



Corporate climate risk and stock market reaction to performance briefings in China

Naiqian Wu¹ · Weiguo Xiao¹ · Wei Liu^{1,2} · Zhan Zhang¹

Received: 29 December 2021 / Accepted: 24 February 2022 / Published online: 15 March 2022
© The Author(s), under exclusive licence to Springer-Verlag GmbH Germany, part of Springer Nature 2022

Abstract

This study aims to enrich our understanding of the valuation consequence of climate risk in financial markets. The primary focus of our study is on the stock price reaction to firms' climate-risk-related information. We employ transcripts of Chinese listed firms' performance briefings to capture the climate risk at the firm level. Using a sample of Chinese listed firms between 2009 and 2021, we find that greater corporate climate risks lead to negative market reactions over a short time window, consistent with the market quickly comprehending corporate climate risks. This result holds for a series of robustness checks. We further find that the negative impact of corporate climate risk on the stock price reaction operates through the increased market trading activities, greater investor attention, and reduced positive media coverage. Finally, we demonstrate that industry carbon emission, local abnormal temperature, state ownership, institutional shareholding, and dividend payout are important moderators that shape the association of the corporate climate risk and the adverse market reaction. Our evidence suggests that disclosures of climate-related information can help the stock market to price climate risk more efficiently.

Keywords Climate change · Climate risk · Corporate disclosure · Performance briefings · Market reaction · Stock returns

Introduction

Global climate change is considered the most important issue confronted by all countries in the twenty-first century. The evolutionary impacts of climate change on economic activities have received much attention among scholars and policymakers (Stern 2007). Meanwhile, climate change also poses substantial challenges to participants in financial markets because various financial assets are ultimately backed

by the real economy (Dietz et al. 2016). For example, on July 20, 2021, a record-breaking heavy rainfall hit Zhengzhou, the provincial capital of China's Henan Province. The resulting severe flooding further affected the stock market performance of some publicly listed companies, such as Zhengzhou Coal Industry & Electric Power whose stock price experienced a 13.25 percent decline within seven days immediately after the disaster. As stated by Giglio et al. (2021), climate change exposes firms to new risks and has significant financial implications for the underlying stocks. However, despite the recently growing attention on the relation between climate risks and financial asset prices, relatively little is known about how investors perceive such risks based on public information. In this paper, we address the important question by investigating whether investors react to climate risks revealed in firms' disclosures.

To what extent does climate risk impact stock prices? In light of Fama (1970)'s efficient market hypothesis, financial market efficiency relies on quick and sufficient price adjustment regarding new public information. That is, a change in stock price occurs when investors revise their views on a firm's future performance. A large body of literature in finance suggests that corporate disclosure mechanisms are of great importance for transmitting value-relevant information

Responsible Editor: Nicholas Apergis

✉ Wei Liu
liuweiabc9055@whu.edu.cn

Naiqian Wu
naiqianwu@whu.edu.cn

Weiguo Xiao
wgxiao@whu.edu.cn

Zhan Zhang
zzhan9426@whu.edu.cn

¹ Economics and Management School, Wuhan University, Wuhan 430072, China

² Climate Change and Energy Economics Study Center, Wuhan University, Wuhan 430072, China

to the market, and thus help new information to be efficiently impounded into stock prices (Price et al. 2012; Pevzner et al. 2015; Bochkay et al. 2020). Particularly, recent studies by Sautner et al. (2021) and Li et al. (2020) demonstrate that climate-related narratives in earnings conference calls can reflect firms' exposure to climate risks. Sautner et al. (2021) also suggest that the firm-level measures of corporate climate risk have valuation implications for year-on-year change in Tobin's Q. However, these studies use samples of earnings conference calls whose audiences are mainly financial analysts rather than individual investors, and thus cannot speak to how corporate climate risk affects investors' perceptions of firm risks over a short window. Given that the performance briefing mechanism of Chinese listed firms is open to all market participants, the Chinese stock market offers an ideal institutional setting to analyze the pricing effects of the climate risk. In this paper, we extend this research and contribute more generally to the larger literature on financial market efficiency by examining the stock market reaction to climate risks revealed in Chinese firms' performance briefings.

Corporate climate risk, which reflects "the climate risk faced by a given firm at a given time" (Li et al. 2020), clearly has the potential to impact investors' attitudes toward and reactions to firms' performance briefings, but its actual influence can be hard to predict *ex ante*. On the one hand, when investors learn about the firm-specific climate risk, they form new expectations about the firm's business conditions. An increase in climate risk might impose higher compliance costs (i.e., costs that arise from the implementation of stringent climate policy and regulation by governments) and proprietary costs (i.e., costs that stem from the physical impacts of climate change and government penalties) on firms' business operation (Matsumura et al. 2014). Therefore, we expect that corporate climate risk generates increased uncertainty and exacerbated outlook for the average firm, leading to negative stock price changes after the performance briefing. On the other hand, the reaction that climate-related information disclosures can generate in the stock market also depends on outside investors' demands for information. In an imperfect market with asymmetry information problems, the climate-related disclosures might provide positive signals that suggest how hard the management works to mitigate climate risks, and thus lower information risks. As a result, we predict that disclosures of corporate climate risk can induce a positive stock price reaction to firms' performance briefings.

In this paper, we employ a textual analysis method to capture the frequency of climate-related keywords in transcripts of Chinese firms' performance briefings. Unlike many contemporary studies that measure corporate climate risks using proxies such as carbon emissions (Bolton and Kacperczyk 2021), local temperature (Choi et al. 2020),

regional drought index (Hong et al. 2019), and Environmental, Social, and Corporate Governance (ESG) performance ratings (Engle et al. 2020), the text-based climate risk measure reflects the combined views of key stakeholders about a firm's climate risks (Sautner et al. 2021). Thus, it offers an important advantage over the other studies when relating climate change issues to investors' risk perceptions. We begin our empirical analysis by examining the relation between our measure of corporate climate risk and the stock price reaction to performance briefings for the Chinese listed firms over the period 2009–2021. We further explore the potential mechanisms by which firm-specific climate risks affect investor perceptions of the firm. In addition, we also conduct several subsample analyses to investigate whether the pricing effects of corporate climate risk exhibit significant heterogeneities.

The contribution of our study is threefold. First, it adds to the burgeoning research on the economic consequence of climate change (Stern 2007; Weitzman 2014; Nordhaus 2017; Lemoine 2021; Bartram et al. 2021). We provide micro-level evidence showing that firms with more extensive discussions about the climate risk in their performance briefings experience a greater stock price decline over a short window. Our results are robust after addressing the potential endogeneity concerns about the omitted variable and sample selection bias, and a series of sensitivity and placebo tests. Second, our paper contributes to the finance literature on the role of climate-related information in stock price discovery (Krüger 2015; Capelle-Blancard and Petit 2019; Grewal et al. 2019; Wong and Zhang 2022). Our empirical findings indicate that the corporate climate risk is quickly impounded into the stock price via three possible channels: more active market trading activities, greater investor attention, and reduced positive news media coverage relative to positive news. Third, our research lends insights into the heterogeneous effects of corporate climate risk in inducing negative stock price changes. We document that the adverse stock price reaction is concentrated in the firms with high carbon emissions, located in abnormally high-temperature cities, owned by the local or central governments, having low institutional shareholdings, and paying dividends to shareholders. The results are of importance for policymakers and investors to adopt differentiated strategies when combating climate change challenges.

The remainder of this paper is organized as follows: "Related literature and theoretical framework" section presents the related research and theoretical framework of this study. "Methodology" section describes the data used and the research design. "Empirical results and discussion" section presents and discusses the empirical results. "Concluding remarks" section summarizes this study and provides policy implications.

Related literature and theoretical framework

Related literature

Climate risks in financial markets

In recent years, a burst of research has focused on the relationship between climate change and financial markets, especially the role of financial markets in potentially mitigating or intensifying the risks associated with climate change. Literature in climate finance categorizes climate risks into physical risks and transition risks (Giglio et al. 2021). Physical risks of climate change refer to risks that directly impair firm performance and profitability. For instance, the threat of damage from extreme climate events, such as drought, heatwaves, flooding, storm, can adversely affect firms' business operations and is detrimental to asset value and business sustainability (Ginglinger and Moreau 2021). Transition risks are those that result from the transition of the economy to a low-carbon path, including possible changes in technology, consumer demand, policy, regulation, etc. (Li et al. 2021). An example of the transition risk is the carbon tax imposed on high-carbon emission firms, cutting down the profitability of the industry.

Given the considerable impact of climate change on firms' operation and profitability, asset prices should reflect the exposure of their cash flows to climate risks. Much prior literature has debated the efficiency of financial markets concerning climate risks, and a consensus has yet to emerge. Bansal et al. (2016) examine whether temperature fluctuations brought about by global warming affect the aggregate stock market valuation. They find that temperature risks have a negative influence on equity valuation, even if the effect of global temperature increase is expected to realize in the distant future. Dietz et al. (2016) demonstrate that global financial assets suffer considerable value loss from climate risks, based on their estimates of the VaR (value at risk) from climate change. Engle et al. (2020) find that firms subject to higher regulatory climate risk have lower stock returns during periods with substantial negative news about long-run climate risk. Choi et al. (2020) show that carbon-intensive firms underperform those with low emissions when the local temperature is abnormally high, a period during which investors' attention to global warming also increases. Bolton and Kacperczyk (2021) analyze the effect of firms' carbon emissions on the cross-sectional pattern of stock returns. They document that stock markets correctly prices firms with high carbon emissions at a discount.

In the meantime, a few researchers have addressed their concerns on potential inefficiencies of the market. For

example, Hong et al. (2019) examine the impact of long-term drought trends on cross-country food stock returns. They claim that the stock market cannot fully understand climate risk information, leading to a significant delay in stock price adjustment. Murfin and Spiegel (2020) explore the effect of climate risk of sea level rise on house prices. They find evidence that the market fails to detect the threat of sea level rise and there is a limited price effect.

The majority of studies focus only on one or a few aspects of climate risks (e.g., abnormal temperature, carbon emission, flooding, ESG rating). However, there is a lack of measures reflecting the overall climate risk faced by firms. To overcome this empirical challenge, Sautner et al. (2021) constructed a measure of firm-level climate risk by applying the machine learning approach to identify climate-related information from conversations between analysts and the management team in earnings conference calls. In a similar vein, Li et al. (2020) use earnings call transcripts data to measure firms' climate change, though their textual analysis relies on a preset dictionary containing climate-related keywords.

Overall, most of the preceding research has discussed the pricing effects of climate change on financial assets using various climate risk metrics. However, none of the studies analyze how climate risks faced by individual firms are perceived by investors and incorporated into stock prices, particularly in the context of corporate public disclosure mechanisms.

Corporate disclosures and stock price movements

Much literature in finance has focused on the valuation implication of firms' qualitative disclosures. There is a growing consensus that qualitative disclosures are important sources and are informative above and beyond traditional financial factors that impact asset prices. Price et al. (2012) examine the tone of the textual content in earnings conference calls and find that the market reacts positively to the tone, suggesting that management use qualitative narrative to communicate their private information about the future performance of the firm. Blau et al. (2015) investigate whether more sophisticated investors interpret qualitative information from earnings conferences differently than naïve investors. They document that the short seller can better understand the language of management than investors at large. Milian and Smith (2017) find that complimentary language by analysts in earnings conference calls positively predicts the subsequent stock returns. More recently, several studies find that qualitative information related to a specific topic (e.g., political risk, COVID-19) is reflected in stock market returns (Hassan et al. 2019, 2021).

Furthermore, several researchers have studied the effects of firms' environmental disclosure on stock price discovery.

Clarkson et al. (2013) investigate the value relevance of the management's environmental disclosure. They find evidence that both mandatory and voluntary disclosures provide useful information about the company and lead to stock price adjustment. Plumlee et al. (2015) indicate that the quality of voluntary environmental disclosure has a positive association with the future stock price of the company. Griffin et al. (2017) find that the voluntary disclosure of greenhouse gas emissions under the Carbon Disclosure Project induces penalties for a firm's equity value, giving rise to an immediate stock price reaction when investors receive new emission-related information. Ng and Rezaee (2020) show that ESG-related information disclosed by a firm facilitates useful information being impounded into its stock price.

In sum, prior literature finds evidence that corporate qualitative disclosures provide rich information to the market. Whereas much of the focus of environmental disclosures are on the content of a stand-alone environmental performance report, our study examines the stock market reaction to the more generalized and broader disclosure of the climate-related information. In addition, despite the emergence of the climate finance literature, there are acknowledged weaknesses as to the effects of climate risk in financial markets at the asset level (Giglio et al. 2021). Our study attempts to fill this gap by examining the mechanisms by which the firm-specific climate risk can result in stock price changes.

Theoretical framework

The efficient market hypothesis provides a theoretical foundation for our research. In a semi-strong form of efficient market, stock prices reflect all public information as well as the historic information already incorporated into prices (Fama 1970). Since investors face ambiguity toward the climate risk in stock markets, the arrival of new information leads to beliefs updates by investors, resulting in stock price adjustment in response to the relevant information. Specifically, performance briefings disclosures of climate risks can lead to both costs and benefits from an investor standpoint. First, the revelation of climate risks faced by a firm can increase information relevant for valuation purposes, and thus mitigate information asymmetry between stakeholders. This reduces information risk and is beneficial to lower firms' cost of capital, which in the long run improves the firm value. Second, the climate risks disclosed by a firm may convey material information regarding the firm's coping strategies, such as green innovation or actions to reduce carbon emissions. That is, the firm signals favorable information to the market to establish a good reputation. Third, disclosures of firm-level climate risks can increase the effectiveness of monitoring and mitigate the agency problem.

In contrast, investors may expect sources of costs associated with climate risk. The first is the direct costs that

have detrimental impacts on firms' operation and competitiveness, including the proprietary costs of climate change shocks (e.g., flooding, draughts, heat waves, etc.) and the possible regulatory interventions (e.g., pollution fines). The second includes regulation costs that governments and regulators pressure firms to invest in more climate-friendly projects which ultimately have negative net present value to shareholders. The third source of costs is effects associated with firms' financial risk due to inadequate cash flows to meet the financial obligation in the future (Jagannathan et al. 2018; Ilhan et al. 2021).

Given the random and interactive nature of performance briefings, climate-related information disclosures are hard to be prearranged by the management. Hence, as Grewal et al. (2019) suggest, if investors expect firms to make optimal disclosure decisions before the performance briefings, equilibrium conditions would generate the prediction that punishment will outweigh the reward. Consequently, we conjecture that there is a negative stock price reaction to climate risks revealed in firms' performance briefings.

There are several channels in which one might expect climate risk to affect stock returns. First, since trading is the mechanism that can move stock prices (Campbell et al. 1993), climate risk might influence investor perception of firm value through market trading activities. In the presence of climate risk, shareholders are likely to reduce the valuation of the underlying stock, thus there will be a higher selling pressure after the briefing. Specifically, trading volume is a signal for shifts in the demand/supply for stocks. As discussed in Karpoff (1987), higher trading volumes are correlated with a greater absolute change in stock prices. To trigger more powerful negative stock price changes in the face of climate risks, there should be a positive trading volume response. In the meantime, the effect of climate risks on investors' trading behaviors can be also reflected in stock return volatility. Miller (1977) states that investors under uncertainty due to asymmetric information are more likely to create higher risk (i.e., having higher stock return volatility) and more likely to have lower stock returns. When firms are uncovering climate risks, existing stockholders are facing greater uncertainty regarding firms' prospects. In this case, these stocks become riskier and less attractive to investors, leading to negative stock price changes in response to the disclosure of corporate climate risk.

A second channel is that disclosures of corporate climate risks can draw investor attention and help climate-related information to be quickly incorporated into prices. Traditional asset pricing theory assumes that individuals have unconstrained abilities to trade immediately as new information arrives (Jagannathan and Wang 1996). However, literature in behavioral economics indicates that attention is a scarce source for individuals (Kahneman 1973), especially in the context of financial markets where investors

face a vast amount of various information (Hirshleifer et al. 2009). In consequence, only a subset of information can be observed by investors. An interesting question in this respect is whether firms more exposed to climate risk are more likely to be noticed by market participants. Recent research highlights the fact that climate change is a salience topic that grabs much attention in financial markets, and higher attention to climate change can result in greater stock price changes (Choi et al. 2020). Therefore, we contend that the disclosure of climate risk provides a stimulus that stands out relative to other stimuli in the information environment. The higher salience can improve the cognitive process of firms' climate-related information, leading to more timely adverse stock price reactions to climate risk.

Third, we argue that media plays a crucial role in affecting investor recognition of corporate climate risk. Among a bunch of information intermediaries in stock markets, the news media is widely regarded as the broadest source of corporate information (Bushee et al. 2010). Investors largely rely on the media press to gather information related to climate change with relatively lower costs, which helps the spread of information in a wider range. Furthermore, in addition to its information disseminating role, the media can also create information with its own judgments (Wu and Lin 2017). News media might provide investors with new information indicating whether the climate-related information of the firm is good or bad news. For example, Wong and Zhang (2022) find that a firm's ESG performance can cause stock price shocks through media channels. They document that a more negative ESG media coverage indicates a decrease in stock price and firm value. Similar to this work on a firm's ESG performance, we focus on the climate risk revealed in performance briefings. As mentioned earlier, on average the disclosure of firm-specific climate risks exacerbates the market's concerns about the firm's future business operation. Therefore, we conjecture that corporate information related to climate risks can affect investor perception of firm value through more (less) negative (positive) media coverage. This will result in a reduction of stock price after the corporate disclosure.

Based on these discussions, it is plausible that climate risks can cause negative stock price reactions via three distinct but not mutually exclusive channels: market trading, investor attention, and media coverage. To examine the average pricing effects of firm-specific climate risks, this research focuses on climate change information that appears in the performance briefings transcripts of Chinese listed companies. Recall that the premise of stock price reaction to climate-related information requires the market to be efficient. Numerous studies in market microstructure provide substantial evidence that the Chinese stock market can correctly recognize various information in a timely fashion. For example, Xu et al. (2012) provide empirical evidence that

stock prices adversely adjust to information disclosures of firms' environmental violations in China. Guo et al. (2020) find that the announcement of environmental policies by the Chinese government induces a negative stock market response. Further, studies such as Chong et al. (2012) and Li et al. (2022) examine the efficiency problem of the Chinese stock market and observe that the market becomes more efficient with the improvement of market liberalization and deregulation. Overall, prior literature provides substantial evidence that the Chinese stock market is expected to identify various disclosure information and our primary focus is to assess the existence of priced climate risk at the firm level.

Methodology

Variable measurement and sample selection

Measuring corporate climate risk

Our key variable of interest in this paper is corporate climate risk, which captures a firm's exposure to climate change. Specifically, we measure individual firms' time-varying climate risks using transcripts of Chinese firms' performance briefings. Several studies utilize meteorological or geographical proxies, such as temperature shocks, draughts trends, and sea level rise, to measure risks associated with climate change in financial markets (Bernstein et al. 2019; Hong et al. 2019; Choi et al. 2020). However, given a lack of compatibility at the firm level, these measures are not particularly relevant in our setting. Further, while climate change could impose either physical risks or transition risks on firms' business operations (Giglio et al. 2021), it is not feasible to use a single geographical proxy to reflect the overall climate risks faced by firms. As such, we follow the recent literature that has employed transcripts of corporate disclosures (Li et al. 2020; Sautner et al. 2021).

The performance briefings transcripts of Chinese firms provide us with a unique setting for analyzing the impact of firm-level climate risks on investors' judgments. Since 2000, some listed firms in the Chinese stock markets have begun to voluntarily hold performance briefings. In 2004, the Shenzhen stock market exchange enacted a mandatory policy that requested all firms on SEM (Small and Medium Enterprise) board to hold performance briefings every year. The mandatory requirement further applies to firms on GEM (Growth Enterprise Market) in 2009 and performance briefings become an important communication channel between the management team and external investors. The briefings typically begin with prepared statements by management and are followed by a question-and-answer session between management and other participants. As noted by Price et al. (2012), given the interactive nature of the briefing,

climate-related contents are less susceptible to be “greenwashing” or window dressing by the management team, thus the transcripts are less likely to be cheap talk. More importantly, unlike developed capital markets’ earnings conference calls that only invite financial analysts, the performance briefings in China are open to all shareholders and potential investors. The questions put forward and the answer cannot be set in advance, hence bringing incremental information to the market.

In constructing our corporate climate risk variable, we implement the following procedure. First, we construct a word list related to severe weather phenomena or unanticipated meteorological events. As Henry and Leone (2016) suggest, although a more complex machine learning approach is potentially advantageous, the word count measures are as powerful and more amenable to replication when analyzing corporate disclosure narratives. Hence, we refer to Li et al. (2020)’s list for the most used words to measure corporate climate risks and adapt the climate-related words in the Chinese language setting.¹ Second, we summarize the total number of climate-related words that appear in each transcript of the firm’s annual performance briefings and calculate the Corporate Climate Risk (*CCR*) index as the fraction of the climate-related words in the whole transcripts. For robustness, we also calculate the fraction of sentences that include climate words (i.e., *CCR SENT*) as an alternative measure of corporate climate risk.

Table 1 illustrates some excerpts of the transcripts with the climate-related keywords. For example, the performance briefing of China Yangtze Power, on April 30, 2010, discusses their concern that climate change will affect their operation due to reducing water inflow. Shimg Pump Industry, in its briefing on March 13, 2012, states that the company benefits from increasing drought trends by selling more water pumps. The transcript of Hainan Shennong Technology, on April 25, 2013, reveals investors’ concern that climate change affects the company’s dividend payment. Therefore, rather than focusing on specific aspects of climate change exposure (e.g., physical risk or transition risk), our *CCR* index captures the firm-level climate risk in general.

Measuring stock market reaction

Aside from the corporate climate risk measure, the dependent variable for the stock market reaction tests is the cumulative abnormal return over a two-day event window. Following Price et al. (2012), we calculate the daily abnormal return as the size adjusted return:

$$AR_{i,t} = Ret_{i,t} - Ret_{p,t} \quad (1)$$

where $AR_{i,t}$ is the daily abnormal return for firm i on day t , $Ret_{i,t}$ is the daily raw return for firm i on day t , $Ret_{p,t}$ is the equally-weighted average return for all firms in the same size decile as firm i on day t . Then the cumulative abnormal return is calculated as:

$$CAR(t, t+k) = \sum_t^{t+k} AR_{i,t} \quad (2)$$

where $t=0$ on the firm’s performance briefing date.

We computed the two-day $CAR(0, 1)$ to measure the immediate stock price response to corporate climate risk revealed from firms’ performance briefing.² To ensure the robustness of the empirical results, we follow prior literature to use alternative daily abnormal return measures, such as the market adjusted return; size and market-to-book adjusted return; size, market-to-book and momentum adjusted return. Our results are insensitive as to what benchmark we use. In addition, we also use a thirty-day window of (2,31) to further examine whether there is a delayed price reaction after the briefing.

Control variables

We selected a set of controls as follows. First, we use a set of firm characteristics following Price et al. (2012). The lagged stock price volatility before the briefing, *VOLATILITY*, is the standard deviation of daily returns over the window (-90,-10). Lagged stock return, $CAR(-60,-2)$, is defined as the cumulative stock return over the window (-60,-20). *LEV*, measured by the ratio of the total debts to the total assets at the end of the previous fiscal year. Profitability, *ROA*, is the net income scaled by the total assets at the end of the previous fiscal year. Firm size, *SIZE*, is the natural log of the total assets at the end of the previous fiscal year. *BM* is the book-to-market ratio at the end of the previous fiscal year. Unexpected earnings, *UE*, is calculated as the difference between the earnings per share between the previous two fiscal years. Second, we add a set of controls based on the characteristics of the firm’s briefings. *WC_INRO* is the total word count of the introduction section of the briefing. *WC_QA* is the dialogue section of the briefing. *LAG* is the number of days between the end of the previous fiscal year and the announcement date of the firm’s annual report. *INTER* is the interval between the annual report date

¹ The selected words reflecting climate risks and the corresponding English translation are shown in Appendix Table 14.

² We follow Pevzner et al. (2015) to use the two-day CAR because the performance briefing is held on day 0, and then the related information is disseminated by various media on the next day. More importantly, since the asked questions in the briefings are unlikely to be perceived ex ante, the market can hardly react to the revealed climate risk prior to day 0. Hence, the two-day time window of (0,1) can reflect the initial market reaction to climate risk revealed in the performance briefing.

Table 1 Excerpts of the performance briefings transcripts

Firm Name (Code)	Fiscal Year	Briefing Date	Content
China Yangtze Power Co. Ltd. (600900)	2009	30/04/2010	The general trend of the inflow of water from the Yangtze River is stable, but the annual amount of water inflow is a more complicated issue. Generally speaking, the water has decreased in recent years. The melting of glaciers is closely related to the climate, so it is a very important issue to take energy-saving and emission-reduction measures to reduce greenhouse gas emissions
Shimge Pump Industry Co. Ltd (002532)	2011	13/03/2012	In recent years, the southwest region has been suffering from drought. In order to provide timely supply of goods, the company set up a regional warehouse in the southwest region and developed new sales outlets. In 2011, sales in the southwest region increased by 29.38% compared with that in 2010
Hainan Shennong Technology Co Ltd. (300189)	2012	25/04/2013	Will Shennong Dafeng's dividend be affected by the season and climate? Is there a peak period and a trough period?
Chengdu Wintrue Holding Co. Ltd. (002539)	2014	20/04/2015	In 2014, due to drought in Yingcheng, Hubei Province, where our company is located, the company was forced to suspend production for maintenance due to drought, resulting in a large shutdown loss
Baoshan Iron & Steel Co. Ltd (600019)	2019	29/04/2020	In 2019, the dam failure in Vale, Brazil, and the strong typhoon in Australia, combined with strong domestic iron ore demand, caused iron ore prices to soar. In the first quarter of this year, Brazil suffered the worst flood in a century, and shipments fell month-on-month and year-on-year, resulting in tight iron ore supply and demand fundamentals in the first quarter, which indeed supported ore prices

This table reports excerpts of climate-related discussion in performance briefings in our sample.

and the briefing date for the same fiscal year. In addition, we control for the time fixed effects and industry fixed effects to mitigate the omitted bias problem.

Data and sample construction

We collect research data from multiple sources. We use the transcripts of performance briefings of Chinese listed firms to measure corporate climate risk. The textual data of the transcripts can be retrieved from the WinGo Textual Analytics database. The briefing characteristics data are obtained from the Chinese Research Data Services (CNRDS) platform. Firm accounting data and stock trading data are from China Stock Market and Accounting Research (CSMAR) database. The sample period is 2009 through 2021 and the beginning of the sample is determined by the availability of the performance briefing transcripts. We require firms to have mentioned any climate-related keywords in the briefing transcripts. We also exclude firms with incomplete financial and market trading data. The final sample consists of 618 firm-year observations.

Regression model

To investigate the stock market reaction to corporate climate risk, we regress the cumulative return on the corporate

climate risk revealed by performance briefings and a set of control variables:

$$CAR_{i,t} = \beta_0 + \beta_1 CCR_{i,t} + \beta_Z Z_{i,t} + IND_j + \mu_t + \varepsilon_{i,t} \quad (3)$$

where the subscript i denotes firms, t denotes the fiscal year. The dependent variable CAR denotes the cumulative abnormal return over the firm's performance briefing event window, which is defined in the previous section. CCR represents the value of the corporate climate risk of a firm. Z is a vector of controls that have been shown to impact the market reaction to a firm's performance briefings. IND_j is the industry fixed effects and μ_t is the time fixed effects. Petersen (2009) finds that if there is a persistent effect in the data (e.g., firms' climate risks might be cross-correlated within the industry), then standard errors of the coefficients could be biased. In estimating our regression, we correct all standard errors by clustering on industry.

Table 2 reports the summary statistics of key variables across all firm-year observations in our sample. The percent $CARs$ have an average initial reaction of -0.0206 with a standard deviation of 3.2535 . The post-event period $CARs$, in percent, have a mean value of -0.3631 with a standard deviation of 12.83 . The distribution of $CARs$ indicates the volatile feature of the Chinese stock market. For the corporate climate risk variable, to facilitate exposition, we multiple the risk measure by 10^3 . The

Table 2 Summary statistics

VarName	Mean	Std. Dev	Min	P25	Median	P75	Max
CAR(0,1)	-0.0206	3.2535	-16.1805	-1.7861	-0.2052	1.5285	18.5298
CAR(2,31)	-0.3631	12.8347	-51.2110	-7.8900	-1.5690	6.0367	53.8481
CCR ($\times 10^3$)	0.9144	1.2799	0.0578	0.3308	0.5527	1.0657	15.4991
VOLATILITY	0.0288	0.0086	0.0089	0.0226	0.0276	0.0333	0.0694
CAR(-60,-2)	-2.4132	17.5894	-60.3834	-12.9349	-3.1632	7.2974	89.6111
LEV	0.3788	0.2020	0.0140	0.2148	0.3587	0.5396	0.9408
ROA	0.0440	0.0520	-0.3385	0.0177	0.0449	0.0691	0.2112
SIZE	22.4171	1.1211	20.1292	21.6408	22.3009	22.9365	27.4844
BM	0.4076	0.2782	0.0585	0.2150	0.3420	0.5213	2.5405
UE	-0.0691	0.4196	-2.6943	-0.2212	-0.0369	0.1119	2.3474
WC_QA	3459.0728	2256.9220	450.0000	1936.0000	2920.0000	4226.0000	1.66e + 04
WC_INTRO	97.6974	331.6915	0.0000	0.0000	0.0000	76.0000	6836.0000
LAG	97.5065	19.1127	18.0000	86.0000	103.0000	113.0000	143.0000
INTER	12.2443	16.2598	0.0000	7.0000	9.0000	13.0000	172.0000

mean (median) value of *CCR* is 0.9144 (0.5527) with a range of 0.0578 to 15.4991, which suggests our measure of climate risks exhibit substantial variation, albeit with a slightly negative skew.

Empirical results and discussion

This study aims to analyze the impact of firm-specific climate risk on the market reaction of stock price. We begin our tests by examining the univariate relation between *CCR* and *CAR*. Next, we estimate regression models to evaluate the overall effect of corporate climate risk on a firm's stock price reaction. To ensure the credibility of the results, we conduct a series of robustness checks. Then we discuss the possible mechanisms from three aspects: market trading activities, investor attention to firm information, and news media coverage. Finally, we explore the heterogeneous impacts of climate risk on stock price reaction to a firm's performance briefings.

Univariate analysis

Following Price et al. (2012), we conduct a univariate analysis to obtain a preliminary picture about the correlation between climate risk faced by an individual firm and its stock price reaction. First, we rank firms into quintiles based on their *CCRs*. Second, we calculate the mean and median of the *CAR* within each quintile, which allows us to compare the difference between the top and the bottom quintiles.

In Table 3, we find that over a time window of (0,1), both the mean and the median value of *CARs* turns from positive to negative as the *CCR* quintile increases. The *t*-Statistic reports the significance of the difference in mean values between quintiles. As shown in the second column, firms in the bottom *CCR* quintile exhibit a lower average *CAR* than firms in the bottom *CCR*, which is significant at the 10% level. In the

third column, the *z*-Statistic suggests that the median difference between the fifth quintile and the first quintile is still statistically significant at the 5% level. These results support the view that corporate climate risk is related to the subsequent stock price changes. We further consider *CARs* over the time window of (2,31) in the last two columns. The results show that neither the mean nor the median *CAR* value significantly differs between the top quintile and the bottom quintile. Overall, these findings provide evidence that firms with higher climate risk are more likely to experience immediate stock price declines during the initial reaction window.

Baseline regression results

To provide more concrete empirical evidence, this section presents the regression results of the effect of corporate climate risk on the firms' stock price reaction.

Table 3 Univariate analysis

CCR Quintiles	CAR(0,1)		CAR(2,30)	
	Mean	Median	Mean	Median
1 (Low)	0.237	0.201	-0.050	-0.119
2	0.089	0.003	-0.092	-0.160
3	-0.005	-0.112	0.151	0.085
4	-0.074	-0.072	-0.144	-0.208
5 (High)	-0.178	-0.215	0.067	-0.113
Difference: Mean Q5-Q1	-0.415*		0.118	
<i>t</i> -Statistic	(-1.748)		(0.607)	
Wilcoxon rank-sum test				
Difference: Median Q5-Q1			-0.417**	
<i>z</i> -Statistic			(-1.987)	

For *t*-Statistic and *z*-Statistic tests, *, **, and *** denotes significance level at 10%, 5%, and 1%, respectively.

Columns (1) to (4) in Table 4 show the regression results for the initial reaction period *CARs* over a (0,1) time window while including time fixed effects and industry fixed effects. Column (1) reports the result without control variables, showing that the coefficient of *CCR* is significantly negative at the 5% level. To ensure that the firm characteristics do not bias the results, firm-level stock trading and accounting control variables are included in column (2). In column (3), we alternatively use a set of variables to control a firm's performance briefing characteristics. In column (4), we include all control variables as well as fixed effects of time and industry. The coefficients of *CCR* remain negative and statistically significant after adding control variables. These results indicate that the stock market responds negatively to the climate risk immediately after the firm's performance briefing, which confirms our conjecture that the climate-risk-related information is quickly impounded into stock prices.

Robustness tests

To validate the robustness of the results obtained in the previous section, we conduct several robustness checks. This includes a series of sensitivity tests by using alternative measures of variables, addressing the endogeneity concern for the omitted variable and sample selection bias, excluding confounding events, and placebo tests.

Alternative measure of corporate climate risk

We replace the measure of climate risk by using the sentence frequency related to climate risk in transcripts of firms' performance briefings, which is denoted by *CCR SENT*. Column (1) of Table 5 shows the results when using *CCR SENT* as the independent variable. The

Table 4 Baseline regression results

	(1) CAR(0,1)	(2) CAR(0,1)	(3) CAR(0,1)	(4) CAR(0,1)	(5) CAR(2,31)
CCR	-0.2414** (-2.33)	-0.2737** (-2.35)	-0.2127* (-1.91)	-0.2244* (-1.97)	-0.4401 (-1.49)
VOLATILITY		23.5228 (1.37)		25.4917 (1.52)	1.8440 (0.02)
CAR(-60,-2)		0.0113 (1.48)		0.0109 (1.43)	0.0122 (0.28)
LEV		0.2044 (0.16)		0.3871 (0.33)	1.5255 (0.43)
ROA		-1.2446 (-0.40)		-0.4378 (-0.15)	17.1480 (0.88)
SIZE		-0.2967 (-1.43)		-0.2980 (-1.41)	-1.8720** (-2.30)
BM		0.5761 (1.62)		0.5969 (1.51)	1.6916 (0.83)
UE		-0.1225 (-0.31)		-0.0761 (-0.20)	-2.3956 (-1.63)
WC_QA			-0.0719 (-0.67)	0.0515 (0.45)	0.4491 (1.28)
WC_INTRO			0.0956 (1.23)	0.0959 (1.15)	0.3643 (1.20)
LAG			0.2692* (1.72)	0.2729* (1.85)	1.4545*** (3.12)
INTER			-0.2917*** (-2.85)	-0.2322** (-2.29)	-0.3559 (-1.17)
Constant	0.2002** (2.11)	5.9633 (1.29)	0.1740* (1.71)	5.7793 (1.21)	39.7922** (2.22)
Time effect	Included	Included	Included	Included	Included
Industry effect	Included	Included	Included	Included	Included
N	618	618	618	618	618
R-sq	0.0928	0.1069	0.1072	0.1190	0.1961

The *t*-values in parentheses are adjusted to industry-level clustering standard error. *, **, and *** denotes significance level at 10%, 5%, and 1%, respectively.

Table 5 Alternative measures of corporate climate risk and stock market reaction

	(1) CAR(0,1)	(2) CAR(0,2)	(3) CAR(0,2)	(4) AR	(5) AR
CCR		-0.2814* (-1.74)		-0.1668** (-2.48)	
CCR SENT	-0.0164** (-2.45)		-0.0211** (-2.06)		-0.0130*** (-3.34)
Controls	Included	Included	Included	Included	Included
Time effect	Included	Included	Included	Included	Included
Industry effect	Included	Included	Included	Included	Included
N	618	618	618	618	618
R-sq	0.1208	0.1238	0.1260	0.1487	0.1519

The *t*-values in parentheses are adjusted to industry-level clustering standard error. *, **, and *** denotes significance level at 10%, 5%, and 1%, respectively.

coefficient of *CCR SENT* on *CAR(0,1)* is still negative at the 5% significant level, which is consistent with our main findings.

Alternative time windows for the market initial reaction

To ensure our results are not driven by the selection of a specific time window, in columns (2) and (3) of Table 5, we adopt the *CARs* over the event window (0,2) as the dependent variable. The results reveal that the effect of corporate climate risk on stock price reaction remains significantly negative, indicating our results are robust to this adjustment. Besides, we use the daily abnormal return (*AR*) on the day next to the firm's performance briefings. As reported in columns (4) and (5) of Table 5, using this alternative return measure yields qualitatively similar results.

Alternative benchmarks for abnormal return

We employ methods other than the size-adjust abnormal return to calculate *CARs*. In columns (1)-(2) of Table 6,

we rerun the event study using the market-adjusted returns, where daily abnormal returns are raw stock returns minus the market value-weighted return (Nekrasov et al. 2021). As can be seen, the results remain robust when using market-adjusted *CARs*. In columns (3)-(4) of Table 6, we adjust the cumulative abnormal returns based on the size and book-to-market (B/M) following Hirshleifer et al. (2009) and our results are still similar. Lastly, we use *CARs* adjusted by size, book-to-market, and momentum (Druz et al. 2020). As shown in columns (5)-(6), the results further verify the robustness of our findings.

Endogeneity: omitted variable bias

To mitigate the potential problem of omitted variables, we employ an instrumental variable two-stage least squares (2SLS) approach. Specifically, we adopt the average value of *CCR* at the industry level as the instrumental variable to estimate the effect of climate risk on the stock price. A valid instrument in the current context should satisfy two criteria. On the one hand, the industry average of *CCR* is correlated

Table 6 Adjustments of abnormal return benchmarks

	(1) CAR(0,1)	(2) CAR(0,1)	(3) CAR(0,1)	(4) CAR(0,1)	(5) CAR(0,1)	(6) CAR(0,1)
	Market Adjusted		Size & BM Adjusted		Size, BM, & Momentum Adjusted	
CCR	-0.2127* (-1.83)		-0.2475** (-2.54)		-0.2242** (-2.46)	
CCR SENT		-0.0160** (-2.32)		-0.0179*** (-3.15)		-0.0160*** (-3.05)
Controls	Included	Included	Included	Included	Included	Included
Time effect	Included	Included	Included	Included	Included	Included
Industry effect	Included	Included	Included	Included	Included	Included
N	618	618	618	618	618	618
R-sq	0.1166	0.1186	0.1176	0.1196	0.1239	0.1254

The *t*-values in parentheses are adjusted to industry-level clustering standard error. *, **, and *** denotes significance level at 10%, 5%, and 1%, respectively.

with climate risks faced by individual firms. On the other hand, the industry-level climate risk should impact a company’s share price only because it affects the firm-specific climate change exposure. Our measure of the short-window CARs captures the abnormal change of a company’s stock price within a short period. However, the industry-level climate risk is unlikely to exert its influence on the company’s abnormal return within the short time window. The timing of the company’s performance briefings largely differs from its industry peers. Moreover, according to Ginglinger and Moreau (2021), short-window CARs are unlikely to depend on the average risk level of the industry when industry fixed effects are considered. Therefore, the CCR at the industry level is unlikely to have a direct influence on the firm’s short-window stock price reaction, which satisfies the criteria of exclusion restriction.

The 2SLS results are reported in Table 7. In columns (1)–(2), we instrument the endogenous variable CCR using the variable IND CCR. Column (1) presents the first-stage results for the relationship between IND CCR and CCR. Firms with higher industry-level climate risk are more likely to exhibit higher firm-specific climate risk. The reasonably high F-statistics suggest that the model does not

suffer from the weak instrument issue. Column (2) shows the estimated coefficients from the second-stage regression with the dependent variable of CAR(0,1). Consistent with the baseline results, corporate climate risk has a significantly negative effect on the firms’ stock price initial reaction. In columns (3)–(4), we instrument the endogenous variable CCR SENT using IND CCR SENT. As can be seen, the coefficient of CCR SENT remains significantly negative after re-estimating the 2SLS regression.

In addition to the 2SLS regression, we include additional control variables in the regression model to alleviate the omitted variable bias. First, the climate risk faced by firms is associated with the regulatory burden, natural disasters, and green innovation activities (Sautner et al. 2021), which are already perceived by the market before the briefings. These factors might have impacts on the firm’s expected return as well as our CCR variable, leading to biased estimates for CCR. Second, to address the concern that our results could be affected by unobserved regional characteristics, we further control for city fixed effects, which is based on the listed firm’s headquarter location. The results in columns (5) and (6) of Table 7 demonstrate that, after we add both additional control variables and city fixed effects, the coefficients of

Table 7 Endogeneity concern for omitted variable bias

	(1)	(2)	(3)	(4)	(5)	(6)
	CCR	CAR(0,1)	CCR SENT	CAR(0,1)	CAR(0,1)	CAR(0,1)
	1st stage	2nd stage	1st stage	2nd stage	With additional controls	
IND CCR	0.9603*** (37.87)					
CCR		-0.5384*** (-3.46)			-0.2390** (-2.41)	
IND CCR SENT			0.9791*** (31.72)			
CCR SENT				-0.0347*** (-4.77)		-0.0185*** (-2.92)
REGULATION					-0.6387 (-1.00)	-0.6918 (-1.05)
DISASTER					0.1087 (0.17)	0.1076 (0.17)
INNOVATION					-0.3687* (-1.70)	-0.3769* (-1.75)
Controls	Included	Included	Included	Included	Included	Included
Time effect	Included	Included	Included	Included	Included	Included
Industry effect	Included	Included	Included	Included	Included	Included
City effect					Included	Included
F-Statistic	1433.87***		1006.17***			
N	608	608	608	608	618	618
R-sq	0.4307	0.0226	0.4375	0.0266	0.3030	0.3054

The t-values in parentheses are adjusted to industry-level clustering standard error. *, **, and *** denotes significance level at 10%, 5%, and 1%, respectively.

CCR and *CCR SENT* remain negative and statistically significant. And the magnitude is similar to our baseline estimate. The results suggest that these factors have relatively little effect on our findings.

Endogeneity: self-selection bias

Another endogeneity concern may arise because firms have great discretion in disclosing their climate risks. Therefore, it is possible our sample has a certain degree of self-selection bias. Hence, we add the firm-year observations whose performance briefing did not include textual content related to climate risk. Results in columns (1)–(2) of Table 8 show that the coefficients of *CCR* and *CCR SENT* on *CAR*(0,1) are still significantly negative.

To further address the selection bias problem, we estimate a two-step Heckman test (Heckman 1979). In the first stage, we run a Probit regression to model the likelihood that a firm will disclose any climate-related information in the performance briefings. We add a series of exogenous variables that include the set of controls used in the main regression and the regulation, natural disaster, and green innovation variables discussed in the previous section. Then we calculate the inverse Mill's Ratio for each observation and add it to Eq. (3) to correct sample selection bias. Columns (3) and (4) in Table 8 report the results after the Heckman correction. We find that our sample is not affected by the self-selection bias (because the inverse Mill's Ratios are insignificant in our regressions) and the negative effects of corporate climate risk on stock prices are robust.

Given the relatively low proportion of firms that have discussed the climate change issue in their performance briefings, the logit model based on rare events can correct

this small sample estimation bias (King and Zeng 2001). Therefore, we adopt the logit model based on rare events to estimate the first-stage Heckman procedure. The results shown in columns (5)–(6) of Table 8 are still consistent with our baseline estimates.

Excluding confounding events

Concurrent announcements of other corporate events for a given firm (e.g., announcements of dividend distribution, mergers and acquisition initiations, seasoned equity offerings, etc.) and the enactment of new government policy may lead to biased estimates. To alleviate this estimation bias, we exclude firms that have released other announcements within 3 days before and after their performance briefings date. Column (1) of Table 9 reports the result. In column (2), we exclude firms with new government policies introduced within 3 days before and after the performance briefings date. In column (3), we drop both two types of firm-year observations mentioned above. The results still hold after excluding observations with these cofounding events.

Placebo tests

To provide further evidence that our findings are not driven by spurious correlation, we design placebo tests. Specifically, we use a placebo event date by assuming that the performance briefing occurs 3 or 5 days earlier than their actual date. The results in columns (4) and (5) of Table 9 demonstrate that the corporate climate risk does not have a significant effect on the stock price reaction. Therefore, these placebo test results suggest that our main results are not driven by chance.

Table 8 Endogeneity concern for sample selection bias

	(1)	(2)	(3)	(4)	(5)	(6)
	CAR(0,1)	CAR(0,1)	CAR(0,1)	CAR(0,1)	CAR(0,1)	CAR(0,1)
	Add Zero CCR Firms			Heckman Selection Model		
CCR	-0.1003* (-1.74)		-0.2159* (-1.73)		-0.2296** (-2.08)	
CCR SENT		-0.0088* (-1.99)		-0.0161** (-2.17)		-0.0152** (-2.11)
InvMills			-0.1078 (-0.08)	-0.0608 (-0.05)	-0.9498 (-0.65)	-1.6690 (-1.07)
Controls	Included	Included	Included	Included	Included	Included
Time effect	Included	Included	Included	Included	Included	Included
Industry effect	Included	Included	Included	Included	Included	Included
N	10,753	10,753	612	612	618	618
R-sq	0.0130	0.0131	0.1149	0.1168	0.1197	0.1228

The *t*-values in parentheses are adjusted to industry-level clustering standard error. *, **, and *** denotes significance level at 10%, 5%, and 1%, respectively.

Table 9 Excluding confounding events and placebo tests

	(1)	(2)	(3)	(4)	(5)
	CAR(0,1)	CAR(0,1)	CAR(0,1)	CAR(0,1)	CAR(0,1)
	Exclude firm events	Exclude market events	Exclude both	Placebo: 3 days	Placebo: 5 days
CCR	-0.0711** (-2.09)	-0.0815* (-1.89)	-0.0681* (-2.01)	0.0165 (0.32)	0.0505 (0.68)
Controls	Included	Included	Included	Included	Included
Time effect	Included	Included	Included	Included	Included
Industry effect	Included	Included	Included	Included	Included
N	447	613	444	444	444
R-sq	0.1748	0.1147	0.1725	0.1414	0.1242

The *t*-values in parentheses are adjusted to industry-level clustering standard error. *, **, and *** denotes significance level at 10%, 5%, and 1%, respectively.

Potential channels

The previous sections pointed to evidence suggesting that corporate climate risk is negatively related to the initial stock price reaction to performance briefings. In this section, we discuss the potential economic channels through which corporate climate risk can exert negative influences on the short-window stock price movements, including market trading activities, investor attention, and news media coverage.

Trading activities

The conventional wisdom in finance studies emphasizes that trading activity is an important mechanism that drives stock prices to move (Campbell et al. 1993; Chordia et al. 2011). On the one hand, greater climate-related risks increase the selling pressure of the underlying stocks. This will be manifested as higher trading volumes, contributing to the stronger negative stock price reactions. On the other hand, greater climate-related risks provide signals regarding an uncertain future to the market, resulting in stock price fluctuations. More volatile stocks are therefore less attractive to investors and the stock price will be going down. We use the stock turnover rate (*TURNOVER*) and the realized volatility (*RET VOL*) over the two-day event window (0,1) to proxy the trading volume and the stock price fluctuation, respectively.

The results are shown in Table 10. Columns (1) and (2) present the univariate regression estimates and columns (3) and (4) report the estimates with the full set of controls. The coefficients of *CCR* are significantly positive in all columns. This finding is consistent with our conjecture that corporate climate risk pushes up the trading volume and amplifies stock return volatility, causing more negative immediate stock price changes after the briefing.

Investor attention

We next investigate the extent to which corporate climate risk affects investor attention. As discussed previously, greater investor attention can help information to be quickly impounded into stock prices (Hirshleifer et al. 2009; Ben-Rephael et al. 2017). Among various value-relevant information in capital markets, information related to climate change is likely to catch investors’ attention and affect their investment judgments, resulting in stock price changes (Choi et al. 2020). Following Ben-Rephael et al. (2017)’s method, we measure investor attention over the event window (0,1) using the online search volume index (*SVI*) provided by the CNRDS database. We employ the abnormal search volume index, which is calculated as the log of *SVI* during the event period minus the log of median *SVI* of the same weekdays for the previous eight weeks. In particular, we construct two measures of investor attention of which one is based on the search frequency of the stock code (*ASVII*), while another incorporates both the company’s name and stock code (*ASVI2*).

Table 10 Trading activity channel

	(1)	(2)	(3)	(4)
	TURNOVER	RET VOL	TURNOVER	RET VOL
CCR	0.2997** (2.26)	1.1233*** (3.35)	0.3074*** (2.83)	0.9375** (2.50)
Controls			Included	Included
Time effect	Included	Included	Included	Included
Industry effect	Included	Included	Included	Included
N	618	618	618	618
R-sq	0.2891	0.7260	0.3869	0.7792

The *t*-values in parentheses are adjusted to industry-level clustering standard error. *, **, and *** denotes significance level at 10%, 5%, and 1%, respectively.

In Table 11, we find that investor attention is increased by corporate climate risk. The univariate regression results in columns (1) and (2) show that the coefficients of *CCR* are both significantly positive with different measures of investor attention, indicating that corporate climate risk draws higher investor attention. The results are robust when further adding control variables in columns (3) and (4). The results provide supportive evidence for the investor attention channel through which corporate climate risk impacts short-window stock price changes.

Media coverage

Finally, we examine how news media responds to climate risks revealed in performance briefings. Existing research indicates that news media plays an important role in stock markets as an information intermediary (Bushee et al. 2020). Besides, investors' trading decisions can be affected by the media tone of the firm. An increase in corporate climate risk might impede positive news coverage and induce more negative news, leading to a negative stock price reaction. To measure the news media coverage, we use three proxies, which are the number of positive news (*POS MEDIA*), the negative news (*NEG MEDIA*), and Ru et al. (2020)'s measure of media tone (*TONE*) over the event window (0,1). Specifically, a more negative tone of a firm reflects the media's pessimistic attitude toward the firm's valuation.

As shown in Table 12, we conduct univariate regressions in the first three columns. The dependent variables are *POS MEDIA*, *NEG MEDIA*, and *TONE* from columns (1) to (3), respectively. In column (1), the coefficient of *CCR* is significantly negative, indicating that an increase in corporate climate risk is associated with a decrease in positive media coverage. In column (2), the coefficient of *CCR* differs insignificantly from zero. This means that negative media coverage is not significantly affected by climate risks revealed by performance briefings. The effect of *CCR* on media tone is

significantly negative at the 5% level in column (3), suggesting that climate risk reduces media favoritism. In columns (4) to (6), we repeat our tests by adding the set of control variables and obtain qualitatively similar results. These findings support our interpretation that the disclosure of corporate climate risk could impact the news media coverage, which results in contemporaneous stock price changes.

In summary, this section finds that climate risk revealed by a firm's performance briefings adversely affects its stock price by increasing market trading activities, promoting investor attention, and reducing positive media coverage relative to the negative news. As a result, firms that are more exposed to climate risks tend to experience more negative stock price changes immediately after the briefings.

Further exploration

Heterogeneity of vulnerability to climate change

We investigate whether the market reacts differently to performance briefings of publicly listed firms concerning their vulnerability to climate change. Previous literature finds that climate change can exert differential influences depending on the industry characteristics and firm locations (Choi et al. 2020). Hence, we re-estimate our baseline regression by partitioning the sample into high or low carbon emission industry, east or non-east, and high or low abnormal local temperature.

First, we adopt the definition provided by the Intergovernmental Panel on Climate Change (IPCC), and divide the sample into high-emission firms (High Carbon) and low-emission firms (Low Carbon) (Choi et al. 2020; Engle et al. 2020). The high-emission firms belong to the industries that the IPCC identifies as major emission sources, including transport; buildings; industry (e.g., chemicals and metals); agriculture, forestry, and other land use (AFOLU). In Panel A of Table 13, columns (1) and (2) present the results, showing that the negative effect of corporate climate risks on stock price changes is only significant in the subsample of high carbon emission firms. One possible explanation is that the firms emitting more carbon are more vulnerable to climate risk, especially when the climate risk is related to environmental regulation constraints. In contrast, low-carbon emission firms have a higher tolerance for climate change exposure.

Second, we explore the cross-sectional effects based on firms' location. In China, there are great differences in the level of economic development between the eastern and the non-eastern region. Thus, two subsamples are obtained by dividing firms into eastern enterprises (East) and non-eastern enterprises (Non-East). The results are shown in columns (3) and (4) of Panel A in Table 13. We find that the negative effect is both significant in two subsamples. In untabulated analysis, we conduct a bootstrapping test as in Cleary (1999)

Table 11 Investor attention channel

	(1)	(2)	(3)	(4)
	ASVII	ASVI2	ASVII	ASVI2
CCR	0.0240** (2.19)	0.0269** (2.15)	0.0220** (2.67)	0.0226** (2.14)
Controls			Included	Included
Time effect	Included	Included	Included	Included
Industry effect	Included	Included	Included	Included
N	529	529	529	529
R-sq	0.1225	0.1354	0.1982	0.2328

The *t*-values in parentheses are adjusted to industry-level clustering standard error. *, **, and *** denotes significance level at 10%, 5%, and 1%, respectively.

Table 12 Media coverage channel

	(1)	(2)	(3)	(4)	(5)	(6)
	POS MEDIA	NEG MEDIA	TONE	POS MEDIA	NEG MEDIA	TONE
CCR	-0.1078** (-2.27)	-0.0037 (-0.18)	-0.0247** (-2.10)	-0.0799** (-2.10)	0.0059 (0.23)	-0.0252* (-1.83)
Controls				Included	Included	Included
Time effect	Included	Included	Included	Included	Included	Included
Industry effect	Included	Included	Included	Included	Included	Included
N	407	407	407	407	407	407
R-sq	0.5876	0.8122	0.1434	0.6138	0.8172	0.1732

The *t*-values in parentheses are adjusted to industry-level clustering standard error. *, **, and *** denotes significance level at 10%, 5%, and 1%, respectively.

to examine the difference in the *CCR* coefficient estimates between two subgroups and find the difference is insignificant. This indicates that the effects of corporate climate risk on the stock price reaction are virtually identical for firms located in eastern and non-eastern cities.

Third, as the recent evidence shows that abnormally warm weather influences investors' perception of climate change (Choi et al. 2020), we consider the heterogeneity of abnormal local temperature. Following the method in Choi et al. (2020), we calculate the abnormal temperature in the cities where the company is located. Then we divide the sample into low and high groups (i.e., the High Ab_Temp group and the Low Ab_Temp group) by the median of the abnormal temperature. Columns (5)–(6) report subsample analysis results for local abnormal temperature. We find that the coefficient of *CCR* is significantly negative only for firms located in cities with high abnormal temperatures. This may be because individuals are more aware of the climate-related information disclosed by the local company when experiencing higher abnormal temperatures.

Heterogeneity of other firm characteristics

In Panel B of Table 13, we explore other firm characteristics that may explain the cross-sectional effects of corporate climate risk on stock price reaction. We attempt to analyze three aspects: state ownerships, institutional investor shareholdings, and dividend payouts.

First, the effect of corporate climate risk on stock price reaction may vary across different ownership types. We classify our sample firms into state-owned enterprises (SOEs) and non-state-owned enterprises (Non-SOEs). The results in columns (1)–(2) in Table 13, Panel B show that the coefficient of *CCR* is only significantly negative in non-SOEs. This finding is supported by the view that SOEs are more favored by the government and have preferential access to finance and business opportunities (Shleifer and Vishny 1994; Song et al. 2011; Lai et al. 2021). Thus, SOEs may be more resilient to climate change shocks and less skeptical

of suffering from various regulation costs, leading to a lower sensitivity of stock price reaction to climate risk than non-SOEs. Moreover, investors may think that SOEs have higher incentives to undertake investments to transit into a low-emission path for political reasons, while non-SOEs are more likely to exhibit myopic behaviors and neglect long-term benefits. As a result, climate risk causes the stock price of non-SOEs to decline more significantly.

Next, to the extent that institutional investors consider climate risks in their investment decisions (Krueger et al. 2020), we investigate the heterogeneity of institutional investor shareholdings. Our baseline sample is partitioned into high and low institutional investor shareholding firms by the median of firms' institutional shareholding ratios. The results in columns (3)–(4) of Panel B in Table 13 show that the coefficient of *CCR* is only significant for firms whose shares are not intensively held by institutional investors. The argument is that institutional investors have wider access to firm information than retail investors. Prior to the performance briefing date, institutional investors may be already aware of the company's climate change exposures to a certain degree, which leads to a weaker price shock for firms with relatively higher institutional ownerships. On the contrary, individual investors have limited sources to obtain corporate information related to climate risks, giving rise to a stronger reaction to corporate climate risk.

Third, given that the propensity to pay dividends is related to firm risk (Hoberg and Prabhala 2009), we further explore the heterogeneity of corporate dividend payouts. In columns (5)–(6) of Table 13, Panel B, we classify our sample into dividend paying (Dividend Payer) and non-dividend paying firms (Non-Dividend Payer) based on their dividend distribution record at the previous fiscal year. For firms that pay dividends, corporate climate risk has significant negative effects on their stock price reactions. In comparison, the non-dividend paying firms do not experience significant stock price declines. Since dividend payouts provide signals that the firm can generate stable cash flows, a greater climate risk may lead investors to update their expectations

Table 13 Subsample analysis

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Heterogeneity of vulnerability to climate change						
	High Carbon	Low Carbon	Non-East	East	High Ab_Temp	Low Ab_Temp
CCR	-0.2710** (-2.24)	-0.2299 (-0.46)	-0.5903*** (-2.76)	-0.2655*** (-3.06)	-0.2212*** (-2.88)	-0.4033 (-1.32)
Time effect	Included	Included	Included	Included	Included	Included
Industry effect	Included	Included	Included	Included	Included	Included
N	446	172	168	450	313	305
R-sq	0.1301	0.2643	0.2868	0.1454	0.1813	0.1784
Panel B: Heterogeneity of other firm characteristics						
	(1)	(2)	(3)	(4)	(5)	(6)
	Non-SOEs	SOEs	Low Institution	High Institution	Dividend Payer	Non-Dividend Payer
CCR	-0.4145*** (-2.79)	-0.0394 (-0.40)	-0.5390*** (-3.28)	-0.1551 (-1.68)	-0.3066** (-2.34)	0.0252 (0.08)
Time effect	Included	Included	Included	Included	Included	Included
Industry effect	Included	Included	Included	Included	Included	Included
N	492	126	309	309	469	149
R-sq	0.1477	0.4339	0.2088	0.2452	0.1688	0.1985
Panel C: Different sub-periods						
	(1)	(2)				
	Before 2015	After 2015				
CCR	-0.2484* (-1.97)	-0.3336* (-1.84)				
Time effect	Included	Included				
Industry effect	Included	Included				
N	300	318				
R-sq	0.1914	0.1585				

The *t*-values in parentheses are adjusted to industry-level clustering standard error. *, **, and *** denotes significance level at 10%, 5%, and 1%, respectively.

downward with higher cash flow uncertainty. Therefore, the incremental effect of climate risk on dividend paying firms' cash flow uncertainty may be higher than non-dividend paying firms.

Pre- vs. Post-Paris Agreement sub-period

On December 12, 2015, the Paris Agreement was signed at the 21st United Nations Climate Change Conference, raising awareness of investors regarding climate risk (Ginglinger and Moreau 2021). To investigate whether our baseline result varies across sub-periods, we split the sample into the pre-Paris agreement (before 2015) and post-Paris agreement (after 2015). The results shown in Panel C of Table 13 demonstrate that the coefficients of *CCR* are significantly negative in both subsamples. In untabulated analysis, we follow Cleary (1999)'s bootstrapping procedure and find that the observed difference between *CCR* coefficients in the two groups is insignificant. This suggests that our main findings hold for both subsamples, which alleviates the concern arising from the length of our sample period.

The post-event market reaction to corporate climate risk

To further examine whether there exists delayed reactions to corporate climate risk, we regress the post-event *CAR*(2,31) on corporate climate risk in column (5) of Table 4. The regression result shows that the coefficient of *CCR* is insignificant, suggesting that corporate climate risk revealed from performance briefings has no predictive power in explaining stock price movements over longer horizons.³ Thus, this evidence combined with our baseline results suggests that corporate climate risk only has immediate effects on the initial stock price reaction to firms' performance briefings. This finding is consistent with our conjecture that the stock market can efficiently comprehend the climate-related information that appeared in corporate disclosures. As a consequence, firm-specific climate risk is quickly impounded into stock prices and does not influence the subsequent stock price changes.

Concluding remarks

Since the pioneering work by the Nobel laureate Nordhaus (1977), researchers have devoted great efforts to study the relationship between climate change and economic

activities. Recent studies in climate finance have suggested many ways in which financial markets can efficiently price climate risks (Bernstein et al. 2019; Capelle-Blancard and Petit 2019; Bolton and Kacperczyk 2021; Huynh and Xia 2021; Ilhan et al. 2021). However, the important issue of how information related to climate risks is impounded into stock prices remains to be explored. To this end, this paper investigates the effects of corporate disclosures of climate risk on the firm's stock price reaction. We employ transcripts of Chinese firms' performance briefings to conduct a textual analysis and construct a measure of corporate climate risk. The empirical results show that: (i) Corporate climate risk is negatively related to the immediate stock price reaction to the briefings. The impacts of corporate climate risk on the short-window stock price movements remain significant after we perform a series of robustness tests; (ii) the underlying mechanisms by which corporate climate risks negatively affect the stock price reaction are mainly through more active and volatile market trading activities, increasing investor attention, and lower positive news media coverage; (iii) the impacts of corporate climate risks on stock price reaction are more pronounced for firms that are more likely to have high carbon emissions, located in abnormally high-temperature cities, non-SOEs, with low institutional ownerships, and paying dividends. We do not detect, however, any differences in subsamples before and after the Paris Agreement, and the existence of a delayed market reaction to corporate risk. Overall, the evidence documented in this paper suggests that the Chinese stock market can quickly comprehend the disclosure of information related to climate change, which enriches our understanding of the price discovery process regarding corporate climate risk.

Based on the above conclusions, several implications can be drawn for policymakers and market participants. First, since a greater climate risk would raise the market's concern about the firm's future profitability, policymakers must take appropriate actions to ensure climate risks would not overly worsen the firm's bank credit supply and financing costs. Particularly, the government should pay more attention to maintaining a stable financial environment for firms tackling climate change issues. Second, financial regulation authorities should consider providing incentives for firms to disclose more climate-related information. Our findings prove that disclosures of firm-specific climate risk can help the market to evaluate the underlying stock more efficiently. Hence, there is a compelling need to introduce more stringent regulations for climate information disclosure. Third, our findings guide investors to allocate a reasonable portion of their investments in stocks less sensitive to climate risks. Correspondingly, investors should be more aware of the short-window evaluation effects of corporate climate risk according to firms' characteristics.

³ In untabulated analysis, we also use the cumulative abnormal return over the sixty-day time window (2,61) as the dependent variables. We repeat the regression specifications in columns (5) to (8) of Table 4 and find qualitative similar results.

Appendix

Table 14 Climate-risk-related keywords

空气污染	(air pollution)	极涡	(polar vortex)
空气质量	(air quality)	降水	(precipitation)
二氧化碳	(carbon dioxide)	降雨量	(precipitation)
碳排放	(carbon emissions)	雨水	(rainfall)
气候变化	(climate change)	降雨	(rainfall)
气候风险	(climate risk)	严冬	(severe winter)
寒季	(cold season)	下雪	(snow)
冷季	(cold season)	降雪量	(snowfall)
冷夏	(cool summer)	降雪	(snowfall)
凉夏	(cool summer)	暴风雪	(snowstorm)
度数	(degree days)	风暴	(storm)
干旱	(drought)	暴风雨	(storm)
旱灾	(drought)	沙尘暴	(storm)
地震	(earthquake)	气温	(temperature)
极寒	(extreme cold)	北极	(the arctic)
高温	(extreme heat)	大气	(the atmosphere)
洪水	(flooding)	最冷的	(the coldest)
洪涝	(flooding)	最寒冷的	(the coldest)
化石燃料	(fossil fuel)	洪灾	(the flood)
全球变暖	(global warming)	雾	(the fog)
温室气体	(greenhouse gas)	霜冻	(the ice)
冰雹	(hailstorm)	热带风暴	(tropical storm)
供暖季	(heating season)	海啸	(tsunami)
涨潮	(high water)	暖冬	(warm winter)
酷暑	(hot summer)	水位	(water level)
飓风	(hurricane)	天气	(weather)
雷击	(lightning strike)	山火	(wildfire)
雷电	(lightning strike)	风雹	(wind hail)
极地漩涡	(polar vortex)	台风	(windstorm)

This table presents the climate-related Chinese keywords referring to Li et al. (2020). The corresponding English translation for each Chinese keyword is shown in parentheses.

Authors' contributions Naiqian Wu: conceptualization, methodology, data curation, formal analysis, writing—original draft. Weiguo Xiao: resources, supervision, project administration, writing—review and editing. Wei Liu: investigation, validation, writing—review and editing, supervision, funding acquisition. Zhan Zhang: conceptualization, validation, writing—original draft.

Funding This work is supported by the National Social Science Fund of China (Grants No. 19BJY008, 20&ZD105), the Humanities and Social Science Foundation of the Ministry of Education of China (Grant No. 18YJA790055), the Graduate Project of Wuhan University (Grant No. 1201-413100137).

Data Availability The datasets generated or analyzed in this study are available upon reasonable request.

Declarations

Ethical approval and consent to participate Not applicable.

Consent to publish Not applicable.

Competing interests The authors declare no competing interests.

References

- Bansal R, Kiku D, Ochoa M (2016) Price of long-run temperature shifts in capital markets. NBER. <https://doi.org/10.3386/w22529>
- Bartram SM, Hou K, Kim S (2021) Real effects of climate policy: financial constraints and spillovers. *J Financ Econ*. <https://doi.org/10.1016/j.jfineco.2021.06.015>
- Ben-Rephael A, Da Z, Israelsen RD (2017) It depends on where you search: institutional investor attention and underreaction to news. *Rev Financ Stud* 30(9):3009–3047. <https://doi.org/10.1093/rfs/hhx031>
- Bernstein A, Gustafson MT, Lewis R (2019) Disaster on the horizon: the price effect of sea level rise. *J Financ Econ* 134(2):253–272. <https://doi.org/10.1016/j.jfineco.2019.03.013>
- Blau BM, DeLisle JR, Price SMK (2015) Do sophisticated investors interpret earnings conference call tone differently than investors at large? Evidence from short sales. *J Corp Financ* 31:203–219. <https://doi.org/10.1016/j.jcorpfin.2015.02.003>
- Bochkay K, Hales J, Chava S (2020) Hyperbole or reality? Investor response to extreme language in earnings conference calls. *Account Rev* 95(2):31–60. <https://doi.org/10.2308/accr-52507>
- Bolton P, Kacperczyk M (2021) Do investors care about carbon risk? *J Financ Econ*. <https://doi.org/10.1016/j.jfineco.2021.05.008>
- Bushee B, Cedergrén M, Michels J (2020) Does the media help or hurt retail investors during the IPO quiet period? *J Account Econ* 69(1):101261. <https://doi.org/10.1016/j.jacceco.2019.101261>
- Bushee BJ, Core JE, Guay W, Hamm SJW (2010) The role of the business press as an information intermediary. *J Account Res* 48(1):1–19. <https://doi.org/10.1111/j.1475-679X.2009.00357.x>
- Campbell JY, Grossman SJ, Wang J (1993) Trading volume and serial correlation in stock returns. *Q J Econ* 108(4):905–939. <https://doi.org/10.2307/2118454>
- Capelle-Blancard G, Petit A (2019) Every little helps? ESG news and stock market reaction. *J Bus Ethics* 157(2):543–565. <https://doi.org/10.1007/s10551-017-3667-3>
- Choi D, Gao Z, Jiang W (2020) Attention to global warming. *Rev Financ Stud* 33(3):1112–1145. <https://doi.org/10.1093/rfs/hhz086>
- Chong TTL, Lam TH, Yan IKM (2012) Is the Chinese stock market really inefficient? *China Econ Rev* 23(1):122–137. <https://doi.org/10.1016/j.chieco.2011.08.003>
- Chordia T, Roll R, Subrahmanyam A (2011) Recent trends in trading activity and market quality. *J Financ Econ* 101(2):243–263. <https://doi.org/10.1016/j.jfineco.2011.03.008>
- Clarkson PM, Fang X, Li Y, Richardson G (2013) The relevance of environmental disclosures: are such disclosures incrementally informative? *J Account Public Policy* 32(5):410–431. <https://doi.org/10.1016/j.jaccpubpol.2013.06.008>
- Cleary S (1999) The relationship between firm investment and financial status. *J Financ* 54(2):673–692. <https://doi.org/10.1111/0022-1082.00121>
- Dietz S, Bowen A, Dixon C, Gradwell P (2016) ‘Climate value at risk’ of global financial assets. *Nat Clim Chang* 6(7):676–679. <https://doi.org/10.1038/nclimate2972>

- Druz M, Petzev I, Wagner AF, Zeckhauser RJ (2020) When managers change their tone, analysts and investors change their tune. *Financ Anal J* 76(2):47–69. <https://doi.org/10.1080/0015198X.2019.1707592>
- Engle RF, Giglio S, Kelly B, Lee H, Stroebe J (2020) Hedging climate change news. *Rev Financ Stud* 33(3):1184–1216. <https://doi.org/10.1093/rfs/hhz072>
- Fama EF (1970) Efficient capital markets: a review of theory and empirical work. *J Financ* 25(2):383–417. <https://doi.org/10.2307/2325486>
- Giglio S, Kelly B, Stroebe J (2021) Climate finance. *Annu Rev Financ Econ* 13(1):15–36. <https://doi.org/10.1146/annurev-financial-102620-103311>
- Ginglinger E, Moreau Q (2021) Climate risk and capital structure. *SSRN Electron J*. <https://doi.org/10.2139/ssrn.3327185>
- Grewal J, Riedl EJ, Serafeim G (2019) Market reaction to mandatory nonfinancial disclosure. *Manage Sci* 65(7):3061–3084. <https://doi.org/10.1287/mnsc.2018.3099>
- Griffin PA, Lont DH, Sun EY (2017) The relevance to investors of greenhouse gas emission disclosures. *Contemp Account Res* 34(2):1265–1297. <https://doi.org/10.1111/1911-3846.12298>
- Guo M, Kuai Y, Liu X (2020) Stock market response to environmental policies: evidence from heavily polluting firms in China. *Econ Model* 86(71401141):306–316. <https://doi.org/10.1016/j.econmod.2019.09.028>
- Hassan TA, Hollander S, van Lent L, Schwedeler M, Tahoun A (2021) Firm-level exposure to epidemic diseases: COVID-19, SARS, and H1N1. *NBER*. <https://doi.org/10.3386/w26971>
- Hassan TA, Hollander S, Van Lent L, Tahoun A (2019) Firm-level political risk: measurement and effects. *Q J Econ* 134(4):2135–2202. <https://doi.org/10.1093/qje/qjz021>
- Heckman JJ (1979) Sample selection bias as a specification error. *Econometrica* 47(1):153–161. <https://doi.org/10.2307/1912352>
- Henry E, Leone JA (2016) Measuring qualitative information in capital markets research: comparison of alternative methodologies to measure disclosure tone. *Account Rev* 91(1):153–178. <https://doi.org/10.2308/accr-51161>
- Hirshleifer D, Lim SS, Teoh SH (2009) Driven to distraction: extraneous events and underreaction to earnings news. *J Financ* 64(5):2289–2325. <https://doi.org/10.1111/j.1540-6261.2009.01501.x>
- Hoberg G, Prabhala NR (2009) Disappearing dividends, catering, and risk. *Rev Financ Stud* 22(1):79–116. <https://doi.org/10.1093/rfs/hhn073>
- Hong H, Li FW, Xu J (2019) Climate risks and market efficiency. *J Econom* 208(1):265–281. <https://doi.org/10.1016/j.jeconom.2018.09.015>
- Huynh TD, Xia Y (2021) Climate change news risk and corporate bond returns. *J Financ Quant Anal* 56(6):1985–2009. <https://doi.org/10.1017/S0022109020000757>
- Ilhan E, Sautner Z, Vilkov G (2021) Carbon tail risk. *Rev Financ Stud* 34(3):1540–1571. <https://doi.org/10.1093/rfs/hhha071>
- Jagannathan R, Ravikumar A, Sammon M (2018) Environmental, social, and governance criteria: why investors should care. *J Invest Manag* 16(1):1–22
- Jagannathan R, Wang Z (1996) The conditional CAPM and the cross-section of expected returns. *J Financ* 51(1):3–53. <https://doi.org/10.1111/j.1540-6261.1996.tb05201.x>
- Kahneman D (1973) *Attention and effort*. Prentice-Hall, Englewood Cliffs, NJ
- Karpoff JM (1987) The relation between price changes and trading volume: a survey. *J Financ Quant Anal* 22(1):109–126. <https://doi.org/10.2307/2330874>
- King G, Zeng L (2001) Logistic regression in rare events data. *Polit Anal* 9(2):137–163. <https://doi.org/10.1093/oxfordjournals.pan.a004868>
- Krueger P, Sautner Z, Starks LT (2020) The importance of climate risks for institutional investors. *Rev Financ Stud* 33(3):1067–1111. <https://doi.org/10.1093/rfs/hhz137>
- Krüger P (2015) Corporate goodness and shareholder wealth. *J Financ Econ* 115(2):304–329. <https://doi.org/10.1016/j.jfineco.2014.09.008>
- Lai X, Yue S, Chen H (2021) Can green credit increase firm value? Evidence from Chinese listed new energy companies. *Environ Sci Pollut Res*. <https://doi.org/10.1007/s11356-021-17038-9>
- Lemoine D (2021) The climate risk premium: how uncertainty affects the social cost of carbon. *J Assoc Environ Resour Econ* 8(1):27–57. <https://doi.org/10.1086/710667>
- Li Q, Shan H, Tang Y, Yao V (2020) Corporate climate risk: measurements and responses. *SSRN Electron J*. <https://doi.org/10.2139/ssrn.3508497>
- Li F, Lin C, Lin T-C (2021) Climate vulnerability and corporate innovation: international evidence. *SSRN Electron J*. <https://doi.org/10.2139/ssrn.3777313>
- Li Q, Liu X, Chen J, Wang H (2022) Does stock market liberalization reduce stock price synchronicity? —Evidence from the Shanghai-Hong Kong stock connect. *Int Rev Econ Financ* 77:25–38. <https://doi.org/10.1016/j.iref.2021.09.004>
- Matsumura EM, Prakash R, Vera-Muñoz SC (2014) Firm-value effects of carbon emissions and carbon disclosures. *Account Rev* 89(2):695–724. <https://doi.org/10.2308/accr-50629>
- Milian JA, Smith AL (2017) An investigation of analysts' praise of management during earnings conference calls. *J Behav Financ* 18(1):65–77. <https://doi.org/10.1080/15427560.2017.1276068>
- Miller EM (1977) Risk, uncertainty, and divergence of opinion. *J Financ* 32(4):1151–1168. <https://doi.org/10.1111/j.1540-6261.1977.tb03317.x>
- Murfin J, Spiegel M (2020) Is the risk of sea level rise capitalized in residential real estate? *Rev Financ Stud* 33(3):1217–1255. <https://doi.org/10.1093/rfs/hhz134>
- Nekrasov A, Teoh SH, Wu S (2021) Visuals and attention to earnings news on Twitter. *Account Rev*. <https://doi.org/10.2139/ssrn.3447484>
- Ng AC, Rezaee Z (2020) Business sustainability factors and stock price informativeness. *J Corp Financ* 64:101688. <https://doi.org/10.1016/j.jcorpfin.2020.101688>
- Nordhaus WD (2017) Revisiting the social cost of carbon. *Proc Natl Acad Sci* 114(7):1518–1523. <https://doi.org/10.1073/pnas.1609244114>
- Nordhaus WD (1977) Economic growth and climate: the carbon dioxide problem. *Am Econ Rev* 67(1):341–346
- Petersen MA (2009) Estimating standard errors in finance panel data sets: comparing approaches. *Rev Financ Stud* 22(1):435–480. <https://doi.org/10.1093/rfs/hhn053>
- Pevzner M, Xie F, Xin X (2015) When firms talk, do investors listen? The role of trust in stock market reactions to corporate earnings announcements. *J Financ Econ* 117(1):190–223. <https://doi.org/10.1016/j.jfineco.2013.08.004>
- Plumlee M, Brown D, Hayes RM, Marshall RS (2015) Voluntary environmental disclosure quality and firm value: further evidence. *J Account Public Policy* 34(4):336–361. <https://doi.org/10.1016/j.jaccpubpol.2015.04.004>
- Price SMK, Doran JS, Peterson DR, Bliss BA (2012) Earnings conference calls and stock returns: the incremental informativeness of textual tone. *J Bank Financ* 36(4):992–1011. <https://doi.org/10.1016/j.jbankfin.2011.10.013>
- Ru Y, Xue J, Zhang Y, Zhou X (2020) Social connections between media and firm executives and the properties of media reporting. *Rev Account Stud* 25(3):963–1001. <https://doi.org/10.1007/s11142-020-09552-x>
- Sautner Z, van Lent L, Vilkov G, Zhang R (2021) Firm-level climate change exposure. *SSRN Electron J*. <https://doi.org/10.2139/ssrn.3642508>

- Shleifer A, Vishny RW (1994) Politicians and firms. *Q J Econ* 109(4):995–1025. <https://doi.org/10.2307/2118354>
- Song Z, Storesletten K, Zilibotti F (2011) Growing like China. *Am Econ Rev* 101(1):196–233. <https://doi.org/10.1257/aer.101.1.196>
- Stern N (2007) *The economics of climate change : the Stern review*. Cambridge University Press, Cambridge, UK
- Weitzman ML (2014) Fat tails and the social cost of carbon. *Am Econ Rev* 104(5):544–546. <https://doi.org/10.1257/aer.104.5.544>
- Wong JB, Zhang Q (2022) Stock market reactions to adverse ESG disclosure via media channels. *Br Account Rev* 54(1):101045. <https://doi.org/10.1016/j.bar.2021.101045>
- Wu CH, Lin CJ (2017) The impact of media coverage on investor trading behavior and stock returns. *Pacific Basin Financ J* 43:151–172. <https://doi.org/10.1016/j.pacfin.2017.04.001>
- Xu XD, Zeng SX, Tam CM (2012) Stock market's reaction to disclosure of environmental violations: evidence from China. *J Bus Ethics* 107(2):227–237. <https://doi.org/10.1007/s10551-011-1035-2>

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.