Leveraging climate change: Estimating the effect of capital structure on shareholder value using the Paris Agreement

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Abstract

We explore how capital structure decisions influence shareholder value around adopting the Paris Climate Agreement. Companies with greater leverage encounter significantly more adverse stock market reactions. Specifically, a rise in leverage by one standard deviation decreases the three-day cumulative abnormal return by 11%. Firms with higher leverage are viewed as more financially constrained and possess less capacity to cope with climate-related concerns in alignment with the Paris Agreement. Interest payments take away resources that could be deployed to tackle climate-related challenges. Higher leverage also raises the probability of financial distress, causing companies to be more cautious and thus less likely to invest in climate-related issues. The adverse effect of leverage on shareholder value is significantly worsened for firms more exposed to the physical risks of climate change. However, the negative impact of leverage is significantly mitigated for firms that exhibit stronger profitability and greater liquidity.

JEL Classification: Q54, G32, G14, Q56

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I. Introduction

Climate change is of paramount importance due to its far-reaching impact on various dimensions of our world. Given the immense threats that global warming poses to corporate profits and financial markets, it is a challenge to adequately grasp the far-reaching implications of climate change (Hong, Karolyi, and Scheinkman, 2020). Consequently, it comes as no surprise that a relatively young, yet rapidly advancing, field of research has emerged, aiming to explore the effects of climate risk on the outcomes, behaviors, and operations of corporations (Matsumura, Prakash, and Vera Munoz, 2014; Choi, Gao, and Jiang, 2020; Painter, 2020; Heo, 2021; Bolton and Kacperczyk, 2021; Huynh and Xia, 2021; Chava, 2014; Javadi and Masum, 2021; Hossain, Masum, Saadi, Benkraiem, and Das, 2022).[1] We extend the body of knowledge in this crucial area by investigating the effect of capital structure choices on shareholder value around the adoption of the Paris Agreement, which is the most comprehensive climate agreement signed by 196 countries to cope with climate change. Companies were expected to take action to reduce their emissions and invest in low-carbon technologies to help achieve the goals of the Paris Agreement.[2]

The literature on capital structure is extensive and began with the seminal work of Modigliani and Miller (1958), who show that, under the assumption of perfect capital markets, capital structure is irrelevant. Over the years, however, a plethora of market imperfections have been incorporated into the model (Rajan and Zingales, 1995; Fama and French, 2002; Myers, 1984; Jiraporn and Gleason, 2007). Extending the existing knowledge in this field, our research focuses

[1] More recent studies on the effects of climate change on corporate outcomes can be found in Ongsakul, Papangkorn, and Jiraporn (2023) and Likitapiwat, Jiraporn, and Treepongkaruna (2023).
[2] Companies were anticipated to demonstrate their commitment towards climate change by establishing challenging goals for reducing emissions, devising and executing strategies to achieve those goals, tracking their emissions and progress, allocating resources towards low-carbon technologies and procedures, and facilitating the growth of a low-carbon economy. Additionally, it was expected of them to collaborate with governmental bodies and other stakeholders to ensure successful implementation of the Paris Agreement.

on the role of climate change, which presents a dynamic challenge that transcends traditional financial considerations. The costs and benefits of leverage and the impact of leverage on shareholder value have been a subject of intense debate but have rarely been viewed from the perspective of climate change. We address this critical gap in the literature.

We put forth two opposing hypotheses. First, the wealth reduction hypothesis suggests that higher leverage introduces financial limitations on companies' capacity to address climate-related issues, as interest payments divert resources that could otherwise be allocated to climate change management in line with the Paris Agreement. Furthermore, higher borrowing increases the risk of financial distress, leading companies to adopt more cautious investment strategies and diminishing their ability to address climate-related challenges. This viewpoint anticipates that firms with greater leverage encounter more adverse market responses to the adoption of the Paris Agreement. By contrast, leverage serves as a mechanism for governance, curbing agency conflicts by incentivizing managers to be more diligent in averting bankruptcy and by redirecting available free cash flow away from potential misuse by opportunistic managers (Rajan and Zingales, 1995). This wealth increase hypothesis suggests that companies with higher leverage possess a stronger ability to navigate climate-related challenges due to reduced agency conflicts. Accordingly, from this perspective, firms with higher leverage are anticipated to experience more favorable stock market reactions.

Utilizing the standard event study methodology to estimate the stock market reactions to the adoption of the Paris Agreement, we find that companies with higher leverage face significantly more negative stock market reactions. In particular, a rise in leverage by one standard deviation decreases the three-day cumulative abnormal return by 11%. These findings align with the concept that interest payments redirect resources away from addressing climate-related issues. Therefore, the effectiveness of managing climate-related concerns diminishes, ultimately resulting in a reduction of shareholder value. Although our findings are already less vulnerable to endogeneity as we rely on stock market reactions, we still execute a variety of robustness checks.[3] Further analysis validates the results, i.e., propensity score matching, entropy balancing, an instrumental-variable analysis, and Lewbel's (2012) heteroscedastic identification. Our findings are therefore not likely susceptible to endogeneity and probably reflect a causal influence, not just an association.

Furthermore, we utilize an innovative text-based measure of firm-specific vulnerability to climate change, derived from sophisticated machine learning algorithms (Sautner, Van Lent, Vilkov, and Zhang, 2023). Our findings reveal that physical risks associated with climate change significantly exacerbate the adverse effect of leverage on shareholder value. Specifically, firms more exposed to extreme weather events, for example, experience a markedly more pronounced negative impact of leverage around the adoption of the Paris agreement. Notably, other aspects of climate change exposure, such as regulatory risks and new business opportunities, neither improve nor exacerbate the effect of leverage.

Moreover, we perform additional cross-sectional analysis and find that the adverse stock market reactions are significantly mitigated for firms with stronger profitability and greater liquidity. This is probably not surprising because more profitable and liquid firms are likely less financially constrained and should be able to handle climate-related issues more effectively, resulting in reduced negative stock market reactions. However, we do not find any evidence that the adverse effect of leverage is softened by stronger corporate governance, suggesting that the

[3] Our results are less vulnerable to endogeneity as the adoption of the Paris Agreement was considered an exogeneous event that was beyond the control of individual firms. This approach mitigates endogeneity considerably.

negative effect is unlikely attributed to agency conflicts. Finally, companies with a more optimistic view about climate change experience significantly less negative market reactions.

Additionally, to further validate our results, we hypothesize that due to the negative impact of high leverage, firms more vulnerable to climate change are expected to significantly reduce their leverage, especially following the adoption of the Paris Agreement. We find evidence supporting this hypothesis. Moreover, the reduction in leverage after the adoption of the Paris agreement appears to be primarily driven by regulatory risk and new business opportunities related to climate change, which become more significant once the Paris Agreement is officially signed.

It is crucial to note that our findings align closely with those of Ginglinger and Moreau (2023). Their research indicates that heightened physical climate risk led to decreased leverage after 2015, following the Paris Agreement's adoption. Both of our studies collectively suggest that higher leverage poses challenges for firms in addressing the requirements of the Paris Agreement. Our results aptly dovetail with those in Ginglinger and Moreau (2023). However, a key advantage of our study over theirs is that we link the impact of leverage on firms within the context of climate change directly to shareholder wealth. This is critically important as the ultimate goal of the corporation is to maximize shareholder value.[4]

[4] Notably, our results are consistent with those of Selzer et al. (2022), as both studies focus on the financial impacts of climate change risk on firms. While Selzer et al. (2022) examine bond ratings and our study investigates stock market reactions, both highlight how exposure to climate-related risks leads to negative financial outcomes. In our study, companies exposed to high climate risks experience significant negative stock market reactions following the Paris Agreement, reflecting market concerns about their ability to manage these risks. Similarly, Selzer et al. (2022) found that firms with significant climate exposure faced bond rating downgrades post-Paris Agreement. Both studies demonstrate the growing importance of climate risk in financial market evaluations, leading to adverse consequences for firms perceived as vulnerable to climate change, whether through declining stock prices or credit rating downgrades.

Finally, relying on a quasi-natural experiment, we demonstrate that high leverage negatively impacts credit ratings, with this adverse effect being significantly more pronounced for firms more vulnerable to climate change and following the adoption of the Paris Agreement. Credit ratings play a crucial role in determining a firm's cost of capital and access to financing. A lower credit rating can lead to higher borrowing costs and reduced investor confidence, which can constrain a firm's financial flexibility and growth potential. Consequently, one way in which high leverage undermines firm value is through its detrimental effect on credit ratings.

Our study contributes significantly to several important areas within the existing body of knowledge. First, we enhance the understanding in the intersection of climate change and finance. Numerous recent studies have highlighted that shifts in climate patterns are among the most recent triggers of unpredictability. Moreover, these studies have emphasized the undeniable influence of climate change on both the economy and financial markets (Barnett, Brock, and Hansen, 2020; Bolton and Kacperczyk, 2021; Engle, Giglio, Kelly, Lee, and Stroebel, 2020). Our work expands the scope of knowledge in this critical field by demonstrating the substantial impact of capital structure decisions. Specifically, we shed light on how these decisions are crucial for firms' ability to effectively address climate-related concerns in alignment with the Paris Agreement. Interestingly, we find that the level of leverage employed by companies plays a pivotal role. Apparently, companies with higher leverage tend to face greater challenges in effectively managing climate-related issues, ultimately resulting in a decrease in shareholder value.

Second, capital structure has remained a cornerstone of research in corporate finance over the past several decades. Our study makes a noteworthy contribution to this significant field by moving beyond the assumption of perfect capital markets (Modigliani and Miller, 1958) and integrating the risk stemming from climate change into the capital structure model. Through our investigation, we reveal a key insight: heightened leverage leads to a reduction in shareholder value when firms are confronted with climate-related challenges. Our study is the first to document such findings.

Moreover, our study adds significant value to a crucial branch of literature that investigates how the stock market responds to events linked to climate change (Hsu and Wang, 2013; Birindelli and Chiappini, 2021; Antoniuk and Leirvik, 2021). This line of research leverages stock market reactions to evaluate the pros and cons of climate-related policies or initiatives, along with their broader outcomes. In this context, our research unveils a pivotal insight: the stock market's response to the adoption of the Paris Agreement hinges greatly on the level of leverage. This observation underscores the crucial role of leverage as a determining factor in how effectively companies navigate the challenges posed by climate change, aligning with the expectations of the Paris Agreement.

In addition to the academic audience, understanding the linkage between debt levels and their potential constraints on corporate initiatives to address climate change holds valuable implications for several important groups of stakeholders. First, shareholders can make informed investment decisions by assessing a company's financial structure and evaluating the potential impact of debt on its ability to allocate resources toward sustainable practices. Second, creditors gain insights into the financial risk associated with lending to companies heavily burdened by debt, while regulators can consider policies that encourage sustainable practices without overly burdening companies with debt obligations. Additionally, corporate management teams can use this knowledge to strike a balance between leveraging financial resources for growth and maintaining flexibility to undertake climate-related endeavors. Overall, this understanding empowers stakeholders to make more nuanced and strategic decisions in the context of environmental sustainability and corporate financial health.

II. Pertinent research and hypothesis development

a. Climate change and finance

Recent research has provided compelling evidence of the profound influence of climate risk on the valuation of various financial assets, including stocks, bonds, and real estate (Bernstein, Gustafson, and Lewis, 2019; Painter, 2020; Seltzer, Starks, and Zhu, 2022; Ginglinger and Moreau, 2023). This impact is further underlined by the fact that the majority of institutional investors view climate risk as a pivotal concern (Krueger, Sautner, and Starks, 2020). The ramifications of climate risk on corporate performance have been extensively explored in recent studies. These studies consistently reveal that companies face challenging circumstances due to climate risk, resulting in unfavorable stock market reactions and elevated capital costs, for example (Matsumura et al., 2014; Bolton and Kacperczyk, 2021; Huynh and Xia, 2021; Chava, 2014; Javadi and Masum, 2021; Hossain et al., 2022).

Furthermore, recent research underscores the exposure of firms to additional substantial risks stemming from climate change. For instance, Choi et al. (2020) demonstrate that the stock prices of carbon-intensive firms decline during periods of abnormally warm weather. Painter (2020) highlights that long-term municipal bonds located in coastal regions vulnerable to sea level rise experience notably wider credit spreads. Heo (2021) further reveals that businesses respond to escalating climate risk by bolstering their cash reserves. Using an instrumental-variable analysis based on climate policy uncertainty, Ongsakul et al. (2023) show that greater climate change exposure leads to lower firm value.

In addition, Ongsakul et al. (2023) suggest that asset redployability is a crucial aspect of sustainability because assets that can be deployed in several ways make it less necessary to produce new assets and thus conserve natural resources. They find that companies more exposed to climate change tend to have fewer redelployable assets. Exploiting data on foreign exchange hedging based on textual analysis, Likitapiwat et al. (2023) report that greater climate change exposure brings about significantly less exchange rate hedging. These findings collectively emphasize the intricate and tangible connections between climate risk and various aspects of the corporate financial landscape.

One recent crucial study is particularly pertinent to our research as it is related to capital structure in the context of climate change. Ginglinger and Moreau (2023) utilize firm-level data to investigate the impact of physical climate risk on capital structure. They document that greater climate risk leads to reduced leverage after 2015, coinciding with the adoption of the Paris Agreement. The findings persist even after accounting for firm-specific factors like credit ratings. The results support the hypothesis that physical climate risk influences leverage through anticipated higher distress and operating costs.

We contribute to this important emerging area of research by investigating the effect of capital structure choices on shareholder value in the context of climate change. We concentrate on shareholder wealth around the adoption of the Paris Agreement, which is the most crucial and comprehensive agreement signed by 196 countries to cope with climate change. The Paris Climate Agreement, adopted in 2015, laid out a global framework to combat climate change by limiting global warming to well below 2 degrees Celsius above pre-industrial levels, with efforts to limit it to 1.5 degrees Celsius.

Companies were expected to play a crucial role in achieving these goals by significantly reducing their greenhouse gas emissions. They were encouraged to set emission reduction targets, adopt cleaner and more sustainable technologies, transition to renewable energy sources, improve energy efficiency, and implement measures to enhance climate resilience. Additionally, businesses were encouraged to disclose their climate-related risks and actions, promoting transparency and accountability. Obviously, the Paris Agreement was expected to have far-reaching ramifications for companies and financial markets.

b. Hypothesis development

Based on existing research on capital structure, we present two competing hypotheses. The first hypothesis suggests that greater reliance on borrowing diminishes shareholder wealth when the Paris Agreement is adopted. This is because interest payments consume resources that could otherwise be allocated to climate-related initiatives in accordance with the Paris Agreement's objectives. For instance, companies might need to invest in innovative technologies aimed at reducing air pollution to comply with the Paris Agreement, but the necessity to make interest payments hinders these investments. Furthermore, higher levels of borrowing raise the likelihood of financial distress (Titman and Wessels, 1988; Shleifer and Vishny, 1992; Jiraporn and Gleason, 2007), prompting companies to exercise greater caution in their investment strategies and weakening their capacity to tackle climate-related challenges. Additionally, firms with higher leverage possess reduced debt capacity, making future borrowing to tackle climate-related issues more challenging. Consequently, businesses with substantial debt are less likely to effectively address climate change in alignment with the Paris Agreement, resulting in more pronounced negative reactions in the stock market. This perspective is referred to as the wealth reduction hypothesis.

On the contrary, the alternative viewpoint suggests that higher leverage leads to more favorable reactions in the stock market. This perspective draws upon agency theory, which highlights how leverage serves as a governance mechanism through various avenues. First, interest payments act to curtail available free cash flow, which could otherwise be exploited by self-interested and opportunistic managers. Second, increased leverage raises the chances of encountering financial distress, thereby incentivizing managers to exert greater effort and reducing the probability of acting at the expense of shareholders (Rajan and Zingales, 1995). Consequently, companies with elevated leverage are better equipped to optimize the utilization of resources, allowing them to tackle climate-related challenges more effectively because they are subject to fewer agency conflicts. Additionally, the deductibility of interest payments for tax purposes contributes to reducing the cost of debt, ultimately leading to a decrease in the overall cost of capital (Frank and Goyal, 2007; Rajan and Zingalez, 1995). This, in turn, enables businesses to execute climate-related investments more effectively. Thus, this hypothesis asserts that companies with greater leverage witness more positive reactions in the stock market. This perspective is labelled the wealth enhancement hypothesis.

III. Sample selection and data description

a. Sample formation

Using the standard event study methodology, we analyze a comprehensive set of firms with adequate data from the CRSP database to gauge how the stock market responded to the adoption of the Paris Agreement. The estimation period spans from Day -300 to Day -46 prior to the event. To calculate the predicted returns, we employ the market model, relying on the CRSP equally-weighted index as the benchmark market index.[5] Our principal measure for evaluating the impact of the Paris Agreement is the cumulative abnormal return (CAR) over the event window (-1,1) and (-2, 2).[6] The Paris Agreement was signed on December 12, 2015. Moreover, we obtain firm-specific data from COMPUSTAT. Additionally, our data on climate change optimism is from Sautner et al.'s (2023). Our final sample comprises a total of 1,772 firms[7].

Notably, we focus on the signing of the Paris climate agreement in December 2015, in line with several prior studies (Chatjuthamard, Singh, Jiraporn, and Lee, 2024; Chen, Huang, Sirianni, 2021; Monasterolo and Angelis, 2020; Antoniuk and Leirvik, 2021; Alessi, Battiston, and Kvedaras, 2024). While it can be argued that the signing of the Paris agreement may have been anticipated to some extent, there are several compelling reasons why it probably had not been fully expected. First, leading up to the signing of the Paris Agreement, there was considerable uncertainty about whether many countries would commit to the accord. The negotiations involved complex dynamics between developed and developing countries, with significant disagreements over responsibilities and funding. This uncertainty about the participation of key nations likely led

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[5] To ensure the robustness of our findings, we carefully implement rigorous criteria to identify potential confounding events that might overlap with the Paris Agreement adoption. First, we turn our focus to quarterly earnings announcements, as numerous studies (such as Watts, 1978) have highlighted abnormal returns associated with these announcements. Second, we take into consideration the potential influence of financial analysts' revisions on stock market reactions. A substantial body of research in finance and accounting acknowledges the value that sell-side analysts bring to investors through their research reports. Notably, analyst upgrades (like earnings, price targets, or recommendations) tend to yield positive abnormal returns, while downgrades lead to negative abnormal returns. To address this, we examine three key analyst measures: recommendations, price targets, and annual EPS forecasts. By using the I/B/E/S data, we compare the current value of each of these measures with its most recent corresponding value made within a year, attributed to the same analyst at the same brokerage firm. To account for these potential confounding events, we carefully exclude companies whose quarterly earnings have been announced and/or any of three key analyst measures (recommendation, price target and annual EPS forecasts) have been revised within a 5-day window for CAR (-1, 1) and a 7-day window for CAR (-2, 2) around the adoption of the Paris Agreement. This step is essential to avoid any simultaneous events that could skew our results. .

[6] The average cumulative abnormal return, CAR (-1,1) is -0.017 and is statistically significant from zero. However, our focus is not on the overall market reactions. Rather, we concentrate on the variation in the stock market reactions with respect to leverage.

[7] As the availability of data varies across regression models, the number of observations can be slightly different, depending on each regression model.

to difficulties for investors in predicting the outcome and its impact on markets (Barnett, Brock, and Hansen, 2020; Dimitrov, 2016; Paine and Sheargold, 2023).

Second, historically, international climate agreements had faced challenges in terms of implementation and enforcement. Investors may have been skeptical about the effectiveness of yet another agreement. (McAllister and Schnakenberg, 2022; Pinske and Kolk, 2007). The Paris Agreement followed several failed attempts to reach a global climate agreement, such as the Copenhagen Summit in 2009. This history of failed attempts would have led investors to be skeptical about the likelihood of a successful agreement. Moreover, the Paris Agreement represented a significant shift towards a more inclusive and ambitious global climate effort. There was no direct precedent for such a comprehensive agreement. Investors may have been less confident about the success of the Paris agreement due to the lack of historical data on how markets would respond to such a transformative event (Falkner, 2016). For the reasons highlighted above, it is reasonable to assume that the adoption of the Paris Agreement was probably not fully anticipated.

b. Variable description

Following the literature in this field, our primary measure of leverage is the ratio of total debt to total assets. In addition, we supplement our analysis using market leverage, which is defined as total debt divided by the market value of assets, where the market value of assets is total assets minus the book value of equity minus deferred taxes and investment tax credits plus the market value of common equity plus preferred stock.

Importantly, we incorporate several control variables that may influence shareholder wealth. Specifically, we include firm size (Ln of total assets), profitability (EBIT/total assets), capital investments (capital expenditures/total assets), cash holdings (cash holdings/total assets), intangible assets (research and development/total assets and advertising expense/total assets), dividend payouts (dividends/total assets), asset tangibility (fixed assets/total assets), and discretionary spending (SG&A expense/total assets), and liquidity (current assets/current liabilities). To account for variation across industries, we incorporate industry fixed effects based on the first two digits of SIC. The variable definitions are shown in Table A1 in the Appendix. The summary statistics are presented in Table 1.

In addition, we explore firm-specific susceptibility to climate change. We exploit the data created by Sautner et al. (2022), who rely on earnings conference call transcripts to produce firm-specific, time-varying indicators of climate change susceptibility. Using machine learning, they collect and count the frequency of climate change-related bigrams, dividing it by the overall bigram count to represent the frequency of climate change-related events or shocks at the company level (Heo, 2021). Conference calls discussing financial results have become increasingly common for engaging stakeholders, with managers highlighting successes or alleviating concerns (Hossain et al., 2022), making this an appropriate way to record individual companies' climate change vulnerability. This metric has advantages over alternatives like carbon emissions data, as it covers a broader spectrum of businesses (Hossain et al., 2022), and has a strong relationship with critical economic factors like public climate change awareness (Sautner et al., 2022; Hossain et al., 2022). Due to these advantages, recent publications have swiftly adopted this measure (e.g., Hossain et al., 2022; Heo, 2022; Chatjuthamard et al., 2024).[8]

IV. Results

a. Main regression results

[8] For more information about the construction of the text-based data for climate change, please see Sautner et al. (2023).

Table 2 reports the regression results. The dependent variables are CAR (-1,1) and CAR (-2,2). The coefficient of leverage and market leverage are all significantly negative, implying that companies that are more leveraged are viewed more negatively by investors. This finding supports the idea that companies with more debt are less likely to be able to address climate-related concerns in line with the Paris Agreement. This is because debt can make it more difficult for companies to invest in new technologies and processes that reduce their emissions. Additionally, debt can increase the risk of bankruptcy, which could prevent companies from taking actions on climate change. Overall, the disadvantages of debt, such as increased risk and decreased financial flexibility, appear to outweigh the benefits of debt, such as reduced agency conflicts and lower taxes. The wealth reduction hypothesis is supported.

It is important to examine economic significance as the effect of leverage on stock market reactions may be statistically significant but economically trivial. We calculate the standardized coefficients of leverage in Model 1 and Model 3 and find that a rise in leverage by one standard deviation results in a decline in stock market reactions by 11% and 5.2% in the three-day and five-day windows respectively. Evidently, not only is the effect of leverage statistically significant, it is also economically meaningful.

b. Propensity score matching (PSM)

Our event study results are already less vulnerable to endogeneity.[9] However, to further reduce endogeneity, we corroborate our findings using propensity score matching (PSM). PSM is a statistical technique that matches treatment and control groups based on observable characteristics. This helps to ensure that the only difference between the two groups is the

[9] Research using an event study is less vulnerable to endogeneity due to its focus on examining the immediate impact of a specific event, such as a policy change or announcement. By analyzing the short-term reaction of the variable surrounding the event, event studies leverage the event's exogenous nature to isolate causal effects. The event's timing is often considered as externally determined, minimizing the potential for confounding factors to influence the results.

treatment itself. Recently, it has been widely used in the literature (Rosenbaum and Rubin, 1983; Lennox, Francis, and Wang, 2011; Chindasombatcharoen, Chatjuthamard, and Jiraporn, 2023; Chatjuthamard, Kijkasiwat, Jiraporn, and Uyar, 2023). In our study, we split the sample into quartiles based on leverage. The treatment group consists of the top quartile (companies with the greatest leverage). For each observation in the treatment group, we select the most similar observation from the remainder of the sample based on ten firm characteristics (the ten control variables included in the regression analysis). This results in treatment and control companies that are virtually identical in every observable respect, except for their leverage.

We perform diagnostic analyses to ensure the accuracy of our matching process. The results of these analyses are reported in Table 3, Panel A. Model 1 employs a logistic regression, with a binary dependent variable indicating whether a company belongs to the treatment group (with the highest leverage) or not. This initial model encompasses the entire sample before matching. The result suggests significant disparities between the treatment firms and the rest of the sample across various dimensions. Notably, the treatment firms are considerably larger, less profitable, invest less in capital, hold smaller cash reserves, exhibit reduced discretionary spending, possess higher fixed assets, and have lower liquidity. To ensure the robustness of our findings, it is essential to account for these significant disparities that could potentially confound our results.

Model 2, which is a logistic regression that follows the execution of propensity score matching (post-match), displays no statistically significant coefficients. As a result, the observable attributes of both our treatment and control firms are statistically comparable. Therefore, we can assume that our treatment and control firms should have similar market reactions if leverage is not a relevant factor. The regression results for the PSM sample can be seen in Panel B of Table 3.

Notably, the coefficients of leverage are significantly negative, reaffirming the prediction of the wealth reduction hypothesis.

c. Entropy balancing

To further mitigate endogeneity, we utilize an innovative technique termed entropy balancing. This method is a statistical technique used to achieve balance in the distribution of covariates between treatment and control groups in observational studies. The main idea behind entropy balancing is to reweight the observations in the dataset in such a way that the distribution of covariates becomes similar between the treatment and control groups. This reweighting is done by assigning weights to each observation based on their covariate values.

As a method to overcome limitations with traditional propensity score matching (PSM), this approach has often been used recently in the literature (McMullin and Schonberger, 2020; Hainmueller, 2012; Chintrakarn, Jiraporn, Treepongkaruna, and Lee, 2022; Treepongkarun, Kyaw, and Jiraporn, 2022). According to Gaver and Utke (2019), entropy balancing significantly improves the balance of covariates after matching. Moreover, this technique enhances testing efficiency by reducing data losses and the randomness associated with traditional matching, as highlighted by Hossain et al. (2022) and Likitapiwat et al. (2022).

This is our approach to employing entropy balancing. To form the treatment group, we select companies from the highest leverage quartile, while the control group consists of the remaining sample. By applying entropy balancing, we ensure that the means, standard deviations, and skewness of observations in both groups are comparable. In Table 4, the regression results for the entropy-balanced sample are presented. The negative and statistically significant coefficients of leverage remain, demonstrating its detrimental impact on shareholder value. Notably, our findings derived from entropy balancing align with earlier documented results, reinforcing their reliability and credibility.

d. Instrumental-variable analysis

Even though our results are less vulnerable to endogeneity because we rely on the stock market reactions to a major event that is beyond the control of individual firms, to further validate our results, we run an instrumental-variable analysis. This method reduces the endogeneity biases that can be attributed to measurement errors, reverse causality, and unobserved heterogeneity. This approach is therefore well-regarded as especially helpful and is widely adopted in the literature.

To ensure robustness, we employ a few alternate instruments. First, we exploit the insights in Gao, Ng, and Wang (2011), where firms located nearby share similar local characteristics and thus exhibit similar capital structure choices. Our first instrumental variable is the average value of leverage of all firms located in the same three-digit zip code. Zip-code-level leverage is expected to influence firm-level leverage, according to Gao, Ng, and Wang (2011). Yet, it is unlikely that zip-code-level leverage is directly correlated with stock market reactions of individual firms as there are many firms in the same zip code. Using zip code assignments is also advantageous in the sense that zip codes are allocated to maximize efficiency in mail delivery and should not be related to firm characteristics. In other words, zip codes assignments are plausibly exogenous. This identification strategy based on zip codes has been frequently adopted in the literature (Jiraporn et al., 2014; Chintrakarn, Jiraporn, Jiraporn, and Davidson, 2017; Chintrakarn, Jiraporn, Tong, and Chatjuthamard, 2015).

Table 5 reports the results. Model 1 is the first-stage regression where the dependent variable is firm-specific leverage. The coefficient of the average value of leverage at the zip code level is significantly positive, as expected. Model 2 is the second-stage regression. The coefficient of leverage instrumented from the first stage is significantly negative. To ensure robustness, we adopt an alternative instrumental variable, which is the average value of all firms located in the same city. The results in Model 3 and Model 4 remain similar, once again showing that more leverage results in more adverse stock market reactions.

Furthermore, we run an instrumental-variable analysis using two instrumental variables. In addition to the zip-code average, we employ the average value of leverage of all firms in the same industry based on the first two digits of SIC. The major advantage of this approach is that we can run a test of over-identifying restrictions when there are two instruments. The results are shown in Table 6. The coefficient of leverage instrumented from the first stage is still significantly negative in Model 2. Crucially, Sargan's (1958) statistic is not statistically significant, suggesting that our instrumentation is acceptable. Overall, the results are consistent even when we apply an instrumental-variable analysis, which is substantially less susceptible to endogeneity. Our findings are robust.

e. The role of firm-specific exposure to climate change

To obtain further insights, we conduct a cross-sectional analysis. The extent of exposure to climate change likely varies across individual firms. Certain firms may be substantially prone to climate risk. For instance, agriculture and fishery companies are highly vulnerable to climate change as they rely directly on natural conditions. Shifts in weather and oceanic changes can drastically impact crop yields and fish populations, posing significant risks to their operations. By contrast, information technology firms, such as Google, are significantly less prone to climate change risk because they primarily offer digital services and cloud-based solutions that are not directly impacted by weather conditions or climate variability. Their operations are largely indoor and their infrastructure, while energy-intensive, can often be adapted to use renewable energy sources.

Consistent with this notion, Chatjuthamard, Singh, Jiraporn, and Lee (2024) show that companies more exposed to climate change experience more favorable market reactions to the adoption of the agreement. In particular, an increase in climate change exposure by one standard deviation improves market reactions by 7.3%–8.8%. Apparently, firms more exposed to climate change tend to experience more positive market reactions because actions facilitated by the Paris Agreement are expected to mitigate the adverse effects of climate change, ultimately lessening the negative impacts on these more vulnerable firms.

Motivated by the results in Chatjuthamard et al. (2024), we execute additional analysis to investigate whether the effect of leverage varies significantly across individual firms with varying degrees of climate change exposure. In particular, we utilize the text-based measures of firm-specific vulnerability to climate change that are derived from sophisticated machine learning algorithms and textual analysis, as developed by Sautner et al. (2023). This text-based approach has gained wide acceptance in recent literature, highlighting its usefulness and practicality (Hossain et al., 2022; Ongsakul, Papangkorn, and Jiraporn, 2023; Chatjuthamard et al., 2024; Ongsakul, Chintrakarn, Papangkorn, and Jiraporn, 2024).

In addition to an overall measure of firm-specific exposure to climate change, Sautner et al. (2023) also develop three sub-components of this exposure: 1) physical risk, 2) regulatory risk, and 3) additional business opportunities. Some businesses face heightened susceptibility to physical risks, such as extreme weather events and sea-level rise. Others may be particularly vulnerable to regulatory changes driven by climate change policies. Meanwhile, certain companies could experience growth in business opportunities related to sectors like renewable energy, energy efficiency, and climate-friendly agriculture.

It is reasonable to hypothesize that the effect of leverage on the stock market reactions to the adoption of the Paris agreement depends on the extent to which each firm is exposed to climate change. To explore this issue, we create interaction terms between leverage and the variable for the overall exposure to climate change and between leverage and each of the three sub-components. This approach allows us to explore how leverage interacts with firm-specific climate change vulnerability.

The results, presented in Table 8, reveal that the coefficients of leverage by itself are significantly negative across all regressions, confirming its adverse impact on shareholder wealth. Moreover, the interaction term between leverage and physical risk is also negatively significant, indicating that the detrimental effects of leverage are markedly more pronounced for firms with higher exposure to physical risks from climate change. This finding is logical, as physical risks associated with climate change can cause severe damage to properties and equipment. Firms with high leverage are likely to face greater challenges in managing these damages when they are more exposed to physical risks, compounding their financial difficulties.

None of the coefficients for the other interaction terms are significant, indicating that the negative impact of leverage is not intensified by regulatory risks or new business opportunities associated with climate change. These findings are especially noteworthy as they highlight that only physical risks related to climate change exacerbate the adverse effect of leverage. This underscores the unique role that physical risks play in influencing the financial stability of leveraged firms. Our study is the first to document such findings.

f. Further cross-sectional analysis

It is intuitive to expect companies with more profitability to possess more resources that can be directed at climate-related concerns. Therefore, we expect the negative effect of leverage on stock market reactions to be mitigated for firms with greater profitability. The same logic also applies to financial liquidity as firms with greater liquidity should be less constrained.

To test these hypotheses, we construct interaction variables between leverage and profitability (the EBIT ratio) and between leverage and liquidity (the current ratio) and include them in the regression analysis. The results are presented in Table 9. The coefficients of both interaction terms are significantly positive, indicating that the adverse effect of leverage on shareholder value around the adoption of the Paris Agreement is significantly softened for firms that are more profitable and liquid, consistent with our expectations.

f. the role of corporate governance and climate change sentiment

Furthermore, we investigate the role of corporate governance. It is conceivable that the negative effect of leverage on stock market reactions might be attributed to agency conflicts as capital structure decisions may be influenced by agency problems (Rajan and Zingales, 1995; Jiraporn and Gleason, 2007; Jiraporn, Kim, Kim, and Kitsabunnarat, 2012). If this is the case, there should be a relationship between leverage and corporate governance to the extent that governance helps alleviate agency conflicts. We focus on two critical governance mechanisms. First, we concentrate on managerial ownership. It is well-known that greater managerial ownership helps align the interests of managers and shareholders and thus is widely regarded as an important governance mechanism (Himmelberg, Hubbard, and Palia, 1999; Short and Keasey, 1999; Jiraporn and Nimmanunta, 2018; Withisuphakorn and Jiraporn, 2019, Chatjuthamard et al., 2023). Second, board independence is considered a crucial instrument of governance as outside independent directors are widely regarded as more objective and impose more stringent monitoring (Rosenstein and Wyatt, 1990; Cotter, Shivdasani, and Zenner, 1997; Core, Holthausen, and Larcker, 1999; Nguyen and Nielsen, 2010; Jenwittayaroje and Jiraporn, 2019).[10]

We create two interaction variables between leverage and managerial ownership and between leverage and board independence and include them in the regression analysis. To the extent that the negative effect of leverage on shareholder value is attributed to agency problems, the coefficients of these two interaction variables should be significant. The results are presented in Table 10. The coefficients of the interaction variables in Model 1 and Model 2 are not significant, however. Therefore, it does not appear that agency conflicts play a role.

Additionally, we explore the impact of climate change sentiment. Some companies have a more positive outlook about climate change than others. For instance, certain companies may be better prepared to cope with climate change or may even benefit from climate change (for example, some firms enjoy new business opportunities related to green products and green technologies). The negative effect of leverage on stock market reactions may be softened for firms with a more favorable outlook on climate change. To test this hypothesis, we utilize a variable on climate change sentiment devised by Sautner et al. (2023), who employ cutting-edge machine learning algorithms and textual analysis of earnings conference calls to create a text-based measure of climate change sentiment. The more positive expressions about climate change appear in earnings conference calls transcripts, the more optimistic firms are about climate change.

[10] For instance, Rosenstein and Wyatt (1990) highlight a positive stock market response when companies bring in independent directors. In a study of mergers and acquisitions, Cotter et al., (1997) find that independent directors enhance profits for target shareholders during tender offers. Examining the market-to-book ratio, Core et al., (1997) identify a positive link between the proportion of independent directors and this ratio. When it comes to the sudden passing of independent directors, Nguyen and Nielsen (2010) uncover a substantial drop in stock prices, underscoring the vital role of these directors. During the 2008 financial crisis, Jenwittayaroje and Jiraporn (2019) examine how independent directors impact business performance and conclude that they have a notable positive influence, particularly during crises.

We construct an interaction variable between leverage and climate change sentiment. The result is shown in Model 3 Table 9. The coefficient of the interaction term is significantly positive, implying that companies with a more optimistic outlook on climate change experience less negative market reactions associated with higher leverage. In other words, climate change optimism helps cushion the adverse impact of leverage.

g. The effect of climate change exposure on capital structure after the adoption of the Paris agreement.

To gain deeper insights, we explore how exposure to climate change affects leverage following the adoption of the Paris Agreement. Our findings up to this point indicate that high leverage hinders firms' responses to climate change, as shown by more negative stock market reactions for highly leveraged firms. Consequently, it is reasonable to hypothesize that firms, particularly those more exposed to climate change risks, are likely to reduce their leverage after the Paris Agreement's adoption. To explore this hypothesis, we run the following regression analysis:

$$CAR_{i,t} = \beta_0 + \beta_1 * Interaction + \beta_2 * Post - Paris \quad + \beta_3 * Climate\ change\ expoure_{i,t} + \beta_4 * Control\ variables_{i,t} + \sum Firm\ fixed\ effects_{j,t} + \varepsilon_{i,t},$$

where *i, t* and *j* denote company, event day, and industry respectively. *Post-Paris* is set to one after 2015 and zero otherwise while *Interaction* represents the interaction term between *Post-Paris* and *Climate change exposure*. The control variables include all company-level control variables described in subsection III.b (Variable description) above. Standard errors are clustered by firm.

The results are presented in Table 11, where the dependent variable is leverage. The focus is on the interaction term between climate change exposure and Post-Paris. Model 1, covering the full sample period, shows that the coefficient of the interaction variable is significantly negative, implying that companies more exposed to climate change reduce leverage more aggressively after the adoption of the Paris agreement, compared to their counterparties with less exposed to climate change risks. This finding is consistent with the results from the event study presented earlier, where leverage is viewed as detrimental to firms' ability to address climate change. As a result, companies more vulnerable to climate change actively diminish leverage significantly after the adoption of the Paris agreement. Notably, our results are remarkably consistent with those reported by Ginglinger and Moreau (2023), although they use different measures of climate change exposure.

In addition, we further validate the results by using a more narrow period as the effect of the Paris agreement may be more pronounced in a more narrow period centered around the adoption of the agreement. A narrower period also helps isolate the impact of the agreement and exclude potential confounding events. Model 2 covers a 9-year period centered around the signing of the agreement (4 years before and 4 years after 2015), whereas Model 3 encompasses a 5-year period (2 years before and 2 years after 2015). In both models, the coefficients of the interaction variable remain significant negative, indicating that our results are robust.

Moreover, to obtain deeper insights, we explore each aspect of climate change exposure individually. We construct interaction terms between Post-Paris and each of the three dimensions of climate change exposure, i.e., physical risk, regulatory risk, and new business opportunities. The results, shown in Table 12, demonstrate that the coefficients are significantly negative of the interaction variables between Post-Paris and regulatory risk as well as between Post-Paris and new business opportunities. Therefore, firms with more regulatory risk and new opportunities lower their leverage significantly. These findings are consistent with the argument that high leverage makes it more challenging for firms to address climate concerns effectively, probably due to the risk of bankruptcy and high interest payments. That is why firms more vulnerable to climate change reduce leverage considerably after 2015.

h. Discussion on the specific dimensions of climate change exposure

Notably, according to the results in Table 12, it is regulatory risk and new business opportunities that motivate firms to reduce leverage. However, in our earlier event study analysis, it was physical risk that triggered negative stock market reactions. At first glance, these findings may seem contradictory, but there is a logical explanation. Prior to the adoption of the Paris Agreement, investors could more readily envision natural disasters and extreme weather events, the most visible aspects of climate change, leading to a market reaction driven predominantly by physical risk.

In contrast, regulatory risks and new business opportunities were harder to assess due to the uncertainty surrounding the adoption of the Paris agreement and the specifics of its implementation and resulting regulations. Therefore, at the time of the adoption of the Paris agreement, physical risk was the more pronounced concern, predominantly driving the negative market reactions. Consistent with this argument, Bernstein et al. (2019) find that properties exposed to sea level rise sell at a discount relative to equivalent properties not at risk. This study supports the notion that physical risk of climate change (like natural disasters and extreme weather events) are immediately recognizable by the market and can lead to negative reactions.

Conversely, after the adoption of the Paris agreement, the focus shifts towards regulatory risk, as new regulations are anticipated to combat climate change. Similarly, new business opportunities related to climate change become more tangible with the agreement in place. This explains why, post-2015, regulatory risk and new business opportunities significantly gain in importance and seem to drive the reduction in leverage for firms more vulnerable to climate change. Consistent with this notion, Krueger et al. (2020) argue that regulatory risk become a more significant concern post-regulation as firms and investors start to assess the long-term implications of compliance and potential benefits from new climate-related regulations. Similarly, Bolton and Kacperczyk (2021) highlights that after regulatory frameworks like the Paris Agreement are put in place, firms begin to adjust their strategies in anticipation of new regulations.

V. Conclusions

Climate change is undoubtedly one of the most pressing concerns of our times, and the Paris Agreement stands out as the most comprehensive climate agreement that has garnered international recognition. Thus, it is crucial to comprehend the factors that either facilitate or obstruct companies' ability to tackle climate-related issues in line with the Paris Agreement. Our approach to tackling this issue involves an examination of the stock market reactions to the Paris Agreement's adoption. Our findings indicate that increased leverage significantly diminishes shareholder value. This observation corroborates the idea that interest payments deprive businesses of resources that could otherwise be directed towards addressing climate change. Furthermore, higher debt levels raise the likelihood of bankruptcy, leading companies to exercise more caution and make fewer investments aimed at addressing climate change.

Even though our findings are already less vulnerable to endogeneity because they are based on an event study, we still run further analysis. Additional robustness checks strongly validate the results, i.e., propensity score matching, entropy balancing, an instrumental-variable analysis, and Lewbel's (2012) heteroscedastic identification. Overall, it is unlikely that our findings are driven by endogeneity and therefore should reflect a causal influence, rather than a mere correlation.

Furthermore, we use a novel, text-based measure of firm-specific vulnerability to climate change developed through advanced machine learning algorithms (Sautner et al., 2023) to demonstrate that physical risks from climate change, like extreme weather events, significantly intensify the negative impact of leverage on shareholder value around the adoption of the Paris Agreement. Interestingly, other factors related to climate change, such as regulatory risks and new business opportunities, do not influence the effect of leverage.

We also execute a cross-section analysis and document that the adverse effect on stock market reactions associated with leverage is significantly softened for firms with stronger profitability and greater liquidity, probably because these firms are less financially constrained. Our study is the first to document the significant impact of capital structure decisions on shareholder value in the context of the most crucial climate change agreement. Given the rising importance of climate change that has increasingly affected various dimensions of our lives, our findings are especially relevant and useful.

Also, we document that, following the adoption of the Paris Agreement, firms more vulnerable to climate change significantly reduce their leverage, primarily driven by increased regulatory risk and new business opportunities that gain prominence after the signing of the Paris agreement. Our findings are in strong agreement with those of Ginglinger and Moreau (2023), who show that increased physical climate risk led to reduced leverage in firms post-2015, particularly following the Paris Agreement. Both of our studies similarly underscore the challenges high leverage presents in complying with the Paris Agreement, although our study is arguably more insightful as we directly link leverage and climate change exposure to shareholder value. Finally, we demonstrate that high leverage negatively impacts credit ratings, especially for firms vulnerable to climate change and after the Paris Agreement. Credit ratings are crucial as they affect borrowing costs and investor confidence. Thus, high leverage harms firm value by lowering credit ratings.

Our findings offer practical implications for a broad range of stakeholders. First, investors and shareholders gain insight into the financial implications of leveraging for companies aligned with the Paris Agreement. They can make more informed decisions about their investments, considering the impact of debt on a company's ability to address climate concerns. This understanding empowers investors to support or engage with companies pursuing sustainable practices. Second, company management and boards can use the knowledge from our research to evaluate their capital structure decisions. Understanding the link between leverage and diminished resources for climate initiatives can prompt them to consider more sustainable financial strategies.

Furthermore, organizations advocating for climate actions can leverage our findings to engage with companies and policymakers. They can highlight the negative consequences of high leverage on climate-related efforts, advocating for financial practices that align with sustainable goals. Additionally, regulators and policymakers can incorporate these findings into their decision-making processes. For instance, they might consider implementing measures that incentivize companies to maintain a balanced approach to debt, ensuring financial stability without compromising efforts to combat climate change. In conclusion, our research findings are useful to a variety of important stakeholders.

References

1. Alessi, L., Battiston, S., & Kvedaras, V. (2024). Over with carbon? Investors' reaction to the Paris Agreement and the US withdrawal. Journal of Financial Stability, 71(101232), 101232. https://doi.org/10.1016/j.jfs.2024.101232
2. Antoniuk, Y., & Leirvik, T. (2021). Climate change events and stock market returns. Journal of Sustainable Finance & Investment, 1–26. https://doi.org/10.1080/20430795.2021.1929804
3. Baker, M., & Wurgler, J. (2002). Market timing and capital structure. The Journal of Finance, 57(1), 1–32. https://doi.org/10.1111/1540-6261.00414
4. Barnett, M., Brock, W., & Hansen, L. P. (2020). Pricing Uncertainty Induced by Climate Change. The Review of Financial Studies, 33(3), 1024–1066. https://doi.org/10.1093/rfs/hhz144
5. Barnett, M., Brock, W., & Hansen, L. P. (2020). Pricing Uncertainty Induced by Climate Change. The Review of Financial Studies, 33(3), 1024–1066. https://doi.org/10.1093/rfs/hhz144
6. Bernstein, A., Gustafson, M. T., & Lewis, R. (2019). Disaster on the horizon: The price effect of sea level rise. Journal of Financial Economics, 134(2), 253–272. https://doi.org/10.1016/j.jfineco.2019.03.013
7. Birindelli, G., & Chiappini, H. (2021). Climate change policies: Good news or bad news for firms in the European Union? Corporate Social Responsibility and Environmental Management, 28(2), 831–848. https://doi.org/10.1002/csr.2093
8. Bolton, P., & Kacperczyk, M. (2021). Do investors care about carbon risk? Journal of Financial Economics, 142(2), 517–549. https://doi.org/10.1016/j.jfineco.2021.05.008
9. Chatjuthamard, P., Kijkasiwat, P., Jiraporn, P., & Lee, S. M. (2023). Customer concentration, managerial risk aversion, and independent directors: A quasi-natural experiment. The Quarterly Review of Economics and Finance: Journal of the Midwest Economics Association, 89, 358–368. https://doi.org/10.1016/j.qref.2022.10.002
10. Chatjuthamard, P., Kijkasiwat, P., Jiraporn, P., & Uyar, A. (2023). The takeover market's effect on managerial ownership: evidence from hostile takeover susceptibility.

Management Research Review, 46(7), 996–1015. https://doi.org/10.1108/mrr-03-2022-0164

11. Chatjuthamard, P., Ongsakul, V., & Jiraporn, P. (2022). Do hostile takeover threats matter? Evidence from credit ratings. PloS One, 17(1), e0260688. https://doi.org/10.1371/journal.pone.0260688
12. Chatjuthamard, P., Singh, S., Jiraporn, P., & Lee, S. M. (2024). Climate change exposure, shareholder wealth, and the adoption of the Paris agreement: A text-based approach. International Review of Financial Analysis, 94, 103327. https://doi.org/10.1016/j.irfa.2024.103327
13. Chava, S. (2014). Environmental Externalities and Cost of Capital. Management Science, 60(9), 2223–2247. https://doi.org/10.1287/mnsc.2013.1863
14. Chen, K., Huang, Z. (james), & Sirianni, P. (2021). Stock Price Reactions to the Paris Climate Agreement. Quarterly Journal of Finance and Accounting, 59(3/4), 79–108. https://www.jstor.org/stable/27159085
15. Chindasombatcharoen, P., Chatjuthamard, P., & Jiraporn, P. (2023). Corporate culture, cultural diversification, and independent directors: Evidence from earnings conference calls. *Journal of Behavioral and Experimental Finance, 37*, 100773.
16. Chintrakarn, P., Jiraporn, P., Jiraporn, N., & Davidson, T. (2017). Estimating the effect of corporate social responsibility on firm value using geographic identification. Asia-Pacific Journal of Financial Studies, 46(2), 276–304. https://doi.org/10.1111/ajfs.12170
17. Chintrakarn, P., Jiraporn, P., Tong, S., & Chatjuthamard, P. (2015). Estimating the effect of entrenched boards on firm value using geographic identification. Finance Research Letters, 12, 109–116. https://doi.org/10.1016/j.frl.2014.11.002
18. Chintrakarn, P., Jiraporn, P., Treepongkaruna, S., & Mook Lee, S. (2022). The effect of board independence on dividend payouts: A quasi-natural experiment. The North American Journal of Economics and Finance, 63, 101836. https://doi.org/10.1016/j.najef.2022.101836
19. Chintrakarn, P., Treepongkaruna, S., Jiraporn, P., & Lee, S. M. (2020). Do LGBT-supportive corporate policies improve credit ratings? An instrumental-variable analysis. Journal of Business Ethics: JBE, 162(1), 31–45. https://doi.org/10.1007/s10551-018-4009-9

20. Choi, D., Gao, Z., & Jiang, W. (2020). Attention to Global Warming. The Review of Financial Studies, 33(3), 1112–1145. https://doi.org/10.1093/rfs/hhz086
21. Core, J. E., Holthausen, R. W., & Larcker, D. F. (1999). Corporate governance, chief executive officer compensation, and firm performance. Journal of Financial Economics, 51(3), 371–406. https://doi.org/10.1016/s0304-405x(98)00058-0
22. Cotter, J. F., Shivdasani, A., & Zenner, M. (1997). Do independent directors enhance target shareholder wealth during tender offers? Journal of Financial Economics, 43(2), 195–218. https://doi.org/10.1016/S0304-405X(96)00886-0
23. Dimitrov, R. S. (2016). The Paris Agreement on climate change: Behind closed doors. Global Environmental Politics, 16(3), 1–11. https://doi.org/10.1162/glep_a_00361
24. Engle, R. F., Giglio, S., Kelly, B., Lee, H., & Stroebel, J. (2020). Hedging Climate Change News. The Review of Financial Studies, 33(3), 1184–1216. https://doi.org/10.1093/rfs/hhz072
25. Falkner, R. (2016). The Paris Agreement and the new logic of international climate politics. International Affairs, 92(5), 1107–1125. https://doi.org/10.1111/1468-2346.12708
26. Fama, E. F., & French, K. R. (2002). Testing Trade-Off and Pecking Order Predictions about Dividends and Debt. The Review of Financial Studies, 15(1), 1–33. http://www.jstor.org/stable/2696797
27. Frank, M. Z., & Goyal, V. K. (2007). Corporate Leverage: How Much Do Managers Really Matter? In Available at SSRN 971082. https://doi.org/10.2139/ssrn.971082
28. Gao, W., Ng, L., & Wang, Q. (2011). Does corporate headquarters location matter for firm capital structure? Financial Management, 40(1), 113–138. https://doi.org/10.1111/j.1755-053x.2010.01136.x
29. Gaver, J. J., & Utke, S. (2019). Audit quality and specialist tenure. The Accounting Review, 94(3), 113–147. https://doi.org/10.2308/accr-52206
30. Ginglinger, E., & Moreau, Q. (2023). Climate Risk and Capital Structure. Management Science, 69, 7151-7882.
31. Hainmueller, J. (2012). Entropy Balancing for Causal Effects: A Multivariate Reweighting Method to Produce Balanced Samples in Observational Studies. Political

Analysis: An Annual Publication of the Methodology Section of the American Political Science Association, 20(1), 25–46. https://doi.org/10.1093/pan/mpr025

32. Heo, Y. (2021). Climate Change Exposure and Firm Cash Holdings. In Available at SSRN 3795298. https://doi.org/10.2139/ssrn.3795298
33. Himmelberg, C. P., Hubbard, R. G., & Palia, D. (1999). Understanding the determinants of managerial ownership and the link between ownership and performance. Journal of Financial Economics, 53(3), 353–384. https://doi.org/10.1016/S0304-405X(99)00025-2
34. Hong, H., Karolyi, G. A., & Scheinkman, J. A. (2020). Climate Finance. The Review of Financial Studies, 33(3), 1011–1023. https://doi.org/10.1093/rfs/hhz146
35. Hossain, A., Masum, A. A., Saadi, S., Benkraiem, R., & Das, N. (2023). Firm-level climate change risk and CEO equity incentives. British Journal of Management. https://doi.org/10.1111/1467-8551.12652
36. Hsu, A. W.-H., & Wang, T. (2013). Does the market value corporate response to climate change? Omega, 41(2), 195–206. https://doi.org/10.1016/j.omega.2011.07.009
37. Huynh, T. D., & Xia, Y. (2021). Climate Change News Risk and Corporate Bond Returns. Journal of Financial and Quantitative Analysis, 56(6), 1985–2009. https://doi.org/10.1017/S0022109020000757
38. Javadi, S., & Masum, A. A. (2021). The impact of climate change on the cost of bank loans. Journal of Corporate Finance, 69, 102019. https://doi.org/10.1016/j.jcorpfin.2021.102019
39. Jenwittayaroje, N., & Jiraporn, P. (2019). Do independent directors improve firm value? Evidence from the great recession. International Review of Finance, 19(1), 207–222. https://doi.org/10.1111/irfi.12163
40. Jiraporn, P., & Gleason, K. C. (2007). Capital structure, shareholder rights, and corporate governance. Journal of Financial Research, 30(1), 21–33. https://doi.org/10.1111/j.1475-6803.2007.00200.x
41. Jiraporn, P., & Nimmanunta, K. (2018). Estimating the effect of board independence on managerial ownership using a quasi-natural experiment. Applied Economics Letters, 25(17), 1237–1243. https://doi.org/10.1080/13504851.2017.1412072

42. Jiraporn, P., Jiraporn, N., Boeprasert, A., & Chang, K. (2014). Does corporate social responsibility (CSR) improve credit ratings? Evidence from geographic identification. Financial Management, 43(3), 505–531. https://doi.org/10.1111/fima.12044
43. Jiraporn, P., Kim, J.-C., Kim, Y. S., & Kitsabunnarat, P. (2012). Capital structure and corporate governance quality: Evidence from the Institutional Shareholder Services (ISS). International Review of Economics & Finance, 22(1), 208–221. https://doi.org/10.1016/j.iref.2011.10.014
44. Klusak, P., Agarwala, M., Burke, M., Kraemer, M., & Mohaddes, K. (2023). Rising Temperatures, Falling Ratings: The Effect of Climate Change on Sovereign Creditworthiness. Management Science, 69(12), 7468–7491. https://doi.org/10.1287/mnsc.2023.4869
45. Krueger, P., Sautner, Z., & Starks, L. T. (2020). The Importance of Climate Risks for Institutional Investors. The Review of Financial Studies, 33(3), 1067–1111. https://doi.org/10.1093/rfs/hhz137
46. Lee, S. M., Jiraporn, P., Kim, Y. S., & Park, K. J. (2021). Do co-opted directors influence corporate risk-taking and credit ratings? The Quarterly Review of Economics and Finance: Journal of the Midwest Economics Association, 79, 330–344. https://doi.org/10.1016/j.qref.2020.07.003
47. Lennox, C. S., Francis, J. R., & Wang, Z. (2012). Selection models in accounting research. The Accounting Review, 87(2), 589–616. https://doi.org/10.2308/accr-10195
48. Lewbel, A. (2012). Using Heteroscedasticity to Identify and Estimate Mismeasured and Endogenous Regressor Models. Journal of Business & Economic Statistics: A Publication of the American Statistical Association, 30(1), 67–80. https://doi.org/10.1080/07350015.2012.643126
49. Likitapiwat, T., Jiraporn, P., & Treepongkaruna, S. (2023). Weathering exchange rates: estimating the effect of climate change vulnerability on foreign currency hedging using a text-based approach. *Journal of Accounting Literature*.
50. Liu, Y., & Jiraporn, P. (2010). The effect of CEO power on bond ratings and yields. Journal of Empirical Finance, 17(4), 744–762. https://doi.org/10.1016/j.jempfin.2010.03.003

51. Matsumura, E. M., Prakash, R., & Vera-Muñoz, S. C. (2014). Firm-value effects of carbon emissions and carbon disclosures. The Accounting Review, 89(2), 695–724. https://doi.org/10.2308/accr-50629
52. McAllister, J. H., & Schnakenberg, K. E. (2022). Designing the Optimal International Climate Agreement with Variability in Commitments. International Organization, 76(2), 469–486. https://doi.org/10.1017/S0020818321000400
53. McMullin, J. L., & Schonberger, B. (2020). Entropy-balanced accruals. Review of Accounting Studies, 25(1), 84–119. https://doi.org/10.1007/s11142-019-09525-9
54. Modigliani, F., & Miller, M. H. (1958). The Cost of Capital, Corporation Finance and the Theory of Investment. The American Economic Review, 48(3), 261–297. http://www.jstor.org/stable/1809766
55. Monasterolo, I., & de Angelis, L. (2020). Blind to carbon risk? An analysis of stock market reaction to the Paris Agreement. Ecological Economics: The Journal of the International Society for Ecological Economics, 170, 106571. https://doi.org/10.1016/j.ecolecon.2019.106571
56. Myers, S. C. (1984). Finance Theory and Financial Strategy. Interfaces, 14(1), 126–137. https://doi.org/10.1287/inte.14.1.126
57. Nguyen, B. D., & Nielsen, K. M. (2010). The value of independent directors: Evidence from sudden deaths. Journal of Financial Economics, 98(3), 550–567. https://doi.org/10.1016/j.jfineco.2010.07.004
58. Ongsakul, V., Chintrakarn, P., & Jiraporn, P. (2023). Climate Change, Asset Redeployability, and Sustainability: Evidence From Earnings Conference Calls. Journal of Sustainable Finance and Investment, forthcoming.
59. Ongsakul, V., Chintrakarn, P., Papangkorn, S., & Jiraporn, P. (2024). Climate change exposure and dividend policy: evidence from textual analysis. International Journal of Accounting & Information Management, ahead-of-print(ahead-of-print). https://doi.org/10.1108/IJAIM-07-2023-0170
60. Ongsakul, V., Papangkorn, S., & Jiraporn, P. (2023). Estimating the effect of climate change exposure on firm value using climate policy uncertainty: A text-based approach. Journal of Behavioral and Experimental Finance, 100842. https://doi.org/10.1016/j.jbef.2023.100842

61. Paine, J., & Sheargold, E. (2023). A Climate Change Carve-Out for Investment Treaties. Journal of International Economic Law, 26(2), 285–304. https://doi.org/10.1093/jiel/jgad011
62. Painter, M. (2020). An inconvenient cost: The effects of climate change on municipal bonds. Journal of Financial Economics, 135(2), 468–482. https://doi.org/10.1016/j.jfineco.2019.06.006
63. Pinkse, J., & Kolk, A. (2007). Multinational Corporations and Emissions Trading:: Strategic Responses to New Institutional Constraints. European Management Journal, 25(6), 441–452. https://doi.org/10.1016/j.emj.2007.07.003
64. Rajan, R. G., & Zingales, L. (1995). What do we know about capital structure? Some evidence from international data. The Journal of Finance, 50(5), 1421–1460. https://doi.org/10.1111/j.1540-6261.1995.tb05184.x
65. Rosenbaum, P. R., & Rubin, D. B. (1983). The central role of the propensity score in observational studies for causal effects. Biometrika, 70(1), 41–55. https://doi.org/10.1093/biomet/70.1.41
66. Rosenstein, S., & Wyatt, J. G. (1990). Outside directors, board independence, and shareholder wealth. Journal of Financial Economics, 26(2), 175–191. https://doi.org/10.1016/0304-405X(90)90002-H
67. Sargan, J. D. (1958). The Estimation of Economic Relationships using Instrumental Variables. Econometrica: Journal of the Econometric Society, 26(3), 393–415. https://doi.org/10.2307/1907619
68. Sautner, Z., Van Lent, L., Vilkov, G., & Zhang, R. (2023). Firm-level climate change exposure. The Journal of Finance. https://doi.org/10.1111/jofi.13219
69. Seltzer, L. H., Starks, L., & Zhu, Q. (2022). Climate Regulatory Risk and Corporate Bonds (No. 29994). National Bureau of Economic Research. https://doi.org/10.3386/w29994
70. Shleifer, A., & Vishny, R. W. (1992). Liquidation values and debt capacity: A market equilibrium approach. The Journal of Finance, 47(4), 1343–1366. https://doi.org/10.1111/j.1540-6261.1992.tb04661.x

71. Short, H., & Keasey, K. (1999). Managerial ownership and the performance of firms: Evidence from the UK. Journal of Corporate Finance, 5(1), 79–101. https://doi.org/10.1016/s0929-1199(98)00016-9
72. Titman, S., & Wessels, R. (1988). The determinants of capital structure choice. The Journal of Finance, 43(1), 1–19. https://doi.org/10.1111/j.1540-6261.1988.tb02585.x
73. Treepongkaruna, S., Kyaw, K., & Jiraporn, P. (2022). Shareholder litigation rights and ESG controversies: A quasi-natural experiment. International Review of Financial Analysis, 84, 102396. https://doi.org/10.1016/j.irfa.2022.102396
74. Watts, R. L. (1978). Systematic 'abnormal' returns after quarterly earnings announcements. Journal of Financial Economics, 6(2–3), 127–150. https://doi.org/10.1016/0304-405x(78)90027-2
75. White, L. J. (2010). Markets: The Credit Rating Agencies. The Journal of Economic Perspectives: A Journal of the American Economic Association, 24(2), 211–226. https://doi.org/10.1257/jep.24.2.211
76. Withisuphakorn, P., & Jiraporn, P. (2019). Deciphering the motives behind corporate social responsibility (CSR) using managerial ownership: evidence from heteroskedastic identification. Applied Economics Letters, 26(12), 963–970. https://doi.org/10.1080/13504851.2018.1524973

Table 1: Summary statistics

This table presents the descriptive statistics for the variables. The variable definitions are available in Table A1 in the Appendix. We employ the standard event study methodology to calculate the cumulative abnormal returns (CARs). The estimation period spans from Day -300 to Day -46 prior to the event. To calculate the predicted returns, we employ the market model, relying on the CRSP equally-weighted index as the benchmark market index. To account for these potential confounding events, we carefully exclude companies whose quarterly earnings have been announced and/or any of three key analyst measures (recommendation, price target and annual EPS forecasts) have been revised within a 5-day window for CAR (-1, 1) and a 7-day window for CAR (-2, 2) around the adoption of the Paris Agreement.

	Mean	SD	25th	Median	75th
Leverage	0.268	0.255	0.026	0.226	0.425
Market Leverage	0.187	0.201	0.014	0.128	0.289
CAR (-1,1)	-0.017	0.054	-0.037	-0.011	0.009
CAR (-2,2)	-0.012	0.069	-0.038	-0.010	0.016
Ln (Total Assets)	6.608	1.794	5.431	6.562	7.800
EBIT/Total Assets	-0.010	0.234	-0.031	0.057	0.107
Capital Expenditures/Total Assets	0.042	0.049	0.012	0.026	0.052
R&D Expense/Total Assets	0.065	0.116	0.000	0.007	0.084
Advertising Expense/Total Assets	0.014	0.032	0.000	0.000	0.009
Cash Holdings/Total Assets	0.229	0.247	0.043	0.131	0.337
Dividends/Total Assets	0.014	0.029	0.000	0.000	0.018
SG&A Expense/Total Assets	0.277	0.274	0.075	0.198	0.394
Fixed Assets/Total Assets	0.447	0.447	0.123	0.296	0.638
Current Assets/Current Liabilities	3.007	3.796	1.235	2.046	3.272

Table 2: The effect of leverage on shareholder value around the adoption of the Paris Agreement

This table shows the regression results for the stock market reactions. The variable definitions are available in Table A1 in the Appendix. We employ the standard event study methodology to calculate the cumulative abnormal returns (CARs). The estimation period spans from Day -300 to Day -46 prior to the event. To calculate the predicted returns, we employ the market model, relying on the CRSP equally-weighted index as the benchmark market index. To account for these potential confounding events, we carefully exclude companies whose quarterly earnings have been announced and/or any of three key analyst measures (recommendation, price target and annual EPS forecasts) have been revised within a 5-day window for CAR (-1, 1) and a 7-day window for CAR (-2, 2) around the adoption of the Paris Agreement.

	(1)	(2)	(3)	(4)
	CAR (-1,1)	CAR (-1,1)	CAR (-2,2)	CAR (-2,2)
Leverage	**-0.023*** **		**-0.014***	
	(-3.367)		**(-1.819)**	
Market Leverage		**-0.049*** **		**-0.040*** **
		(-5.624)		**(-3.512)**
Firm Size	0.002**	0.002**	0.002	0.002*
	(2.324)	(2.487)	(1.415)	(1.649)
Profitability	0.023	0.016*	0.000	-0.009
	(1.477)	(1.845)	(0.036)	(-0.771)
Capital Expenditures	0.017	0.025	0.032	0.039
	(0.389)	(0.766)	(0.743)	(0.884)
R&D Intensity	-0.024	-0.040**	-0.037	-0.058**
	(-0.770)	(-2.074)	(-1.536)	(-2.269)
Advertising Intensity	0.052	0.051	0.101	0.086
	(1.221)	(1.021)	(1.641)	(1.308)
Cash Holdings	0.013	0.010	0.017	0.015
	(1.442)	(1.084)	(1.518)	(1.257)
Dividends	-0.098	-0.120***	-0.138**	-0.158***
	(-1.623)	(-2.623)	(-2.340)	(-2.627)
Discretionary Spending	0.000	-0.000	0.001	0.005
	(0.024)	(-0.050)	(0.183)	(0.633)
Asset Tangibility	-0.004	-0.004	-0.003	-0.003
	(-0.828)	(-0.952)	(-0.527)	(-0.549)
Liquidity	-0.000	-0.000	0.001	0.001
	(-0.261)	(-0.298)	(1.547)	(1.433)
Constant	-0.026***	-0.021**	-0.024**	-0.021*
	(-2.691)	(-2.541)	(-2.279)	(-1.942)
Industry Fixed Effects	Yes	Yes	Yes	Yes
Observations	1,769	1,665	1,767	1,664
Adjusted R-squared	0.129	0.141	0.094	0.102

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3: Propensity score matching (PSM)

This table shows the regression results for the stock market reactions with propensity score matching (PSM). The variable definitions are available in Table A1 in the Appendix. We employ the standard event study methodology to calculate the cumulative abnormal returns (CARs). The estimation period spans from Day -300 to Day -46 prior to the event. To calculate the predicted returns, we employ the market model, relying on the CRSP equally-weighted index as the benchmark market index. To account for these potential confounding events, we carefully exclude companies whose quarterly earnings have been announced and/or any of three key analyst measures (recommendation, price target and annual EPS forecasts) have been revised within a 5-day window for CAR (-1, 1) and a 7-day window for CAR (-2, 2) around the adoption of the Paris Agreement.

Panel A: Diagnostic testing

	(1)	(2)
	Treatment	Treatment
	High Leverage	High Leverage
Firm Size	0.195***	-0.098
	(4.614)	(-1.578)
Profitability	-2.498***	0.588
	(-4.942)	(0.906)
Capital Expenditures	-2.997**	0.642
	(-2.022)	(0.294)
R&D Intensity	-0.435	-0.383
	(-0.372)	(-0.251)
Advertising Intensity	0.835	1.148
	(0.344)	(0.347)
Cash Holdings	-1.666***	0.123
	(-2.806)	(0.177)
Dividends	4.836**	-0.102
	(2.032)	(-0.039)
Discretionary Spending	-1.682***	-0.347
	(-4.180)	(-0.808)
Asset Tangibility	0.428**	0.169
	(2.468)	(0.685)
Liquidity	-0.227***	-0.037
	(-4.117)	(-0.633)
Constant	-1.353***	0.730
	(-3.677)	(1.358)
Pseudo R-squared	0.157	0.008
Observations	1,772	882

Robust z-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3: Propensity score matching (Continued)

This table shows the regression results for the stock market reactions with propensity score matching (PSM). The variable definitions are available in Table A1 in the Appendix. We employ the standard event study methodology to calculate the cumulative abnormal returns (CARs). The estimation period spans from Day -300 to Day -46 prior to the event. To calculate the predicted returns, we employ the market model, relying on the CRSP equally-weighted index as the benchmark market index. To account for these potential confounding events, we carefully exclude companies whose quarterly earnings have been announced and/or any of three key analyst measures (recommendation, price target and annual EPS forecasts) have been revised within a 5-day window for CAR (-1, 1) and a 7-day window for CAR (-2, 2) around the adoption of the Paris Agreement.

Panel B: Regression analysis

	(1)	(2)
	CAR (-1,1)	CAR (-2,2)
Leverage	**-0.034*** **	**-0.030*** **
	(-4.376)	**(-2.945)**
Firm Size	0.002	0.001
	(1.523)	(0.417)
Profitability	0.027**	-0.009
	(2.163)	(-0.509)
Capital Expenditures	-0.027	0.033
	(-0.634)	(0.581)
R&D Intensity	-0.067**	-0.090**
	(-2.098)	(-2.101)
Advertising Intensity	0.155*	0.140
	(1.701)	(1.165)
Cash Holdings	0.038**	0.044*
	(2.262)	(1.933)
Dividends	-0.153**	-0.148*
	(-2.339)	(-1.707)
Discretionary Spending	-0.006	-0.008
	(-0.551)	(-0.524)
Asset Tangibility	0.009	0.003
	(1.591)	(0.415)
Liquidity	0.001	0.003
	(0.327)	(1.631)
Constant	-0.030**	-0.022
	(-2.265)	(-1.255)
industry Fixed Effects	Yes	Yes
Observations	879	878
Adjusted R-squared	0.473	0.350

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4: Entropy balancing

This table shows the regression results for the stock market reactions with entropy balancing. The variable definitions are available in Table A1 in the Appendix. We employ the standard event study methodology to calculate the cumulative abnormal returns (CARs). The estimation period spans from Day -300 to Day -46 prior to the event. To calculate the predicted returns, we employ the market model, relying on the CRSP equally-weighted index as the benchmark market index. To account for these potential confounding events, we carefully exclude companies whose quarterly earnings have been announced and/or any of three key analyst measures (recommendation, price target and annual EPS forecasts) have been revised within a 5-day window for CAR (-1, 1) and a 7-day window for CAR (-2, 2) around the adoption of the Paris Agreement.

	(1)	(2)
	CAR (-1,1)	CAR (-2,2)
Leverage	**-0.028*** **	**-0.028*** **
	(-5.000)	**(-3.939)**
Firm Size	0.002	0.000
	(1.475)	(0.070)
Profitability	0.011	-0.023**
	(1.281)	(-1.963)
Capital Expenditures	0.015	-0.019
	(0.477)	(-0.494)
R&D Intensity	-0.088***	-0.108***
	(-3.874)	(-3.663)
Advertising Intensity	0.095	0.111
	(1.516)	(1.362)
Cash Holdings	0.021*	0.017
	(1.753)	(1.052)
Dividends	-0.172***	-0.125**
	(-3.602)	(-2.009)
Discretionary Spending	0.018**	0.021**
	(2.372)	(2.141)
Asset Tangibility	0.001	0.003
	(0.156)	(0.532)
Liquidity	0.002*	0.005***
	(1.762)	(3.096)
Constant	-0.026***	-0.015
	(-2.646)	(-1.195)
Industry Fixed Effects	Yes	Yes
Observations	1,769	1,767
Adjusted R-squared	0.159	0.146

t-statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 5: Instrumental-variable analysis (IV)

This table shows the regression results for the stock market reactions with an instrumental-variable analysis (IV). The variable definitions are available in Table A1 in the Appendix. We employ the standard event study methodology to calculate the cumulative abnormal returns (CARs). The estimation period spans from Day -300 to Day -46 prior to the event. To calculate the predicted returns, we employ the market model, relying on the CRSP equally-weighted index as the benchmark market index. To account for these potential confounding events, we carefully exclude companies whose quarterly earnings have been announced and/or any of three key analyst measures (recommendation, price target and annual EPS forecasts) have been revised within a 5-day window for CAR (-1, 1) and a 7-day window for CAR (-2, 2) around the adoption of the Paris Agreement.

	(1)	(2)	(3)	(4)
	Leverage	CAR (-1,1)	Leverage	CAR (-1,1)
Leverage (Zip Code- Average)	**0.640***** **(15.670)**			
Leverage (City-Average)			**0.757***** **(25.193)**	
Leverage (Instrumented)		**-0.034**** **(-2.087)**		**-0.026**** **(-2.301)**
Firm Size	0.028*** (7.857)	0.003*** (2.654)	0.024*** (7.417)	0.002*** (2.578)
Profitability	-0.264*** (-8.488)	0.019** (2.085)	-0.227*** (-7.965)	0.022** (2.559)
Capital Expenditures	-0.127 (-1.031)	0.016 (0.500)	-0.066 (-0.587)	0.017 (0.540)
R&D Intensity	-0.045 (-0.641)	-0.024 (-1.353)	-0.052 (-0.812)	-0.024 (-1.321)
Advertising Intensity	0.046 (0.260)	0.052 (1.143)	0.139 (0.856)	0.052 (1.137)
Cash Holdings	-0.173*** (-5.297)	0.011 (1.170)	-0.105*** (-3.505)	0.013 (1.469)
Dividends	0.188 (1.103)	-0.096** (-2.189)	0.293* (1.879)	-0.098** (-2.229)
Discretionary Spending	-0.112*** (-4.803)	-0.001 (-0.179)	-0.106*** (-4.983)	-0.000 (-0.015)
Asset Tangibility	0.072*** (4.418)	-0.003 (-0.714)	0.062*** (4.178)	-0.004 (-0.916)
Liquidity	-0.008*** (-5.008)	-0.000 (-0.459)	-0.008*** (-5.129)	-0.000 (-0.294)
Constant	-0.020 (-0.642)	-0.385*** (-10.731)	-0.045 (-1.599)	-0.384*** (-10.723)
Industry Fixed Effects	Yes	Yes	Yes	Yes
Observations	1,769	1,772	1,769	1,772
Adjusted R-squared	0.433	0.126	0.528	0.128

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6: Instrumental-variable analysis with two instruments

This table shows the regression results for the stock market reactions with an instrumental-variable analysis. The variable definitions are available in Table A1 in the Appendix. We employ the standard event study methodology to calculate the cumulative abnormal returns (CARs). The estimation period spans from Day -300 to Day -46 prior to the event. To calculate the predicted returns, we employ the market model, relying on the CRSP equally-weighted index as the benchmark market index. To account for these potential confounding events, we carefully exclude companies whose quarterly earnings have been announced and/or any of three key analyst measures (recommendation, price target and annual EPS forecasts) have been revised within a 5-day window for CAR (-1, 1) and a 7-day window for CAR (-2, 2) around the adoption of the Paris Agreement.

	(1) Leverage	(2) CAR (-1,1)
Leverage (Zip Code-Average)	**0.642***** **(16.080)**	
Leverage (Industry-Average)	**0.451***** **(9.344)**	
Leverage (Instrumented)		**-0.041***** **(-3.141)**
Firm Size	0.024*** (7.111)	0.003*** (3.362)
Profitability	-0.229*** (-7.827)	0.025*** (2.819)
Capital Expenditures	-0.181 (-1.521)	0.002 (0.076)
R&D Intensity	0.084 (1.274)	-0.015 (-0.865)
Advertising Intensity	0.010 (0.064)	0.056 (1.302)
Cash Holdings	-0.148*** (-4.725)	0.014 (1.574)
Dividends	0.206 (1.252)	-0.099** (-2.221)
Discretionary Spending	-0.111*** (-5.095)	0.004 (0.594)
Asset Tangibility	0.033** (2.349)	-0.010** (-2.564)
Liquidity	-0.007*** (-4.850)	-0.000 (-0.841)
Constant	-0.113*** (-3.550)	-0.025*** (-3.152)
Observations	1,772	1,772
Adjusted R-squared	0.425	0.055
Sargan Statistic		0.493

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 7: Regression analysis based on Lewbel's (2012) heteroscedastic identification

This table shows the regression results for the stock market reactions with Lewbel's (2012) heteroscedastic identification. The variable definitions are available in Table A1 in the Appendix. We employ the standard event study methodology to calculate the cumulative abnormal returns (CARs). The estimation period spans from Day -300 to Day -46 prior to the event. To calculate the predicted returns, we employ the market model, relying on the CRSP equally-weighted index as the benchmark market index. To account for these potential confounding events, we carefully exclude companies whose quarterly earnings have been announced and/or any of three key analyst measures (recommendation, price target and annual EPS forecasts) have been revised within a 5-day window for CAR (-1, 1) and a 7-day window for CAR (-2, 2) around the adoption of the Paris Agreement.

	(1)	(2)
	CAR (-1,1)	CAR (-2,2)
Leverage	**-0.023*****	**-0.014***
	(-3.986)	**(-1.859)**
Firm Size	0.002***	0.002
	(2.636)	(1.446)
Profitability	0.023***	0.000
	(2.804)	(0.036)
Capital Expenditures	0.017	0.032
	(0.552)	(0.759)
R&D Intensity	-0.024	-0.037
	(-1.312)	(-1.570)
Advertising Intensity	0.052	0.101*
	(1.135)	(1.677)
Cash Holdings	0.013	0.017
	(1.594)	(1.551)
Dividends	-0.098**	-0.138**
	(-2.242)	(-2.391)
Discretionary Spending	0.000	0.001
	(0.034)	(0.187)
Asset Tangibility	-0.004	-0.003
	(-0.988)	(-0.538)
Liquidity	-0.000	0.001
	(-0.247)	(1.581)
Constant	-0.384***	-0.365***
	(-10.720)	(-7.741)
Industry Fixed Effects	Yes	Yes
Observations	1,772	1,770
Adjusted R-squared	0.128	0.093

z-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 8: The role of climate change exposure

This table shows the regression results for the stock market reactions accounting for firm-specific exposure to climate change. The variable definitions are available in Table A1 in the Appendix. We employ the standard event study methodology to calculate the cumulative abnormal returns (CARs). The estimation period spans from Day -300 to Day -46 prior to the event. To calculate the predicted returns, we employ the market model, relying on the CRSP equally-weighted index as the benchmark market index. To account for these potential confounding events, we carefully exclude companies whose quarterly earnings have been announced and/or any of three key analyst measures (recommendation, price target and annual EPS forecasts) have been revised within a 5-day window for CAR (-1, 1).

	(1)	(2)	(3)	(4)
	CAR (-1,1)	CAR (-1,1)	CAR (-1,1)	CAR (-1,1)
Leverage × Climate Change Exposure	**3.490**			
	(0.760)			
Climate Change Exposure	**1.635**			
	(1.043)			
Leverage × Physical Risk		**-115.594****		
		(-2.481)		
Physical Risk		**42.688*****		
		(2.820)		
Leverage × Regulatory Risk			**-39.749**	
			(-0.666)	
Regulatory Risk			**-5.347**	
			(-0.879)	
Leverage × New Opportunities)				**7.524**
				(1.058)
New Opportunities				**5.269****
				(2.049)
Leverage	**-0.025*****	**-0.022*****	**-0.023*****	**-0.024*****
	(-3.416)	**(-3.251)**	**(-3.279)**	**(-3.463)**
Firm Size	0.002**	0.002**	0.002**	0.002**
	(2.426)	(2.395)	(2.303)	(2.357)
Profitability	0.023	0.023	0.022	0.024
	(1.503)	(1.484)	(1.443)	(1.580)
Capital Expenditures	0.012	0.019	0.017	0.004
	(0.259)	(0.424)	(0.372)	(0.079)
R&D Intensity	-0.021	-0.023	-0.025	-0.018
	(-0.675)	(-0.754)	(-0.817)	(-0.610)
Advertising Intensity	0.054	0.050	0.052	0.055
	(1.269)	(1.170)	(1.219)	(1.289)
Cash Holdings	0.014	0.014	0.013	0.013
	(1.471)	(1.480)	(1.414)	(1.368)
Dividends	-0.096	-0.100*	-0.098	-0.090
	(-1.588)	(-1.651)	(-1.627)	(-1.481)
Discretionary Spending	0.001	0.000	0.000	0.001
	(0.142)	(0.046)	(0.005)	(0.146)
Asset Tangibility	-0.004	-0.004	-0.004	-0.004
	(-0.880)	(-0.840)	(-0.776)	(-0.817)

Liquidity	-0.000	-0.000	-0.000	-0.000
	(-0.193)	(-0.333)	(-0.286)	(-0.064)
Constant	-0.028***	-0.027***	-0.025***	-0.028***
	(-2.929)	(-2.797)	(-2.651)	(-2.905)
Industry Fixed Effects	Yes	Yes	Yes	Yes
Observations	1,769	1,769	1,769	1,769
Adjusted R-squared	0.131	0.130	0.129	0.137

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 9: Cross-sectional analysis: The role of profitability and liquidity

This table shows the regression results for the stock market reactions with a cross-sectional analysis. The variable definitions are available in Table A1 in the Appendix. We employ the standard event study methodology to calculate the cumulative abnormal returns (CARs). The estimation period spans from Day -300 to Day -46 prior to the event. To calculate the predicted returns, we employ the market model, relying on the CRSP equally-weighted index as the benchmark market index. To account for these potential confounding events, we carefully exclude companies whose quarterly earnings have been announced and/or any of three key analyst measures (recommendation, price target and annual EPS forecasts) have been revised within a 5-day window for CAR (-1, 1).

	(1)	(2)
	CAR (-1,1)	CAR (-1,1)
Leverage × Profitability	**0.035****	
	(2.493)	
Leverage × Liquidity		**0.004****
		(2.269)
Leverage	-0.020***	-0.033***
	(-3.193)	(-4.482)
Firm Size	0.002**	0.003***
	(2.377)	(2.711)
Profitability	0.011	0.021**
	(1.172)	(2.550)
Capital Expenditures	0.024	0.017
	(0.737)	(0.524)
R&D Intensity	-0.028	-0.024
	(-1.497)	(-1.286)
Advertising Intensity	0.053	0.053
	(1.138)	(1.136)
Cash Holdings	0.014*	0.011
	(1.665)	(1.301)
Dividends	-0.095**	-0.106**
	(-2.138)	(-2.361)
Discretionary Spending	-0.001	0.000
	(-0.139)	(0.004)
Asset Tangibility	-0.004	-0.003
	(-0.863)	(-0.722)
Liquidity	-0.000	-0.000
	(-0.380)	(-0.769)
Constant	-0.026***	-0.025***
	(-3.252)	(-3.212)
Industry Fixed Effects	Yes	Yes
Observations	1,769	1,769
Adjusted R-squared	0.131	0.131

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 10: The role of corporate governance and climate change sentiment

This table shows the regression results for the stock market reactions with a cross-sectional analysis using corporate governance and climate change sentiment. The variable definitions are available in Table A1 in the Appendix. We employ the standard event study methodology to calculate the cumulative abnormal returns (CARs). The estimation period spans from Day -300 to Day -46 prior to the event. To calculate the predicted returns, we employ the market model, relying on the CRSP equally-weighted index as the benchmark market index.

	(1) CAR (-1,1)	(2) CAR (-1,1)	(3) CAR (-1,1)
Leverage × Managerial Ownership	**0.000**		
	(0.168)		
Managerial Ownership	-0.000		
	(-0.237)		
Leverage × % Independent Directors		**0.000**	
		(0.734)	
% Independent Directors		-0.000	
		(-0.881)	
Ln (Board Size)		0.003	
		(0.313)	
Leverage × Climate Change Sentiment			**29.076****
			(2.568)
Climate Change Sentiment			-4.589*
			(-1.785)
Leverage	-0.015**	-0.049	-0.025***
	(-2.236)	(-1.136)	(-4.197)
Firm Size	0.001	0.000	0.002**
	(1.344)	(0.256)	(2.375)
Profitability	0.049***	0.042***	0.023***
	(4.255)	(2.662)	(2.752)
Capital Expenditures	0.050	0.004	0.012
	(1.149)	(0.083)	(0.375)
R&D Intensity	-0.006	0.036	-0.024
	(-0.271)	(1.027)	(-1.327)
Advertising Intensity	0.032	0.103*	0.053
	(0.703)	(1.841)	(1.146)
Cash Holdings	0.033***	0.021*	0.015*
	(3.361)	(1.777)	(1.722)
Dividends	-0.037	-0.062	-0.092**
	(-0.834)	(-1.158)	(-2.054)
Discretionary Spending	-0.025***	-0.013	-0.000
	(-3.474)	(-1.209)	(-0.038)
Asset Tangibility	0.002	0.004	-0.004
	(0.457)	(0.610)	(-0.867)
Liquidity	-0.001**	-0.001**	-0.000
	(-2.025)	(-2.096)	(-0.277)
Constant	-0.020**	-0.004	-0.024***
	(-2.034)	(-0.186)	(-3.088)

Industry Fixed Effects	Yes	Yes	Yes
Observations	855	630	1,769
Adjusted R-squared	0.083	0.105	0.131

t-statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 11: The effect of climate change exposure on capital structure after the adoption of the Paris agreement

This table shows the regression results for the effect of climate change exposure on capital structure after the adoption of the Paris agreement. Our text-based measure of climate change exposure is from Sautner et al. (2023). The variable definitions are available in Table A1 in the Appendix.

	(1)	(2)	(3)
	Full Sample	Year (-4, +4) (2011-2019)	Year (-2, +2) (2013-2017)
	Leverage	Leverage	Leverage
Climate Change Exposure × Post-Paris	-2.631***	-2.311***	-2.136***
	(-3.031)	(-3.067)	(-2.941)
Post-Paris	0.046***	0.035***	0.029***
	(9.236)	(6.653)	(5.592)
Climate Change Exposure	-1.311	0.332	1.669
	(-1.174)	(0.349)	(1.273)
Firm Size	0.029***	0.053***	0.036*
	(5.635)	(4.006)	(1.699)
Profitability	-0.205***	-0.277***	-0.300***
	(-4.643)	(-4.275)	(-3.717)
Capital Expenditures	-0.218***	-0.187	-0.068
	(-2.666)	(-1.470)	(-0.422)
R&D Intensity	-0.215***	-0.108	0.098
	(-3.090)	(-1.074)	(0.724)
Advertising Intensity	-0.047	-0.166	-0.294
	(-0.417)	(-0.966)	(-1.316)
Cash Holdings	-0.068***	-0.077**	-0.105*
	(-2.662)	(-2.166)	(-1.958)
Dividends	0.200*	0.138	0.070
	(1.699)	(1.636)	(0.600)
Discretionary Spending	-0.062*	-0.051	-0.067
	(-1.700)	(-0.635)	(-0.524)
Asset Tangibility	0.108***	0.133***	0.128***
	(4.729)	(4.331)	(3.407)
Liquidity	-0.015***	-0.011***	-0.005*
	(-7.865)	(-5.185)	(-1.754)
Constant	0.072	-0.114	-0.008
	(1.510)	(-0.945)	(-0.043)
Firm Fixed Effects	Yes	Yes	Yes
Observations	36,356	17,737	9,548
Adjusted R-squared	0.712	0.771	0.821

Robust t-statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 12: The effect of various dimensions of exposure on capital structure after the adoption of the Paris agreement

This table shows the regression results for the effect of various dimensions of exposure on capital structure after the adoption of the Paris agreement. The variable definitions are available in Table A1 in the Appendix.

	(1)	(2)	(3)
	Leverage	Leverage	Leverage
Physical Risk × Post-Paris	**-24.425**		
	(-0.883)		
Physical Risk	**10.882**		
	(0.294)		
Regulatory Risk × Post-Paris		**-21.206*** **	
		(-3.388)	
Regulatory Risk		**-9.413** **	
		(-2.501)	
New Opportunities × Post-Paris			**-4.848*** **
			(-2.958)
New Opportunities			**-1.392**
			(-0.732)
Post-Paris	0.043***	0.044***	0.045***
	(9.261)	(9.394)	(9.317)
Firm Size	0.029***	0.029***	0.029***
	(5.636)	(5.641)	(5.629)
Profitability	-0.206***	-0.205***	-0.205***
	(-4.650)	(-4.650)	(-4.649)
Capital Expenditures	-0.221***	-0.220***	-0.219***
	(-2.693)	(-2.685)	(-2.674)
R&D Intensity	-0.215***	-0.215***	-0.215***
	(-3.096)	(-3.095)	(-3.096)
Advertising Intensity	-0.047	-0.047	-0.046
	(-0.417)	(-0.419)	(-0.416)
Cash Holdings	-0.068***	-0.068***	-0.068***
	(-2.689)	(-2.683)	(-2.673)
Dividends	0.200*	0.199*	0.200*
	(1.702)	(1.697)	(1.699)
Discretionary Spending	-0.062*	-0.062*	-0.062*
	(-1.704)	(-1.698)	(-1.700)
Asset Tangibility	0.108***	0.108***	0.108***
	(4.731)	(4.735)	(4.740)
Liquidity	-0.015***	-0.015***	-0.015***
	(-7.853)	(-7.860)	(-7.859)
Constant	0.072	0.072	0.072
	(1.503)	(1.508)	(1.500)
Firm Fixed Effects	Yes	Yes	Yes
Observations	36,356	36,356	36,356
Adjusted R-squared	0.712	0.712	0.712

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix

Table A1: Variable definitions

We employ the standard event study methodology to calculate the cumulative abnormal returns (CARs). The estimation period spans from Day -300 to Day -46 prior to the event. To calculate the predicted returns, we employ the market model, relying on the CRSP equally-weighted index as the benchmark market index.

Variable	Definition
Stock Market Reactions	
CAR (-1,1)	Cumulative Abnormal Returns between Days -1 and 1
CAR (-2,2)	Cumulative Abnormal Returns between Days -2 and 2
Leverage	
Leverage	Total Debt/Total Assets
Market Leverage	Total debt divided by the market value of assets, where the market value of assets is total assets minus book value of equity minus deferred Taxes and investment tax credits plus the market value of common equity plus preferred stock
Climate Change	
Climate Change Exposure	Overall text-based measure of firm-specific exposure developed by Sautner et al. (2023)
Physical Risk	Text-based measure of physical risk
Regulatory Risk	Text-based measure of regulatory risk
New Opportunities	Text-based measure of new business opportunities
Climate Change Sentiment	Text-based measure of climate change sentiment
Firm-specific Characteristics	
Firm Size	Total Assets
Profitability	EBIT/Total Assets
Capital Expenditures	Capital Expenditures/Total Assets
Advertising Intensity	Advertising Expense/Total Assets
R&D Intensity	R&D Expense/Total Assets
Cash Holdings	Cash Holdings/Total Assets
Asset Tangibility	Fixed Assets/Total Assets
Discretionary Spending	SG&A Expense/Total Assets
Liquidity	Current Assets/Current Liabilities
Board Attributes & Managerial Ownership	

% Independent Directors	Proportion of independent directors on the board
Board Size	Total number of directors on the board
Managerial Ownership	Percentage of total ownership held by the top five executives in the firm