*Size*), the ratio of market value of equity to book value of equity (*M/B*), the ratio of total debts to total assets (*Leverage*), the ratio of total earnings to total assets (*ROA*), the ratio of total cash reserves to total assets (*Cash*), the annual growth in total sales (*Sales growth*), the buy-and-hold stock return of the financial year (*Stock return*), the stock return volatility of the financial year (*Stock return volatility*), the ratio of net property, plant, and equipment to total assets (*Tangibility*), and age of the CEO (*CEO age*). I include firm fixed effects to account for time-invariance differences across firms and year fixed effects to account for time trends. Heteroskedasticity-robust standard errors (in parentheses) are adjusted for clustering at the firm level. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% confidence levels, respectively.

Panel A. Matching statistics

Variable	Treated	Control	*p*-value of difference
Size	7.679	7.711	0.458
M/B	3.068	3.027	0.744
ROA	0.032	0.029	0.352
CEO age	55.715	55.796	0.652

Panel B. Difference-in-differences estimation results

	ln(Total pay)	
	(1)	(2)
Treat × Post	0.026**	0.022*
	(0.012)	(0.012)
Size		0.332***
		(0.020)
M/B		0.004**
		(0.001)
Leverage		-0.380***
		(0.070)
ROA		0.226**
		(0.093)
Cash		0.223**
		(0.088)
Sales growth		0.180***
		(0.030)
Stock return		0.075***
		(0.014)
Stock return volatility		-0.217***
		(0.053)
Tangibility		0.162
		(0.134)
CEO age		0.001
		(0.002)
Firm Fixed Effects	Yes	Yes
Year Fixed Effects	Yes	Yes
Observation	12518	12411
Adjusted R-squared	0.682	0.708

establish causal interpretations of the effect of climate change on corporate innovation in a global setting. Using SHELDUS's Presidential Disaster Declaration events, I employ the difference-in-differences framework to investigate the causal effect of climate risks on CEO compensation. The advantage of this approach is that it accounts for unobservable factors that may drive the positive relation between climate risk and CEO compensation. The underlying assumption of the difference-in-differences framework is that before the exogenous shock that affects treated firms, treated firms and controls firms follow a parallel trend.

I start the analysis by identifying firms that are headquartered in areas that were affected by Presidential Disaster Declaration events. SHELDUS provides all counties that were affected by disaster events. I match firms in my sample with affected counties using ZIP codes of their headquarters. Coval and Moskowitz (2001), Brown, Ivkovic, and Weisbenner (2008), Pirinsky and Wang (2006), and Chaney, Sraer, and Thesmar (2012) show that the headquarter is the centre of the firm's operations and business core activities. To ensure treated firms and control firms are similar before natural disaster events, I utilize the propensity score matching technique. According to Rosenbaum and Rubin (1983), treated and control subjects matched by similar propensity scores have similar distributions for covariates. I use a two-to-one nearest neighbor matching estimator. I exclude treated firms from the matching pool of control firms. Covariates used in the propensity score matching procedure are *Size, M/B, ROA*, and *CEO age*. I conduct the matching in the year before (*t-1*) the natural disaster. Treated and control firms must have the same two-digit SIC codes. To ensure the quality of matching and the parallel assumption of the difference-in-differences framework, I compare the characteristics of treated and control firms before natural disaster events.

Panel A of Table 3 presents the matching characteristics of treated and control firms in the year before natural events. I also conduct *t*-tests to examine if the characteristics are statistically different. I show that treated and control firms are similar in firm size (*Size*), equity valuation (*M/B*), profitability (*ROA*), and CEO age. The *p*-values of *t*-tests suggest that the differences are statistically insignificant. The evidence suggests that the parallel trend assumption is not violated in my analysis.

To estimate firms' response to natural disaster events, I compare changes in CEO compensation around the time of new disaster events. Indicator variable *Treat* equals one if a firm is headquartered in the county affected by natural disasters, and 0 otherwise. Indicator variable *Post* equals one if it is the financial year after the disaster year, and 0 if it is the financial year before the disaster year. I estimate the following regression model:

$$ln(Total\ pay)_{i,t} = \beta_0 + \beta_1 Treat \times Post_{i,t} + \beta\ Control_{i,t} + Fixed\ Effects + \epsilon_{i,t}.$$

I include firm fixed effects to capture any time-variant differences across firms and year fixed effects to account for nationwide shocks in each year. As a result, indicator *Treat* is absorbed by firm fixed effects and indicator *Post* is absorbed by year fixed effects. Coefficient β_1 on the interaction term $Treat \times Post_{i,t}$ is the difference-in-differences estimator that captures the effect of natural disasters on

CEO compensation. Standard errors are adjusted for clustering at the firm level to control for serial correlations within firms. Gormley and Matsa (2011) argue that including control variables in the difference-in-differences estimation may lead to a biased estimate of β_1 as these firm characteristics may also be affected by the shocks. For example, natural disaster events may lead to higher leverage or lower sales growth. Therefore, I will estimate the above model with and without control variables.

The difference-in-differences estimation results are reported in Panel B of Table 3. In Column (1), the coefficient on the difference-in-difference estimator $Treat \times Post_{i,t}$ is 0.026 and statistically significant at the 5% confidence level. This result suggests that, on average, following a natural disaster event that increases climate risk, treated firms increase their CEO total compensation by approximately 2.6% ($e^{0.026}$ - 1), compared with firms unaffected by natural disasters. In Column (2), I include the time-varying firm-specific control variables. The coefficient on $Treat \times Post_{i,t}$ is 0.022 and statistically significant at the 10% confidence level.

In summary, using Presidential Disaster Declaration events as exogenous shocks that exacerbate climate risk, I find that CEO compensation of treated firms increases significantly. This result suggests that the positive relation between climate change exposure and CEO compensation is likely causal.

6.3. Possible channels

Since I identify a premium for climate exposure in CEO compensation, it is also essential to understand what drives this premium. The literature generally suggests two channels for a pay rise: CEO power and competitive pay (Frydman and Jenter, 2010). The managerial power hypothesis posits that when firms have weak corporate governance, CEOs have more bargaining power to negotiate for an inefficiently high level of total pays (Bebchuk and Fried, 2004). On the other hand, Murphy and Zabojnik (2004, 2007) and Frydman (2007) argue that the rise in CEO compensation results from an increase in demand for skilled and talented CEOs.

6.3.1. Managerial power

I first investigate whether powerful CEOs can extract compensation premiums when their firms face high exposure to climate risk. The effect of climate exposure on compensation should be stronger for powerful CEOs or poorly governed firms. When firms bear high sensitivity to physical climate risk, powerful CEOs may view this climate exposure as an uncontrollable risk and use their bargaining power to boost their pay for taking the additional risk. If climate exposure is controllable (e.g., transition risk), which requires CEOs to put additional efforts, powerful CEOs may exercise their bargaining power to negotiate for a higher pay premium.

The corporate governance proxies are CEO/Chairman duality (*Duality*), CEO age, the percentage of institutional ownership in the firm (*Institutional ownership*), number of analysts following (*Analyst following*), corporate governance index (*G-index*), and the fraction of independent directors appointed after the CEO assumed the office (*Co-opted independence*). Cyert, Kang, and Kumar (2002) show that CEO total compensation is higher when also serving as chairman of the board, while Coles, Daniel, and Naveen (2014) find higher pay for CEOs at firms with a higher fraction of directors appointed to the board after the CEO assumed office, which indicates weak monitoring. Hartzell and Starks (2003) find that institutional investors are effective monitors in reducing agency problems in CEO compensation. Chen, Harford, and Lin (2015) argue that analysts serve a role in external monitoring. Their findings are that CEO compensation increases significantly after exogenous decreases in analyst following. Gompers, Ishii, and Metrick (2003) construct the Governance Index (G-index) that measures shareholder rights. Firms with a lower G-index have stronger shareholder rights, which results in higher firm value and performance. I also use CEO age as the older CEO may be more influential.

I split the sample using the annual median values of the corporate governance variables. I then create indicators for each of the corporate governance proxies. *Low institutional ownership* or *Low analyst following* takes the value of one if the firm's institutional ownership or the number of analysts following is below the sample of the year and zero otherwise. *Old CEO age*, *High G-index*, or *High co-opted independence* equals one if the governance index, CEO age, or co-opted independence is above the sample of the year and zero otherwise. *Duality* is a binary variable that equals one if the CEO also serves as chairman of the board and zero otherwise. If these indicator variables equal one, the firm is classified as having weak corporate governance. To understand the impact of corporate governance or CEO power on the relation between climate change exposure and CEO compensation, I interact *CC Exposure* with each of the indicator variables.

Panel A of Table 4 presents the results for the effect of climate risk on more powerful CEOs' compensation. Column 1 reports a positive and significant on *CC Exposure* × *Duality*, indicating that the effect of climate change exposure is more pronounced when CEO holds dual positions. Being both CEO and chairperson means that the job is more complex and challenging and thus requires higher pay. Additionally, holding both positions may allow CEOs to have much more bargaining power over the board and earn additional rent extraction (Cyert, Kang, and Kumar, 2002). In column 2, the interaction term between *CC Exposure* and *Older CEO age* is positive and statistically significant at the 1% level, suggesting that older CEOs earn a higher compensation premium than younger CEOs when climate risk is high.

The results in Column (3) and Column (4) show that CEOs are able to negotiate for the higher climate risk premium in compensation when external monitoring is weak as I document significant and positive coefficients on the interaction terms *CC Exposure* × *Low Institutional ownership* and *CC Exposure* × *Low analyst following*. In a smaller sample due to the availability of the G-index, I find a stronger relation between climate change exposure and CEO compensation when shareholder rights are weak. I do not document the significant role of co-opted independence in the climate change - CEO pay relation.

Table 4. Channels of the climate change – CEO compensation relation

This table presents the results of OLS regression models that investigate channels of the relation between climate change exposure and CEO total compensation in the sample from 2001 to 2020. The dependent variable is the natural logarithm of CEO total compensation, *ln(Total Pay).* I investigate the role of CEO bargaining power in Panel A and competitive pay in Panel B. The key independent variable is *CC Exposure,* which is the measure that identifies the firm-level exposure to climate change using word combinations for earnings conference calls (Sautner, van Lent, Vilkov, and Zhang, 2021). In Panel A, in each model, I interact *CC Exposure* with an indicator variable for strong CEO bargaining power. In Panel B, in each model, I interact *CC Exposure* with an indicator variable for high managerial ability and competitive markets. The firm and CEO control variables include: natural logarithm of total assets (Size), the ratio of market value of equity to book value of equity (M/B), the ratio of total debts to total assets (Leverage), the ratio of total earnings to total assets (ROA), the ratio of total cash reserves to total assets (Cash), the annual growth in total sales (Sales growth), the buy-and-hold stock return of the financial year (Stock return), the stock return volatility of the financial year (Stock return volatility), the ratio of net property, plant, and equipment to total assets (Tangibility), and age of the CEO (CEO age). I include firm fixed effects to account for time-invariance differences across firms and year fixed effects to account for time trends. Heteroskedasticity-robust standard errors (in parentheses) are adjusted for clustering at the firm level. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% confidence levels, respectively.

Panel A. CEO bargaining power

	ln(Total pay)					
	Duality	Older CEO age	Low Institutional Ownership	Low analyst following	High G index	High co-opted independence
	(1)	(2)	(3)	(4)	(5)	(6)
CC Exposure	0.053	0.045	0.175***	0.199***	-0.007	0.203***
	(0.057)	(0.052)	(0.052)	(0.051)	(0.343)	(0.059)
Strong CEO power	0.040*	0.021	-0.090***	-0.079***	-0.056	0.056***
	(0.022)	(0.016)	(0.014)	(0.017)	(0.076)	(0.015)
CC Exposure × Strong CEO power	0.119**	0.130***	0.097*	0.145***	0.609*	-0.037
	(0.059)	(0.042)	(0.054)	(0.052)	(0.364)	(0.049)
Size	0.329***	0.330***	0.324***	0.315***	0.376***	0.333***
	(0.015)	(0.015)	(0.016)	(0.017)	(0.089)	(0.017)
M/B	0.003***	0.003***	0.003***	0.003***	0.030***	0.003***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.009)	(0.001)
Leverage	-0.329***	-0.331***	-0.347***	-0.351***	-0.791***	-0.372***
	(0.051)	(0.051)	(0.055)	(0.058)	(0.260)	(0.057)
ROA	0.244***	0.242***	0.224***	0.208***	-0.066	0.217***
	(0.068)	(0.068)	(0.069)	(0.073)	(0.298)	(0.072)
Cash	0.131**	0.130**	0.127*	0.140**	0.514*	0.138**
	(0.064)	(0.064)	(0.066)	(0.069)	(0.307)	(0.069)
Sales growth	0.112***	0.114***	0.124***	0.136***	0.198**	0.133***
	(0.021)	(0.021)	(0.022)	(0.022)	(0.089)	(0.022)
Stock return	0.078***	0.079***	0.075***	0.080***	0.147**	0.075***
	(0.009)	(0.009)	(0.009)	(0.010)	(0.063)	(0.010)
Stock return volatility	-0.208***	-0.210***	-0.199***	-0.220***	-0.045	-0.202***
	(0.040)	(0.040)	(0.044)	(0.045)	(0.231)	(0.046)
Tangibility	0.099	0.103	0.051	0.054	-0.046	0.012
	(0.097)	(0.097)	(0.099)	(0.105)	(0.379)	(0.104)
CEO age	0.000	-0.001	0.001	0.001	-0.007	0.001
	(0.001)	(0.002)	(0.001)	(0.001)	(0.005)	(0.001)
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Obs	28585	28585	26511	25046	2316	24746
Adj.R-sqr	0.713	0.713	0.711	0.710	0.684	0.715

Panel B. Competitive pay

	ln(Total pay)				
	High managerial ability	High fluidity	Low HHI	High similarity	More local rivals
	(1)	(2)	(3)	(4)	(5)
CC Exposure	0.056	0.111**	0.154***	0.109**	0.130**
	(0.071)	(0.054)	(0.051)	(0.055)	(0.054)
Competitive market	0.006	-0.012	-0.020	0.018	0.046*
	(0.014)	(0.015)	(0.021)	(0.019)	(0.028)
CC Exposure × Competitive market	0.034	0.017	-0.089	0.022	-0.043
	(0.084)	(0.060)	(0.067)	(0.060)	(0.070)
Size	0.341***	0.331***	0.329***	0.329***	0.320***
	(0.019)	(0.016)	(0.015)	(0.016)	(0.016)
M/B	0.004***	0.004***	0.003***	0.003***	0.004***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Leverage	-0.383***	-0.356***	-0.332***	-0.357***	-0.344***
	(0.061)	(0.053)	(0.051)	(0.053)	(0.054)
ROA	0.245***	0.205***	0.247***	0.218***	0.212***
	(0.077)	(0.069)	(0.068)	(0.069)	(0.069)
Cash	0.165**	0.139**	0.127**	0.133**	0.159**
	(0.072)	(0.066)	(0.064)	(0.066)	(0.067)
Sales growth	0.134***	0.125***	0.113***	0.123***	0.120***
	(0.024)	(0.022)	(0.021)	(0.022)	(0.022)
Stock return	0.069***	0.076***	0.079***	0.076***	0.074***
	(0.010)	(0.009)	(0.009)	(0.009)	(0.010)
Stock return volatility	-0.116**	-0.212***	-0.210***	-0.215***	-0.212***
	(0.046)	(0.044)	(0.040)	(0.043)	(0.043)
Tangibility	0.015	0.062	0.093	0.079	0.075
	(0.119)	(0.098)	(0.097)	(0.098)	(0.111)
CEO age	0.001	0.001	0.001	0.001	0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observation	20511	26623	28585	26953	24568
Adjusted R-squared	0.702	0.714	0.713	0.714	0.715

In summary, the results in Panel A of Table 4 support Hypothesis 3A that the pay premium in CEO compensation at high climate exposure firm increases with CEO power.

6.3.2. Competitive pay

I turn to examine whether the effect of climate risk on CEO compensation is more pronounced if firms face competitive product or labor mobility markets. In a competitive market, CEOs with high managerial ability tend to receive larger compensation (Graham, Li, and Qiu, 2009, Frydman and Jenter, 2010). I use five proxies to measure CEO ability and market competition, including industry competition, managerial ability, the number of local rivals, the Herfindahl-Hirschman Index (HHI) to measure industry concentration, and product similarity. I utilize the managerial ability measure from Demerjian, Lev, and McVay (2012), which captures the proficiency of a manager in generating revenues.[9] Hoberg, Phillips, and Prabhala (2014) develop the fluidity measure that captures the product market threats of a company. The higher the product market threats, the higher the industry competition. Hoberg and Phillips (2016) develop a text-based measure of product similarity that is positively correlated with industry competition. Also, in an industry with homogenous products, it is easier for CEOs to move from one firm to another, which increases mobility. I calculate HHI as the sum of the squared market shares of all firms in the same industry. Following Chen, Gao, and Ma (2020), I count the number of firms in the same two-digit SIC code and state to measure labor mobility.

High managerial ability, *High fluidity*, *High similarity*, or *More local rivals* equals one if managerial ability, fluidity, product similarity, or the number of local rivals is above the sample median of year, and zero otherwise. *Low HHI* equals one if HHI is below the sample median of the fiscal year and zero otherwise. All these indicator variables indicate high managerial ability, more competitive product markets, and more competitive labor markets.

Panel B of Table 4 reports the results for investigating the role of competitive pay in the climate change-CEO pay relation. The estimated coefficient on *CC Exposure × High managerial ability* in Column (1) is positive but statistically insignificant. Industry competitive or product similarity does not influence the relation between climate change exposure and CEO compensation either as I do not document statistically significant coefficients on the interactions between *CC Exposure and High fluidity*, *High similarity*, or *High HHI*. *CC Exposure × More local rivals* also display similar statistical insignificance.

The results in Panel B of Table 4 show that competitive pay does not explain the climate change exposure – CEO pay relation, which does not support Hypothesis 3B. I find that CEO bargaining power is likely the channel that explains the compensation premium for CEO in firms with high climate risk.

6.4. Pay composition

I turn to investigate whether climate exposure affects each individual component of CEO pay. I follow prior studies in the literature and use the natural logarithm of the annual dollar values of CEO pay components (Otto, 2014; Francis et al., 2016; Hoi, Wu, and Zhang, 2019; Dai et al., 2020). I replace the dependent variable in Model (1) by *ln(Cash pay), ln(Salary), ln(Bonus), ln(Stock pay),* and *ln(Option pay)*. Table 5 presents the regression results of the relation between climate exposure and each CEO compensation component.

[9] I thank Peter Demerjian for sharing the managerial ability data.

Table 5. Climate change and CEO pay compositions

This table presents the results of OLS regression models that investigate the relation between climate change exposure and components of CEO compensation in the sample from 2001 to 2020. The dependent variables are: the natural logarithm of CEO total cash compensation (*ln(Cash Pay)* in Column (1)), the natural logarithm of CEO salary (*ln(Salary)* in Column (2)), the natural logarithm of CEO bonuses (*ln(Bonus)* in Column (3)), the natural logarithm of the value of CEO annual stock grants (*ln(Stock Pay)* in Column (4)), and the natural logarithm of the value of CEO annual option grants (*ln(Option Pay)* in Column (5)). The key independent variable is *CC Exposure,* which is the measure that identifies the firm-level exposure to climate change using word combinations for earnings conference calls (Sautner, van Lent, Vilkov, and Zhang, 2021). The control variables include: natural logarithm of total assets (Size), the ratio of market value of equity to book value of equity (M/B), the ratio of total debts to total assets (Leverage), the ratio of total earnings to total assets (ROA), the ratio of total cash reserves to total assets (Cash), the annual growth in total sales (Sales growth), the buy-and-hold stock return of the financial year (Stock return), the stock return volatility of the financial year (Stock return volatility), the ratio of net property, plant, and equipment to total assets (Tangibility), and age of the CEO (CEO age). I include firm fixed effects to account for time-invariance differences across firms and year fixed effects to account for time trends. Heteroskedasticity-robust standard errors (in parentheses) are adjusted for clustering at the firm level. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% confidence levels, respectively.

	ln(Cash pay)	*ln*(Salary)	*ln*(Bonus)	*ln*(Stock pay)	*ln*(Option pay)
	(1)	(2)	(3)	(4)	(5)
CC Exposure	0.109**	0.098**	0.029	0.058	-0.523**
	(0.045)	(0.048)	(0.175)	(0.226)	(0.235)
Size	0.135***	0.141***	-0.074	0.690***	0.464***
	(0.017)	(0.019)	(0.054)	(0.082)	(0.069)
M/B	0.000	0.001	-0.003	0.009***	0.004
	(0.001)	(0.001)	(0.002)	(0.004)	(0.004)
Leverage	-0.184***	-0.100*	-0.166	-0.532**	-0.402
	(0.054)	(0.051)	(0.184)	(0.263)	(0.246)
ROA	0.191***	0.127**	0.815***	-0.054	0.071
	(0.061)	(0.060)	(0.214)	(0.291)	(0.275)
Cash	-0.126	-0.093	-0.102	-0.611*	0.523*
	(0.080)	(0.085)	(0.221)	(0.345)	(0.314)
Sales growth	0.042*	-0.055**	0.461***	-0.099	0.080
	(0.023)	(0.022)	(0.073)	(0.107)	(0.092)
Stock return	0.058***	0.013*	0.288***	-0.037	-0.015
	(0.008)	(0.008)	(0.032)	(0.046)	(0.044)
Stock return volatility	-0.120**	-0.097*	-0.123	-0.831***	-0.127
	(0.054)	(0.051)	(0.142)	(0.178)	(0.166)
Tangibility	-0.138	-0.129	-0.571*	0.446	0.533
	(0.097)	(0.088)	(0.329)	(0.560)	(0.475)
CEO age	0.001	0.001	-0.004	-0.022***	-0.025***
	(0.002)	(0.002)	(0.004)	(0.006)	(0.005)
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observation	28585	28585	28585	23308	28585
Adjusted R-squared	0.645	0.686	0.526	0.471	0.430

Models (1), (2), and (3) investigate the relation between climate risk on CEO cash pay components, including total cash pay, salary, and bonuses, respectively. I uncover the positive and significant relation between climate change exposure and CEO total cash pay. The estimated coefficient on *CC Exposure* is 0.109 and statistically significant at the 5% confidence level. In Model (2), where the dependent variable is *ln(Salary)*, the estimated coefficient is 0.098 and statistically significant at the 5% level, suggesting that the base salary of CEOs at firms with higher climate risk is higher compared to those at lower climate risk firms. I do not find a significant relation between climate change exposure and bonuses, indicating that salary is the main driver of the higher total cash pay.

I study the association between climate risk and CEO equity-based pay in Model (4) and Model (5) of Table 5. I find no significant association between climate change exposure and CEO annual stock grants in Model (4). This result indicates no material change to CEO stock pay following higher climate risk. However, in Model (5), I document a negative and significant relation between climate change exposure and CEO annual option grants. The coefficient on *CC Exposure* is -0.523 and statistically significant at the 5% confidence level.

Taken together, the results in Table 5 show that CEOs at high climate risk firms prefer higher cash-based compensation, mainly from the higher salary. On the contrary, CEOs receive lower pay in option grants. The evidence supports Hypothesis 2 that CEOs prefer more short-term compensation in cash to reduce exposure to the long-term impact of climate risk on equity valuation.

6.5. Future performance

The documented compensation premiums for higher climate risk may be explained by the CEOs' concern about the adverse effects of climate change on firm future performance. Climate risk can affect CEO compensation if large portions of their compensation are tied with firm performance. Firms that face higher exposure to climate risk are expected to pay higher compensation to their CEOs to compensate for lower future pay in the context of an effective labour market (i.e., Berkovitch et al., 2000; Berk, Stanton, and Zechner, 2010). Therefore, I conduct additional tests on firm future performance to address this justification.

In Table 6, I present the results from my additional analyses, controlling for firm fixed effects, year fixed effects, and all other control variables. My proxies for firm future performance are the three-year average industry-adjusted Tobin's Q and industry-adjusted return on asset (*ROA*). These measures account for the firms' future market valuation and profitability. The results in Columns (1) and (2) show negative associations between climate change exposure and profitability and market valuation. The relations are statistically significant at the 1% confidence level, suggesting that firms with higher climate risk significantly underperform compared with the industry averages. In general, Table 6 indicates that climate exposure has severe impacts on corporate performance, which explains the adjustments in CEO compensation for climate change.

6.6. Sub-sample analysis

In this section, I conduct a sub-sample analysis to lend further support to the documented positive relation between climate change and CEO total compensation. I divide the main sample into sub-

Table 6. Climate change exposure and firm future performance

This table presents the results of OLS regression models that investigate the relation between climate change exposure and firm future performance in sample from 2001 to 2020. The dependent variables are the three-year average of industry adjusted ROA and Tobin's Q. The key independent variable is *CC Exposure,* which is the measure that identifies the firm-level exposure to climate change using word combinations for earnings conference calls (Sautner, van Lent, Vilkov, and Zhang, 2021). The firm and CEO control variables include: natural logarithm of total assets (*Size*), the ratio of market value of equity to book value of equity (*M/B*), the ratio of total debts to total assets (*Leverage*), the ratio of total earnings to total assets (*ROA*), the ratio of total cash reserves to total assets (*Cash*), the annual growth in total sales (*Sales growth*), the buy-and-hold stock return of the financial year (*Stock return*), the stock return volatility of the financial year (*Stock return volatility*), the ratio of net property, plant, and equipment to total assets (*Tangibility*), and age of the CEO (*CEO age*). I include firm fixed effects to account for time-invariance differences across firms and year fixed effects to account for time trends. Heteroskedasticity-robust standard errors (in parentheses) are adjusted for clustering at the firm level. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% confidence levels, respectively.

	Future industry adjusted ROA	Future industry adjusted Tobin's Q
	(1)	(2)
CC Exposure	-0.057***	-6.362***
	(0.015)	(1.079)
Size	-0.014***	-0.655***
	(0.004)	(0.101)
M/B	0.001**	0.028***
	(0.000)	(0.009)
Leverage	0.038***	1.316***
	(0.013)	(0.369)
ROA	0.479***	0.896**
	(0.024)	(0.366)
Cash	0.015	-0.275
	(0.015)	(0.390)
Sales growth	-0.006	-0.046
	(0.007)	(0.115)
Stock return	0.014***	0.126***
	(0.001)	(0.035)
Stock return volatility	-0.006	-1.497***
	(0.007)	(0.237)
Tangibility	-0.082***	-6.654***
	(0.025)	(1.418)
CEO age	0.001***	0.025***
	(0.000)	(0.008)
Firm Fixed Effects	Yes	Yes
Year Fixed Effects	Yes	Yes
Observation	24097	24097
Adjusted R-squared	0.784	0.327

samples for firms that may be more vulnerable to climate change. If the CEO pay premium for climate change risk indeed exists, I expect the effect to be more pronounced on firms: in top climate change exposure industries, with operations in a single country, and with more tangible assets. Firms that operate in multiple countries have the ability to operate and transfer resources between sectors and countries, which may help to minimize climate-related disruptions to their operations and lessen their vulnerability to climate risk. The effect of climate change may be more severe for firms that have operations in the U.S only, compared with firms operating in multiple countries. Firms with more tangible assets may be more affected by climate risk as they face higher physical risks of asset damages following climate events. Also, if firms decide to relocate their headquarter or main operations, it will be more difficult if they need to move considerable physical assets.

I follow the ranking of Sautner et al. (2021) to form sub-samples of firms in high and low climate exposure industries.[10] I use the countries of operation data from Dyreng and Lindsey (2009) to classify firms into single-country and multiple-country sub-samples.[11] Finally, I rank firms using terciles of asset tangibility in each financial year. High (low) capital intensity firms are ones in the top (bottom) tercile of the distributions. I then re-run Model (1) for each sub-sample and report the results in Table 7.

I find that the effect of climate change on CEO compensation mainly concentrates in the *Top exposure industry* sub-sample (Column (1)), *Single country* sub-sample (Column (3)), and *High capital intensity* sub-sample (Column (5)). The findings suggest that the climate change – CEO pay relation is indeed stronger on firms with more vulnerability to climate change.

7. Conclusion

This thesis provides novel evidence on the effect of climate change on CEO compensation. Based on prior studies on the effects of risks on CEO compensation, I conjecture that CEOs of firms with high climate change risk earn higher total pay.

Using a sample of U.S firms from fiscal years 2001 to 2020, I provide the first evidence that there is a climate risk premium in CEO compensation. I use natural disaster events in a difference-in-differences framework to address endogeneity concerns. I find that firms that experience natural disasters increase their CEO pay significantly, indicating that the uncovered effect of climate change exposure on CEO compensation is likely causal. The compensation premium for climate risk is more pronounced when CEOs have high bargaining power. As climate change risk lowers firms' future performance in profitability and firm value, CEOs prefer cash-based compensation to equity-based compensation.

Taken together, the empirical findings in my thesis extend the literature on the important determinants of CEO compensation. The thesis also contributes to the trending and important debate on the pervasive impacts of climate change on people, the macroeconomy, and corporations.

[10] Sautner et.al. (2021) show that top 10 climate exposure industries are: Electric, Gas, & Sanitary Services, Heavy Construction, Except Building, Construction, Coal Mining, Electronic & Other Electric Equipment, Industrial Machinery & Equipment, Transportation Equipment, Petroleum Refining, Fabricated Metal Products, and Engineering & Management Services. Bottom 10 climate exposure industries include: Eating & Drinking Places, Depository Institutions, Educational Services, Printing & Publishing, Home Furniture, Leather & Leather Products, Motion Pictures, Miscellaneous, Tobacco Products, and Apparel & Accessory Stores.

[11] I thank Scott Dyreng for sharing the data.

Table 7. Sub-sample analysis of the climate change– CEO compensation relation

This table presents the results of OLS regression models that investigate the relation between climate change exposure and CEO total compensation in the sample from 2001 to 2020. The dependent variable is the natural logarithm of CEO total compensation, *ln(Total Pay)*. The key independent variable is *CC Exposure*, which is the measure that identifies the firm-level exposure to climate change using word combinations for earnings conference calls (Sautner, van Lent, Vilkov, and Zhang, 2021). Column (1) and (2) report the regression results for sub-samples of firms in the top and bottom climate change exposure industries, respectively. Column (3) and (4) report the regression results for sub-samples of firms that operate in a single country and multiple countries, respectively. Column (5) and (6) report the regression results for sub-samples of firms with asset tangibility in the top and bottom terciles, respectively. The firm and CEO control variables include: natural logarithm of total assets (*Size*), the ratio of market value of equity to book value of equity (*M/B*), the ratio of total debts to total assets (*Leverage*), the ratio of total earnings to total assets (*ROA*), the ratio of total cash reserves to total assets (*Cash*), the annual growth in total sales (*Sales growth*), the buy-and-hold stock return of the financial year (*Stock return*), the stock return volatility of the financial year (*Stock return volatility*), the ratio of net property, plant, and equipment to total assets (*Tangibility*), and age of the CEO (*CEO age*). I include firm fixed effects to account for time-invariance differences across firms and year fixed effects to account for time trends. Heteroskedasticity-robust standard errors (in parentheses) are adjusted for clustering at the firm level. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% confidence levels, respectively.

	ln(Total pay)					
	Top exposure industry	Bottom exposure industry	Single country	Multi country	High capital intensity	Low capital intensity
	(1)	(2)	(3)	(4)	(5)	(6)
CC Exposure	0.134***	0.010	0.324***	-0.019	0.101*	0.008
	(0.052)	(0.290)	(0.082)	(0.092)	(0.052)	(0.111)
Size	0.344***	0.320***	0.396***	0.330***	0.275***	0.356***
	(0.033)	(0.045)	(0.047)	(0.029)	(0.031)	(0.023)
M/B	0.003*	0.003	-0.005	0.009***	0.002	0.002
	(0.002)	(0.002)	(0.006)	(0.003)	(0.001)	(0.002)
Leverage	-0.414***	-0.079	-0.415***	-0.635***	-0.407***	-0.127
	(0.099)	(0.099)	(0.160)	(0.096)	(0.093)	(0.095)
ROA	0.395***	0.629***	0.117	0.232**	0.324***	0.259**
	(0.133)	(0.241)	(0.162)	(0.114)	(0.124)	(0.120)
Cash	0.164	-0.091	0.208	0.216**	0.410**	0.056
	(0.117)	(0.237)	(0.164)	(0.100)	(0.167)	(0.098)
Sales growth	0.124***	0.166**	0.074	0.222***	0.046	0.151***
	(0.044)	(0.083)	(0.048)	(0.035)	(0.034)	(0.035)
Stock return	0.054***	0.137***	0.060***	0.058***	0.081***	0.067***
	(0.018)	(0.026)	(0.022)	(0.015)	(0.015)	(0.016)
Stock return volatility	0.016	-0.333***	-0.338***	-0.213***	-0.227***	-0.334***
	(0.078)	(0.107)	(0.093)	(0.073)	(0.056)	(0.082)
Tangibility	0.156	-0.118	-0.249	-0.123	0.020	0.968
	(0.181)	(0.265)	(0.282)	(0.176)	(0.131)	(0.740)
CEO age	0.000	0.002	0.004	-0.001	0.005**	-0.000
	(0.002)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observation	7202	3986	3441	10364	9457	9430
Adjusted R-squared	0.709	0.701	0.735	0.713	0.719	0.741

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Appendix. Variable definitions

This table describes the definitions of variables used in the analyses. Data sources are in parentheses and variable name from the databases are in Italics.

Variable	Definition
Total pay (in 000$)	Variable *TDC1* (Execucomp).
ln(Total pay)	The natural logarithm of TDC1 plus one (Execucomp).
ln(Cash pay)	The natural logarithm of total annual cash compensation plus one (Execucomp: *TOTAL_CURR*).
ln(Salary)	The natural logarithm of annual salary plus one (Execucomp: *SALARY*).
ln(Bonus)	The natural logarithm of annual bonus plus one (Execucomp: *BONUS*).
ln(Stock pay)	The natural logarithm of the dollar value of annual stock grants plus one (Execucomp: *STOCK_AWARDS_FV*).
ln(Option pay)	The natural logarithm of the dollar value of annual option grants plus one (Execucomp: *OPTION_AWARDS_BLK_VALUE* before FAS 123R and *OPTION_AWARDS_FV* after FAS 123R).
CC Exposure	The firm-level exposure to climate change using word combinations for earnings conference calls (Sautner, van Lent, Vilkov, and Zhang, 2021).
Size	The natural logarithm of total assets (Compustat: *AT*).
M/B	The ratio of market value of equity to book value of equity (Compustat: *PRCC_F*CSHO/CEQ*).
Leverage	The ratio of total debts to total assets (Compustat: *(DLTT+DLC)/AT*))
ROA	The ratio of total earnings to total assets (Compustat: *IB/AT*).
Cash	The ratio of total cash reserves to total assets (Compustat: *CHE/AT*).
Sales growth	The annual growth in total sales (Compustat: $SALE_t/SALE_{t-1}$ -1).
Stock return	The buy-and-hold stock return of the financial year (CRSP).
Stock return volatility	The annualized standard deviation of daily stock returns in the financial year (CRSP).
Tangibility	The ratio of net property, plant, and equipment to total assets (Compustat: *PPENT/AT*).
CEO age	The age of the CEO as of the current financial year (Execucomp: *AGE*).
Industry sales growth	The annual average of sales growth of all firms in the same two-digit SIC.
Industry ROA	The annual average of ROA of all firms in the same two-digit SIC.
Industry Tobin's Q	The annual average of Q of all firms in the same two-digit SIC. Tobin's Q is defined as the ratio of market value of total assets to book value of total assets (Compustat: *(AT-CEQ+PRCC_F*CSHO)/AT*).
Fluidity	The fluidity measure from Hoberg, Philips, and Prabhala (2014).
Product similarity	The industry product similarity measure from Hoberg and Philips (2016).
HHI	The annual sum of squared market shares in sales of firms in the same two-digit SIC (Compustat).
Duality	Equals one if the CEO also serves as chairman of the board, and zero otherwise (Boardex).
Institutional ownership	The fraction of shares owned by institutional investors (Thomson Reuters Ownership 13F).
Co-opted independence	The fraction of independent directors appointed by the CEO from Coles, Daniel, and Naveen (2014).
Analyst following	The number of analysts following in a financial year (IBES).
G index	The shareholder rights index from Gomper, Ishii, and Metrick (2003).
Managerial ability	The managerial ability measure from Demerjian, Lev, and McVay (2012).
Local rivals	The number of firms in the same two-digit SIC and in the same state. (Compustat)
Future industry adjusted ROA	The average of the industry-adjusted ROA over the next three years. Industry-adjusted ROA is the difference between the firm's ROA

	and the average ROA of all firms in the same two-digit SIC in the financial year.
Future industry adjusted Tobin's Q	The average of the industry-adjusted Tobin's Q over the next three years. Industry-adjusted Tobin's Q is the difference between the firm's Q and the average Q of all firms in the same two-digit SIC in the financial year.

URL link to data and code

https://www.dropbox.com/sh/94r41ibbfjcc9hs/AACoKHexWBCafMmudVUcV7TEa?dl=0