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Climate Change and Corporate Cash Holdings: Global Evidence

Abdullah Al Masum, Siamak Javadi, Mohsen Mollagholamali,
and Ramesh Rao[†]

July 24, 2020

ABSTRACT

Using data from 41 different countries including the United States, we find that firms increase their cash holdings when exposed to long-term adverse climate change. Our subsample analyses suggest that the increase in cash holdings is more pronounced for the firms with a cash shortfall, and for the firms that are financially constrained. Overall, our findings fit consistently within the precautionary motive framework for holding cash.

JEL Classification: G15, G32, G38, Q54

Keywords: Climate change, corporate cash holdings, change in cash, constrained firms

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ABSTRACT

Using data from 41 different countries including the United States, we find that firms increase their cash holdings when exposed to long-term adverse climate change. Our subsample analyses suggest that the increase in cash holdings is more pronounced for the firms with a cash shortfall, and for the firms that are financially constrained. Overall, our findings fit consistently within the precautionary motive framework for holding cash.

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1. Introduction

In this paper, we examine if climate risk affects corporate cash holdings. Specifically, we investigate whether firms view climate change as a risk factor and reflect it into their cash holdings decision. Corporate cash holdings policy has received increasing academic attention (see e.g., Harford, 1999; Opler et al., 1999; Dittmar et al., 2003; Pinkowitz et al., 2006; Foley et al., 2007; Harford et al., 2008; Bates et al., 2009; Duchin, 2010; Gao et al., 2013; Nikilov and Whited, 2014; etc.). The studies on corporate cash holdings grow under two broad frameworks namely the precautionary motives due to firms' financing frictions and the agency conflicts. Our empirical findings are consistent with the precautionary motives framework of corporate cash holdings and demonstrate that firms view climate change as a relevant risk factor and increase cash holdings as a result.

There is ample anecdotal evidence that climate risk has a serious negative impact on the economy and its future growth. For instance, according to the US national climate assessment report in 2018, the US GDP is likely to drop by 10% by the end of this century due to losses concerning climate change.² The Economist Intelligence Unit estimated in 2015 that a total of \$4.2 trillion of manageable assets remain under climate risk.³ Recent but fast-growing studies of climate change finance document several corporate policy implications due to climate risk and establish it

² Available at <https://nca2018.globalchange.gov>. This study predicts that farming in the Midwest would decline by 75% and the southern part could also lose 25% soybean production. Heat stress has been responsible for an average \$1.2 billion less dairy production since 2010 and likely to be more extensive in the coming years. Wildfire seasons become the longest and most destructive in the history and the severity is predicted to be six times higher by 2050. Sea levels go up by more than 7 inches over the last century, in lower latitude countries the scenario is even worse.

³ The Economist Intelligence Unit (2015). *The Cost of Inaction: Recognizing the Value at Risk from Climate Change*. [online] London, New York, Hong Kong, Geneva: The Economist Intelligence Unit Limited. Available at: https://www.eiuperspectives.economist.com/sites/default/files/The%20cost%20of%20inaction_0.pdf

as a long-term risk factor (see e.g., Bansal et al., 2016; Bernstein et al., 2019; Addoum et al., 2020; Bolton and Kacperczyk, 2020; Hsu et al., 2020, Painter, 2020; etc.).

Moreover, climate change has become a top shareholder proposal issue in recent years.⁴ Warren Buffet (CEO of Berkshire Hathaway), in his 2015 annual letter to shareholders, proposes that Berkshire would include a section in their annual report on how they are responding to climate change threats in ensuring operations.⁵ Investors increasingly find climate change as a relevant risk factor as companies worldwide have started voluntarily releasing reports on their plans to address climate change along with other corporate social and environmental responsibility issues. A survey by KPMG in 2017 finds that more than 60% of companies across all industries worldwide voluntarily release such corporate responsibility reports.⁶ There has been a substantial increase of this practice by Fortune Global 250 companies in recent years (44% in 2011, 55% in 2013, 65% in 2015, and 78% in 2017). Most recently (in January 2020), Larry Fink (CEO of BlackRock, one of the world's largest asset managers), in his annual letter to the CEOs writes that BlackRock aims at making climate change issues central to its investment decisions. BlackRock CEO also mentions that firms seeking investment from BlackRock will require to release additional disclosure related to their climate risk exposure and how they plan to mitigate it.⁷

LexisNexis (a pioneer aide platform in advanced risk management, business, and law research) recently highlights the adverse impacts of climate change on businesses. It particularly focuses on different aspects of business risks that can be exacerbated by climate change such as physical risks, shareholder activism considerations, compliance risks, federal regulations, international

⁴ See <https://www.issgovernance.com/library/climate-change-in-the-2018-us-agm-season/>

⁵ Link to Annual Letter to shareholders: <https://www.berkshirehathaway.com/letters/2015ltr.pdf>

⁶ See <https://assets.kpmg.com/content/dam/kpmg/xx/pdf/2017/10/kpmg-survey-of-corporate-responsibility-reporting-2017.pdf>

⁷ Link to Annual Letter to CEOs: <https://www.blackrock.com/corporate/investor-relations/larry-fink-ceo-letter>

regulations, litigations risks, etc. It has been also evident that a changing climate pattern has long-term direct effects on the company's property and supply chain.

Given that it is not easy to hedge climate risk, how do firms respond to risk exposure imposed by climate change? Corporate cash holdings provide us with a useful setup to study this question. When firms anticipate a financial friction, they are likely to increase financial slacks that includes increase in corporate cash holdings (Myers and Majluf, 1984). Several studies document that corporate cash holdings help mitigate risks associated with such events that may lead to future liquidity shortage (Froot et al., 1993; Holmstrom and Tirole, 2000; Dessaint and Matray, 2017). Specifically, corporate cash holdings can work as a buffer in avoiding firms' incapacity to finance positive NPV projects if faced with liquidity shocks due to climate risk exposure.

Our study covers data from 41 different countries including the US. As the main measure of climate risk exposure, we use a proxy of long-term climate risk exposure developed by Hong et al. (2019) based on drought severity. Drought is considered as one of the best climate change indicators in climate science.⁸ In developing the long-term climate risk index, a trend-stationary AR (1) model with a time trend is estimated. From the econometric perspective, the coefficient on the time trend could be a reliable measure of long-term exposure to climate risk. We find that for a one standard deviation increase in our long-term climate risk measure firms' cash holdings increase by 0.40%. This change is both statistically and economically significant. This increase in cash holdings is equivalent to a 2.5% rise compared to the average cash holding in our sample. We find similar result when we redo our analysis by moving cash holding variable one year forward

⁸ See https://www.usgs.gov/faqs/what-are-some-signs-climate-change-1?qt-news_science_products=0#qt-news_science_products

(i.e., estimation of the lagged effects). We also use change in cash holdings as our dependent variable. In both cases, results confirm our earlier finding.

About 32% of observations in our sample comes from the US. Therefore, it is a valid concern that the result is mainly driven by US firms. To alleviate this concern, we conduct a separate analysis by excluding the US firms and find even stronger results. Besides, determining firms' climate risk exposure based on their headquarter locations can be misleading as their operations can be conducted at different locations than the headquarters (Garcia and Norli, 2012; Smith, 2016). Restricting the sample to only US firms, we construct a weighted measure that follows Hong et al. (2019) but additionally considers firms' geographic concentrations in different US states rather than only the headquarters. Redoing our previous analysis with this newly constructed firm-level climate risk measure, we find consistent results for the US firms.

In this study, we employ three different identification strategies to validate the effect of climate risk on corporate cash holdings. First, following Painter (2020), we conduct a quasi-natural experiment around the release of Stern Review. The review is a 700-page long report (released for the UK government) that becomes widely known for its detailed discussion on the potential impacts of climate change on economy and businesses. Our analysis based on a difference-in-difference set-up around the Stern Review confirms our earlier findings. Second, we exploit the economic link between firms and their customers. Firms' customers have a major impact on firms' economic growth and prosperity. Therefore, if a firm's customers are exposed to higher climate risk, it could adversely affect that firm's operations, revenue, and productivity. We use Compustat Capital IQ customer segment data to identify firms' customer locations and then we repeat our analysis with long-term climate risk exposure at customer locations instead of firms headquarter. We find that firms' cash holdings increase when their customers are exposed to higher climate

risk. This finding not only increases the credibility of our earlier findings but also alleviates the concern about using firms' headquarters to measure climate risk exposure. Our third identification strategy is a placebo test. Given that corporate cash holdings and climate risk have been trending upwards, there is a concern that our finding is spurious. However, we find an insignificant coefficient on our placebo measure that further affirms our main finding and addresses the possibility of having documented a spurious positive relationship between firms' cash holdings and long-term climate risk exposure.

Moreover, our subsample analyses show that firms increase their cash holdings level in response to higher climate risk exposure when they are financially constrained. Several prior studies suggest cross-sectional heterogeneities for corporate cash holdings based on various sources of firms' financial constraints (see e.g., Fazzari et al., 1988; Kaplan and Zingales, 1997; Kim et al., 1998; Opler et al., 1999; Almeida et al., 2004; Hennessy and Whited, 2007; Bates et al., 2009; Hadlock and Pierce, 2010; Acharya et al., 2012; etc.). The results from our subsample analyses are consistent with our expectation and document stronger effects of climate risk in increasing corporate cash holdings for financially constrained firms.

Our study belongs to the emerging climate finance literature that investigates climate risk implications on different corporate financial policies. Our results suggest that firms are aware of their adverse exposure to climate change and consequently they prepare themselves for the possible financial constraints by increasing cash holdings. A prior study by Dessaint and Matray (2017) also documents an increase in firms' cash holdings due to perceived liquidity risk. Our study is different from Dessaint and Matray (2017) for several reasons. First, while they consider a previously unknown and sudden natural calamity (hurricane) risk, i.e., catastrophic risk, we focus on the long-term climate change pattern. Second, their study builds upon the arguments related to

the managerial overreaction while ours is consistent with firms' rational *precautionary motives*. Lastly, our evidence is global while their study focuses on the US only.

Our study also contributes to the literature on the determinants of corporate cash holdings. There are numerous established factors affecting corporate cash holdings. To the best of our knowledge, our paper is the first empirical corporate finance study in global settings to document evidence that long-term exposure to adverse climate change leads firms to hold more cash.

The remainder of our paper is organized as follows. In section 2, we review relevant literature and formulate hypotheses. Section 3 describes the data and methodology. In section 4, we discuss our main results including baseline and robustness checks. We discuss our several identification strategies in section 5. We present our subsample analyses in section 6 and then write our concluding remarks in section 7.

2. Literature review and hypothesis development

Literature offers two broad frameworks to explain the dynamics of corporate cash holdings. They include firms' precautionary motives, and agency problems. Beginning with Keynes (1936), several studies support and help explain firms' precautionary motives (e.g., Harford, 1999; Opler et al., 1999; Bates et al., 2009; Duchin, 2010; McLean, 2011; etc.) under different settings. Firms' precautionary motives for holding cash arise when they expect a financing friction due to a mismatch between internal and external cost of capital (Opler et al., 1999). In fact, when external financing becomes scarce or costly, a negative cash flow shock (Bates et al., 2009) may prevent firms from undertaking projects with positive Net Present Value (NPV). Holding more cash by the firms could work as a buffer in such situations. The study by Bates et al. (2009) helps partially explain why the US public firms have been increasing cash holdings over the past couple of decades. The findings from Bates et al. (2009) indicate that it is the precautionary motive rather

than the agency problem which drives a firm into holding more cash. Duchin (2010) argues that the “*increasing cash flow uncertainty*” motivates the firms to increase their level of cash. McLean (2011) argues that public firms issue shares as a source of increasing cash when they have the precautionary motives that are reflected in their high cash flow volatility and large Research and Development (RD) expenditures. A few other studies, such as Brav (2009) and Saunders and Steffen (2011), find that the implication of financing friction and therefore the necessity of cash holdings is even more important for private firms.

Another important reason for cash holdings is the managerial agency problem (Jensen, 1986). Stulz (1990) argues that the agency problem is directly linked with firms’ ability to generate enough internal slack. An optimum level of internal slack helps firms avoid underinvestment but not leading towards overinvestment. However, several studies find that corporate insiders have more incentives to hold cash rather than paying dividends to the shareholders since they can use it as a flexible financing option in empire building or self-dealing (Dittmar and Mahrt-Smith, 2007; Harford et al., 2008; Gao et al., 2013). These studies are consistent with a few other country-level studies which find that firms tend to hold more cash in countries with poor shareholder protection right (Dittmar et al., 2003; Kalcheva and Lins, 2007). Harford et al. (2008) argue that firms with entrenched managers have less intension to hold more cash rather they prefer overinvestment, leading to lower cash holdings in these public firms. In contrast, Nikolov and Whited (2014) document that typical agency problem leads to an increase of firms’ cash holding by about 22% which may also result in degradation of shareholder value by about 6%.

Focusing on an environmental risk, Dessaint and Matray (2017) argue that managers perceive “hurricane risk”⁹ as a salient liquidity risk factor and as precautionary steps they increase firms’ cash holding at suboptimal level and express their concerns in financial reports even when firms are located at the neighborhood of the disaster area. Dessaint and Matray (2017) attribute their findings to managerial heuristic behavior (Tversky and Kahneman, 1973). Apart from such managerial behavior, indeed firms’ physical risk due to climate change (i.e., climate risk at firm location) is a significant concern for the firms. Besides ample anecdotal evidence presented in the introduction section, a substantial amount of growing literature has established climate-related concerns as relevant risk factors that have serious corporate policy implications. For instance, Chava (2014) argues that investors demand a higher cost of capital for firms excluded by environmental screens (e.g., firms with climate change concerns, substantial emissions, etc. in their profile), and that lower number of institutional investors and fewer banks participate in their loan syndication. Truong, Nguyen, and Huynh (2017) find that climate change risk in the form of drought is not easily diversifiable and the market prices this risk into firm-level equity risk premium.

Similarly, Bernstein et al. (2019) find that sea level rise reduces the value of exposed homes by about 7% compared to unexposed properties. Hong et al. (2019) examine international food stock performance and find that market still underreacts to drought (climate) risk. In contrast, Bansal et al. (2016) document that capital markets price long-run temperature shift. Bolton and Kacperczyk (2020) and Hsu et al. (2020) study cross-section of stock returns considering carbon

⁹ Hurricane risk is most likely to be exacerbated by climate change related risk factors. For example, see <https://www.c2es.org/content/hurricanes-and-climate-change/>, <https://www.yaleclimateconnections.org/2019/07/how-climate-change-is-making-hurricanes-more-dangerous/>, <https://www.gfdl.noaa.gov/global-warming-and-hurricanes/>, etc.

risk and environmental pollution respectively as climate risk factors and show that climate risks are well priced in the stock market. Painter (2020) finds that the credit spread for the long-term municipal bonds is significantly higher for the municipalities located nearby coastal areas and subject to the threat of sea level rise.

Taken together, the evidence suggests that climate risk exposure increases firms' external cost of capital. Therefore, according to precautionary motives framework, firms should increase their cash holdings to better deal with the potential financial constraints caused by climate risk, leading to our main hypothesis:

H1. Corporate cash holdings increase in exposure to climate risk.

However, an increase in cash holdings can be costly for firms as it may require them to reduce spending on their current valuable investments if they are financially constrained. In this situation firms' financial performance is fundamentally linked to their financial health (Almeida et al., 2004). Under this situation, the financially constrained firms need to make a choice between the profitability of current and future investments and determine their optimal cash holding policies accordingly (Fazzari et al., 1988; Kaplan and Zingales, 1997; Almeida et al., 2004; Acharya et al., 2012). For the financially unconstrained firms, such a situation is not as relevant since they can finance all their current and future NPV projects smoothly. This important difference in cash holdings policy between financially constrained and unconstrained firms has cross-sectional implications. Almeida et al. (2004) suggest that financially constrained firms show higher propensity for cash holdings out of their cash inflow, indicating a higher "cash flow sensitivity of cash". As discussed earlier, firms' cost of capital increase with climate risk (e.g., Chava, 2014; Bansal et al., 2016; Bolton and Kacperczyk, 2020; Painter, 2020; etc.). Consequently, Firms that are more financially constrained have a greater incentive to hold more cash. Therefore, the increase

in cash holding as a result of climate risk should be stronger for these firms. It leads to our supporting hypothesis:

H1-a. The increase in the cash holdings resulting from exposure to climate risk is stronger for financially constrained firms.

3. Data and methodology

3.1 PDSI global data

Following Hong et al. (2019), we use global Palmer Drought Severity Index (PDSI) data as our measure of climate risk.¹⁰ Hong et al. (2019) collect and combine U.S. data from National Oceanic and Atmospheric Administration's (NOAA) National Center for Environmental Information (NCEI) and other countries' data from University Corporation for Atmospheric Research (UCAR). PDSI is the measure of drought intensity that climate studies widely use (see e.g., Alley, 1984; Guttman et al., 1992; Dai et al., 2004; Li et al., 2007; Dai, 2011; Beyaztas et al., 2018). Palmer (1965) develops it through a supply-demand model utilizing soil's moisture, temperature, evaporation and recharge rates. The PDSI value ranges from -10 to +10; the negative values indicate more drought conditions and the positive values indicate moisture conditions.¹¹ Monthly frequency PDSI data is available from January 1900 to December 2014.

¹⁰ Available for download at https://drive.google.com/file/d/1sm_179oVQP1hGHSzOorLpeuqpp1AZO_R/view . We thank Dr. Frank Weikai Li for generously sharing the dataset.

¹¹ If the PDSI value is less than -4, the condition is graded as extreme drought. Likewise, -3.9 to -3: severe drought; -2.9 to -2: moderate drought; -1.9 to 1.9: normal condition; 2 to 2.9: moderate moisture, 3 to 3.9: highly moisture; 4 and above: extreme moisture.

3.2 Estimation of TREND

We follow Hong et al. (2019) to estimate the coefficients of time trend using the following augmented AR (1) model:

$$PDSI_{x,t} = a + b * Time_x + c * PDSI_{x,t-1} + \varepsilon_{x,t} \quad (1)$$

In equation (1), the coefficient b captures the long-term climate change (drought) exposure of each country x , at the time point t . We take arithmetic average of monthly b values to have yearly trend data. For the ease of exposition and a more accessible discussion of our results, we flip the sign of b and multiply it by 1000 to construct our key independent variable, TREND. In this way, a higher value of TREND indicates higher long-term climate change risk exposure (more drought-like condition).

3.3 Firm specific variables and summary statistics

We obtain firm specific balance sheet data from Compustat (combination of North America and Global) fundamental annual database. We remove utility and financial firms (two-digit SIC codes: 49, 60-69) as they are highly regulated. We drop firms with market capitalization of less than \$10 million (we convert global firms' market capitalization to US dollars using exchange rate data from Compustat). We delete observations with missing industry (SIC) information and with missing or negative cash dividend. We drop the observations with greater than 100% change in assets and sales in two consecutive years to eliminate the impact of large corporate events, for instance, mergers and acquisitions. All our continuous variables (except TREND) are Consumer Price Index (CPI) adjusted and winsorized at the top and bottom 1% level. Since the global drought-index (PDSI) used for the construction of TREND is not available beyond the year 2014, and prior to 1985 the climate change was less of an issue, we follow Hong et al. (2019) and restrict

our sample period to 1985-2014. Finally, we are left with an unbalanced panel of 384,966 firm-year global observations from 41 different countries including the United States. Overall, there is a total of 37,361 unique firms in the dataset among which 11,632 are U.S. firms. In the appendix [table A1](#), we provide the description of all variables and their sources. Panel A of table 1 presents the summary statistics.

[Insert [Table 1](#), about here]

In our final sample, the mean of cash (over total asset) is 0.162 which indicates that on average firms hold 16.2% of their total assets as cash. The standard deviation of cash (over total asset) is 0.183 ensuring that there is substantial variation in our dependent variable. Our key independent variable, TREND, also shows a large variation across the sample with a mean of 0.026 and standard deviation of 0.128. The descriptive statistics of other control variables are also consistent with prior empirical studies. We present country-wise breakdown of our dependent variable (CASH) and key independent variable (TREND) in panel B of [table 1](#). In our sample, firms from Taiwan, Israel, Australia, China, US, and Japan are found to hold more cash on average, while firms located in Taiwan, Peru, Israel, Japan, and Austria are found to have relatively higher long-term climate risk exposure. Comparing the standard deviations of both CASH and TREND variables, we find that firms located in Turkey, Australia, New Zealand, China, Philippines, Egypt, and Brazil show higher inclination towards corporate cash holdings in response to the higher variation of climate risk exposure.

3.4 Methodology

Following Opler et al. (1999), Harford et al. (2008), and Bates et al. (2009), we estimate a panel regression model:

$$Cash_{i,x,t} = \alpha_0 + \beta_1 * TREND_{x,t} + \sum_2^q \beta_q * X_{q,i,t} + Macro\ factors_{x,t} + Year_t + Industry_i + Country_x + \varepsilon_{i,x,t} \quad (2)$$

In equation (2), $Cash_{i,x,t}$ is our key dependent variable which we define as the ratio of cash and marketable securities to total assets of firm i located in country x in the year t . $TREND_{x,t}$ is our key independent variable that we construct as a measure of climate change exposure in the year t to the firms located in the country x (details provided in [section 2.2](#)). $X_{q,i,t}$ is the vector of firm-level control variables. Following Bates et al. (2009), we control for firm size, market to book ratio, leverage, research and development expenditure, cash flow, non-cash working capital, acquisitions, dividend, and industry sigma. Given the global setting of our study, it is necessary to include country-specific macroeconomic factors in our model. Following Kacheva and Lins (2007), we add GDP per capita, private credit to GDP ratio, Consumer Price Index (CPI), and stock market capitalization as country-specific macroeconomic factors. All variables are defined in appendix [table A1](#). We apply year fixed effects, industry fixed effects, and country fixed effects in our regression model. We also cluster standard errors at firm-level. The coefficient of interest is β_1 and a positive and statistically significant coefficient would be consistent with our hypothesis H_1 .

4. Univariate analysis, baseline results and robustness checks

4.1 Univariate analysis

In this section, we conduct simple mean difference tests by sorting our data into different quartiles of TREND (Q1: least exposure to Q4: highest exposure). Specifically, we sort our sample based on TREND and create portfolios and then compare the average cash holdings in each portfolio. This portfolio analysis is a widely used technique in asset pricing literature, but it can be

used (and is used) in other contexts. As pointed out by Bali, Engle, and Murray (2016), the main benefit of portfolio analysis is that it is a nonparametric technique that unlike other methodologies does not rely on any assumptions about the functional form of the variables under investigation and is, therefore, useful for understanding the cross-sectional relations. While the main setback of this technique is the difficulty to control for a large number of variables, Bali et al. (2016) argue that if the pattern emerging from a portfolio analysis is monotonic or near monotonic, which happens to be the case here, it is a strong indication that the result of the difference portfolio (Q4-Q1) is not spurious.

[Insert [Table 2](#), about here]

We do this in two different ways. First, we determine TREND quartiles using our whole dataset regardless of its associated country. In this way we find that mean cash holding in our sample is 14.91% for Q1 group and 16.62% for Q4 group. The difference is 1.71% (t-stat. = 22.17) and statistically significant at 1% level. Next, we determine TREND quartiles based on the associated countries (i.e., groups are made for each country separately). In this way we find that the overall difference between mean cash holding of two extreme groups (Q4-Q1) is 2.39% and highly significant (t-stat= 28.93). In similar fashion, we also examine the difference between above median (Q34) and below median (Q12) TREND groups in both ways and find consistent results. From generic statistical and econometric points of view, our univariate analysis, presented in panel A of table 2, is arguably reliable as we use a large sample.

We provide more insight at the country level in panel B of table 2. In most of the cases the difference is in line with our hypothesis and statistically significant. For instance, countries with greater observations in the sample, US, Canada, China, and Australia show a positive and

significant mean difference between the extreme groups. A notable exception is UK, but the magnitude of the difference is relatively small.

4.2 Baseline results

In the first two models of [table 3](#) , cash (over total asset) is our dependent variable. The second model includes additional country-level macroeconomic factors as controls. Consistent with our hypothesis, in both cases the β_1 coefficients are positive and statistically significant. Focusing on model (2), the coefficient of TREND is positive and statistically significant ($\beta = 0.031$; t-statistics = 2.37). It means that for a one standard deviation change in TREND (0.128), there is about 0.40% increase in firms' cash holding. Compared to the mean cash holding in our sample (16.2%), this is equivalent to about 2.5% increase in cash holding.

[Insert [Table 3](#), about here]

While we formally address endogeneity concerns later in the paper, to mitigate endogeneity-related biases related to simultaneity and omitted variables, we move cash, our dependent variable, forward by one year, essentially estimating the effect of $TREND_{t-1}$. We report the results in models (3) and (4). The results we obtain under this setting confirm our previous findings from model (1) and (2). In the last two specifications, we use the change in cash holdings as our dependent variable. Results confirm our earlier finding. The coefficient on TREND is positive and statistically significant, suggesting that firms increase their cash holding when exposed to higher climate risk.

4.3 Robustness checks

4.3.1 Baseline results excluding the US observations

About 32% of our sample comes from the US. To ensure that our baseline results are not driven by a single country, we redo our baseline analysis eliminating the US observations from our sample. In this way, we get a β_1 coefficient of 0.059 (t-statistics: 4.09) for model (2) that is even of higher magnitude than before and statistically significant at 1% level.

[Insert [Table 4](#), about here]

This finding suggests that for the non-US sample a one standard deviation increase in TREND leads to a 5.6% rise in cash holdings compared to average cash holdings.¹² The results from all other models (i.e., models (1), and (3) to (6)) in table 4 are also consistent with our main hypothesis and confirm our earlier baseline results.

4.3.2 Alternative firm-level proxies

4.3.2.1 State-weighted TREND using firms' geographic concentration

The historical PDSI data are separately available at NOAA's website for 48 US mainland states since 1895. Utilizing this dataset, we further explore the state-level impact of long-term adverse climate change pattern on corporate cash holdings for U.S. firms. While doing so, we also consider a potential downside of using firms' headquarter to measure climate risk exposure. Locations other than headquarters can also be important for firms' operations (Garcia and Norli, 2012; Smith, 2016). Garcia and Norli (2012) construct a measure of US firms' geographic concentrations in different states.¹³ Specifically, their measure is based on the proportion of how

¹² The standard deviation of TREND for our international sample (i.e., excluding US) is 0.147 and the average cash holdings of our international sample is 15.48%.

¹³ We are sincerely thankful to Garcia and Norli (2012) for generously sharing their dataset.

many times different states are mentioned in firms' 10-K reports. It resembles a probability distribution of firms' activities in different states. This measure in combination with Hong et al. (2019) enables us to construct a more realistic firm-level proxy of state-weighted climate risk for US firms. We report our analysis based on this firm-level state-weighted climate risk measure (WT_STTREND) in model (1) of table 5.

[Insert [Table 5](#), about here]

Here, we find that the TREND coefficient is 0.121 with t-statistics value of 2.75 (statistically significant at 1% level). This value means that for a one standard deviation increase in state-weighted trend (0.041), US firms increase their cash holdings by about 0.50%. Which is also economically significant as it suggests a 2.6% increase compared to the mean cash holding for the US firms used in this analysis (19%).

4.3.2.2 Firm-level environmental risk

We conduct another robustness test for our findings based on a different firm-level environmental risk proxy (LOG_ENRISK) constructed by Hassan et al. (2019).¹⁴ The construction of the measure involves computational linguistics (i.e., textual analysis) and is based on firms' quarterly earnings conference calls. The proxy we use here is basically a sub-component of firm-level overall political risk that is separately quantified by Hassan et al. (2019). As the authors explicitly mention, this proxy measures the firm-level political risk due to climate legislation (Hassan et al., 2019, p. 2189). We report the results from this analysis in model (2) of table 5. We also find positively significant β_1 coefficient from this analysis that is consistent with our main hypothesis and it confirms our previous findings.

¹⁴ Firm-level environmental risk data available at <https://www.firmlevelrisk.com/>

5. Identification strategies

5.1 The impact of Stern Review

In this section, following Painter (2020), we conduct a quasi-natural experiment, surrounding the release of Stern Review in 2006. The report is the first to widely reveal the impact of climate change on different economic resources and it estimates the costs associated with climate change. This 700-page long report suggests that the early actions on climate change can be economically beneficial in a sense that they will significantly outweigh the future losses (Stern, 2008). This view is consistent with the underlying mechanism of firms' *precautionary motives* framework for corporate cash holdings as we discuss earlier. The intuition is that following the release of the Stern Review firms learn more about the risks and costs associated with climate change. Therefore, to the extent that holding more cash as precautionary motive mitigates such risk, we expect a positive and significant coefficient of the interaction term between our climate risk measure (TREND) and the STERN indicator variable (i.e., prior to 2006 and 2006 = 0 or after 2006 = 1). The results of our difference-in-difference specification, reported in table 6, are consistent with this assertion.

[Insert [Table 6](#) and [Figure 1](#), about here]

The significant and positive coefficients of the interaction term, for instance 0.041 (t-statistics: 5.34) in model (2), tells us that firms do increase cash holding following the release of the Stern Review. Additionally, we find similar results by keeping the window fixed (i.e., considering the equal time span before and after the event) for a six-year period (in the models (3) and (4)) and for a ten-year period (in the models (5) and (6)), respectively.

Figure 1 depicts the evolution in cash holding behavior of firms highly exposed to climate risk (Q4) and all other firms (Q123). We discuss the formation of different quartile groups of samples with respect to firms' exposure to climate risk in section 4.1. This figure uses cash holding residuals. These are the residuals of regressing CASH on all the independent variables of our base model (i.e., Equation (2)) except TREND. As the residuals are by construction orthogonalized with respect to all the independent variables, their behavior around the release of the Stern Report can be more easily attributed to the awareness about the risks and costs associated with climate change. Here, we observe that firms become more cautious when fall in the severe climate risk group and consequently increase their level of cash holdings following the Stern Review. More specifically, we observe a sharp increase of cash holdings in group Q4 after 2006 (an increase of average CASH residuals from about 0.01 in 2006 to over 0.04 in 2011). In contrast, we observe a declining cash holding tendency by the other group (Q123) following Stern Review.

5.2 The impact of customers' climate risk exposure

Our main measurement of climate risk exposure has a legitimate concern related to the use of firms headquarter locations. Though it is evident that firms' major operations and economic activities usually run around their headquarter locations (Pirinsky and Wang, 2006; Chaney et al., 2012), still it can be argued easily that measuring risk at firms headquarter locations is not adequate. We attempt to alleviate this concern using firms' geographic concentration data in the section 4.3.2.1. In this section, we address this issue further and provide more evidence to identify the effect of climate risk by exploiting the economic channel between firms and their customers. The customers play a vital role in firms' growth and prosperity. Thus, when firms' customers are faced with climate risk severity, it may also impact firms' supply chain, productivity, and revenue. Considering this fact, we examine the impact of adverse climate change pattern at firms' customer

locations on firms' cash holdings. The customer segment data of Compustat Capital IQ help us identify firms' customer locations. We employ the same methodology of Hong et al. (2019) to determine TREND at firms' customer locations (CSTMR_TREND). Our analysis, reported in table 7, find that customers' long-term adverse climate change exposure also influences the firms to increase their cash holdings.

[Insert [Table 7](#), about here]

The β_1 coefficient from model (3) of table 1.8 is 0.113 (t-statistics: 1.91). It suggests that for a one standard deviation (0.114) increase in climate risk exposure of a firms' customers leads to about 1.3% increase in that firms' cash holdings. our findings from this section is consistent with the notion that firms increase their cash holdings even when their customers are exposed to climate risk.

5.3 Placebo tests

In this section, we attempt to address that the relation we document in this study between climate risk and corporate cash holdings is not spurious and not simply the reflection of any time-varying unobserved factor(s) other than the climate risk. In doing so, we first divide our sample into quartiles (for each country, as described in section 4.1) and then conduct placebo tests employing nearest neighbor propensity score matching. We match samples in two different ways: first, the least exposure quartile, Q1 vs. the highest exposure quartile, Q4; and then lower median (Q1 and Q2 together) vs. upper median (Q3 and Q4 together). In both cases we match samples based on the variables: SIZE, MB, LEV, RD, CASH_FLOW, NWC, CAPEX, ACQ, DIV_DUM, IND_SIGMA, and industry fixed effects. The key independent variable in this analysis is PLACEBO_TREND. We construct this variable by replacing TREND values associated with

firms in the top quartile, Q4 (or upper median, Q34) with TREND values associated with their matched firms in the bottom quartile, Q1 (or lower median Q12). However, the values of PLACEBO_TREND remain the same as TREND values for the firms in the bottom quartile, Q1 (or lower median, Q12). We expect that the coefficient on PLACEBO_TREND from our regression model (2) to be small and insignificant. If we find a significant coefficient for PLACEBO_TREND, it would indicate that our earlier findings are spurious, and a reflection of some unobserved time-varying factor(s). We report the results from the placebo tests in table 8.

[Insert [Table 8](#), about here]

The small and insignificant coefficients in the models (1), (2), (3), and (4) of table 8 are consistent with our prediction and confirm that our earlier findings are not spurious or the reflection of any other unobserved time-varying factor(s).

6. Subsample analyses

6.1 Financially constrained vs. unconstrained firms

So far, it has been evident from our analyses that consistent with our main hypothesis (H1) there exists an economically and statistically significant positive relation between firms' exposure to climate risk and corporate cash holdings. We now turn to test our supporting hypotheses. In this section, we examine the implications of climate risk under financial constraints.¹⁵ Intuitively, an increase in firms' cash holdings due to their long-term adverse climate change exposure should be more relevant for financially constrained firms that face a trade-off situation between spending on current and future projects. Accordingly, we expect that the increase in cash holdings would be

¹⁵ As we discuss earlier, an important question in finance literature is that how firms behave when they become financially constrained. A few relevant and renowned studies in this area of literature include Fazzari et al. (1988), Whited (1992), Kaplan and Zingales (1997), Almeida et al. (2004), Whited and Wu (2006), Hennessy and Whited (2007), and Hadlock and Pierce (2010), among others.

more pronounced for the cross-section of the financially constrained firms than for the financially unconstrained firms. The researchers rely on different proxies to measure the degree of financial constraints. The recent literature uses three popular financial constraints proxies, namely the Kaplan and Zingales (1997) index (a.k.a. KZ index), the Whited and Wu (2006) index (a.k.a. WW index), and the Hadlock and Pierce (2010) index (a.k.a. SA index). We report the results for the financially constrained vs. unconstrained cross-sections based on our base model using all three common proxies in table 9.

[Insert [Table 9](#), about here]

We find positive and significant β_1 coefficients from the models (1), (3), and (5) of table 9 that represent the financially constrained firms, whereas the effect is insignificant for financially unconstrained firms. Last row of the table shows that the difference between the results of the two subsamples is statistically significant for all specifications. Overall, the findings from table 9 are consistent with our supporting hypothesis, H1-a.

While we follow Bates et al. (2009), the specification in Almeida et al. (2004) is also widely used, particularly for cash holding analyses involving financially constrained firms. Thus, as an additional robustness, we redo our financial constraints analyses reported in table 9 employing the specification in Almeida et al. (2004) and report the results in table 10.

[Insert [Table 10](#), about here]

The results from table 10 are consistent with those of table 9, and together they confirm our earlier findings. Specifically, we only find positive and significant coefficients on TREND from the models (1), (3), and (5) that represent the financially constrained firms. We also find similar results

for two other cases. Overall, the results suggest that the financially constrained firms increase cash holdings more than the financially unconstrained firms following their exposure to climate risk.

6.2 Cash shortfall vs. excess cash

In this section, we examine firms' behavior in our context based on their cash flow positions. The intuition behind this cross-sectional analysis mostly follows from the section 6.1. The firms with excess cash holdings are usually in a better position to finance all their current and future NPV projects. In contrast, firms with a cash shortfall are significantly more exposed to any adverse shock to their cash flows and financing friction would affect them more severely. Therefore, we expect that firms with a cash shortfall would increase their cash holdings more when exposed to long-term climate risk compared to firms with excess cash very much like financially constrained firms.

Following the recent literature (e.g., Phan et al., 2019 among others), we use the predicted values of Bates et al. (2009) cash holding regression as the measure for firms' optimum level of cash holdings. Specifically, we regress CASH on all control variables of our base model excluding our key independent variable, TREND, to get the predicted values of cash holdings. We then split our observations into two groups by comparing their actual and predicted cash holdings. Firms whose actual cash holding is larger (smaller) than the predicted value have excess cash (cash shortfall). We report cash shortfall vs. excess cash subsample analysis results in table 11.

[Insert [Table 11](#), about here]

In table 11 we, per our prediction, find positive and significant β_1 coefficients for the firms with cash shortfall (i.e., models (1) and (2)). In contrast, we get smaller and insignificant β_1 coefficients for models (3) and (4) representing the firms with an excess cash. The results suggest that the firms with a cash shortfall exhibit higher inclination for cash holdings than the firms with an excess cash

when exposed to climate risk. This finding is consistent with our supporting hypothesis. It further strengthens our claims and the enhance the credibility of our earlier findings.

Following the same intuition from the previous section, we run an additional robustness test for our cash shortfall vs. excess cash subsample analysis under Almeida et al. (2004) framework. The results are reported in table 12.

[Insert [Table 12](#), about here]

Here we also find that the increase in cash holdings is positive and significant for the firms from the *cash shortfall* group (models (1) and (2)). The coefficients on our key independent variable, TREND, from the *excess cash* group (models (3) and (4)) remain small and insignificant. The findings from table 12 affirm the case we claim in section 6.3 that the firms with a cash shortfall are more likely to increase their cash holdings than the firms with excess cash following a long-term adverse climate change exposure.

4. Conclusion

In this paper, we find that firms hold more cash to mitigate the risk associated with exposure to climate change. Our findings are consistent with firms' *precautionary motives* framework for cash holdings. We present global evidence with data from 41 countries including the US and our results are robust to different model specifications and different measures of climate risk. We employ three identification strategies. First, we conduct a quasi-natural experiment around a release of Stern Review report in 2006 that has important implications in corporate decision making (Painter, 2020). Our findings from a difference-in-difference analysis around Stern Review indicate that firms increase their cash holdings following the event. Second, we explore an economic channel between firms and their customers and find that the firms increase their cash

holdings when their customers are adversely affected by the climate change. Third, we conduct placebo tests by replacing the magnitude of climate risk exposure of highly exposed firms with that of less exposed but otherwise comparable firms (we use nearest neighbor propensity score matching technique) and find no evidence that our earlier findings are spurious. Our results from subsample analyses suggest the increase in cash holdings due to climate risk is significantly stronger for financially constrained firms.

Our study contributes to the modern literature of climate change finance as well as to the classic corporate cash holding literature. The implications of climate change for major corporate policies is largely unexplored. Our study fills this gap and investigates how the long-term adverse climate change exposure would make the firms reshape their cash holdings policy. Overall, our findings suggest that firms do view climate change as a risk factor, particularly after the release of the Stern Report, and as a result they increase their cash holdings a precaution.¹⁶

¹⁶ The debate regarding the existence of climate change is beyond the scope of our study. We simply follow a widely used climate change indicator originally developed by climate science and document our findings in the context of corporate cash holdings.

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Table 1: Summary Statistics and Country-wise Breakdown

Panel A: Summary Statistics								
VARIABLE	N	MEAN	SD	P10	P25	P50	P75	P90
CASH	384,966	0.162	0.183	0.010	0.035	0.100	0.219	0.406
TREND	384,966	0.026	0.128	-0.100	-0.057	-0.016	0.111	0.252
SIZE	384,966	6.619	3.267	2.555	4.241	6.374	8.884	11.126
MB	384,966	2.026	3.034	0.763	0.950	1.244	1.880	3.279
LEV	384,966	0.236	0.222	0	0.042	0.197	0.359	0.524
RD	384,966	0.028	0.080	0	0	0	0.012	0.077
CASH_FLOW	384,966	-0.031	0.352	-0.169	-0.005	0.046	0.088	0.132
NWC	384,966	0.002	0.303	-0.220	-0.079	0.023	0.149	0.275
CAPEX	384,966	0.065	0.085	0	0.012	0.036	0.083	0.160
ACQ	384,966	0.009	0.032	0	0	0	0	0.016
DIV_DUM	384,966	0.420	0.494	0	0	0	1	1
IND_SIGMA	384,966	0.081	0.070	0.019	0.031	0.055	0.110	0.182

Panel B: Country-wise Breakdown							
COUNTRY	N	MEAN	SD	P50	MEAN	SD	P50
		TREND			CASH		
Australia	15,245	-0.093	0.056	-0.064	0.228	0.251	0.123
Austria	1,175	0.241	0.014	0.239	0.121	0.135	0.076
Belgium	1,545	0.041	0.019	0.034	0.130	0.144	0.081
Brazil	2,604	0.205	0.032	0.215	0.127	0.128	0.093
Canada	22,628	-0.099	0.036	-0.084	0.159	0.216	0.065
Chile	1,402	0.104	0.013	0.103	0.078	0.106	0.047
China	22,516	0.077	0.054	0.099	0.199	0.154	0.157
Denmark	1,878	-0.100	0.019	-0.105	0.148	0.178	0.078
Egypt	739	-0.386	0.048	-0.401	0.150	0.143	0.109
Finland	1,887	0.014	0.017	0.016	0.131	0.139	0.084
France	9,841	0.067	0.015	0.065	0.147	0.145	0.103
Germany	9,891	0.053	0.006	0.054	0.152	0.172	0.088
Greece	2,587	0.145	0.027	0.140	0.081	0.104	0.044
India	15,766	-0.150	0.027	-0.156	0.082	0.120	0.035
Indonesia	3,555	0.004	0.016	0.008	0.115	0.123	0.072
Ireland	1,281	0.039	0.014	0.042	0.173	0.179	0.106
Israel	3,332	0.322	0.020	0.318	0.251	0.235	0.174
Italy	3,040	0.202	0.023	0.211	0.115	0.119	0.078
Japan	56,323	0.254	0.019	0.256	0.175	0.126	0.143
Luxembourg	234	0.044	0.022	0.041	0.134	0.110	0.108
Malaysia	12,166	0.007	0.093	0.043	0.131	0.137	0.087
Mexico	1,314	-0.178	0.014	-0.181	0.090	0.087	0.065
Netherlands	2,730	0.046	0.023	0.037	0.113	0.142	0.061
New_Zealand	1,267	-0.195	0.056	-0.168	0.100	0.160	0.032
Norway	2,241	-0.153	0.018	-0.159	0.166	0.171	0.107
Peru	630	0.363	0.017	0.361	0.080	0.108	0.039
Philippines	1,711	0.176	0.053	0.171	0.129	0.159	0.079
Poland	3,131	0.128	0.011	0.123	0.102	0.133	0.054
Portugal	681	-0.013	0.017	-0.013	0.063	0.069	0.039
Russia	637	-0.093	0.010	-0.090	0.101	0.122	0.061
Saudi_Arabia	803	0.144	0.101	0.179	0.112	0.126	0.066
South_Africa	3,670	0.035	0.020	0.034	0.131	0.136	0.092
South_Korea	10,761	-0.069	0.015	-0.064	0.147	0.125	0.110
Spain	1,805	-0.008	0.024	-0.006	0.095	0.109	0.062
Sweden	4,370	-0.028	0.016	-0.025	0.158	0.175	0.095
Switzerland	3,132	0.136	0.024	0.137	0.169	0.156	0.122
Taiwan	95	0.379	0.012	0.371	0.259	0.188	0.220
Thailand	5,701	0.140	0.008	0.140	0.103	0.117	0.058
Turkey	2,455	-0.075	0.064	-0.057	0.101	0.118	0.058
UK	23,465	-0.029	0.019	-0.028	0.150	0.183	0.085
US	124,732	-0.031	0.020	-0.025	0.178	0.215	0.088
Total	384,966	0.026	0.128	-0.016	0.162	0.183	0.100

Panel A contains summary statistics of a panel dataset consisting of 384,966 firm-year global observations used in our study from 41 different countries. There are 37,361 unique firms among which 11,632 are from the United States. We do not consider financial and utility firms (two-digit SIC codes: 49 and 60-69). Our key independent variable, TREND, is constructed by following Hong et al. (2019) but for the sake of an easier interpretation we flip the sign and multiply it by 1,000 (makes it: the higher the value, the higher the climate exposure is). Since the global drought-index (PDSI) used for the construction of TREND is not available beyond the year 2014, and prior to 1985 the climate change issue was not largely pronounced in corporate literature, following Hong et al. (2019) we restrict our sample period to 1985-2014. All variables except TREND are CPI adjusted. Panel B presents country-wise breakdown summary for the key independent variable (TREND) and dependent variable (CASH) of our sample.

Table 2: Univariate Analysis

Panel A: Mean t-test of Cash Holding				
Mean Difference: first quartile (Q1) and fourth quartile (Q4)				
Basis	Q1	Q4	Difference	t-stats
TREND (Overall)	0.1491	0.1662	0.0171***	22.1715
TREND (Country-wise)	0.1494	0.1733	0.0239***	28.9348
Mean Difference: lower median (Q12) and upper median (Q34)				
Basis	Q12	Q34	Difference	t-stats
TREND (Overall)	0.1605	0.1643	0.0038***	6.4543
TREND (Country-wise)	0.1553	0.1700	0.0147***	24.9502

Panel B: Mean t-test of Cash Holding (Country by Country)								
COUNTRY	Q1	Q4	Q4-Q1	t-Stat.	Q12	Q34	Q34-Q12	t-Stat.
Australia	0.1458	0.2757	0.1299***	23.8626	0.1972	0.2680	0.0708***	17.4272
Austria	0.1280	0.1162	-0.0118	-1.0882	0.1254	0.1159	-0.0095	-1.1951
Belgium	0.1219	0.1409	0.0190*	1.8188	0.1275	0.1320	0.0045	0.6455
Brazil	0.1188	0.1286	0.0098	1.4263	0.1243	0.1297	0.0054	1.0669
Canada	0.1044	0.1866	0.0822***	21.8578	0.1336	0.1852	0.0516***	18.1215
Chile	0.0712	0.0780	0.0068	0.9579	0.0777	0.0791	0.0014	0.2458
China	0.1699	0.2340	0.0641***	21.5944	0.1773	0.2229	0.0456***	22.4504
Denmark	0.1397	0.1714	0.0317***	2.9427	0.1415	0.1546	0.0131	1.5903
Egypt	0.1447	0.1611	0.0164	1.1240	0.1496	0.1510	0.0014	0.1288
Finland	0.1275	0.1250	-0.0025	-0.2937	0.1291	0.1321	0.0030	0.4625
France	0.1444	0.1563	0.0119***	2.7504	0.1436	0.1515	0.0079***	2.6880
Germany	0.1530	0.1631	0.0101**	2.0561	0.1508	0.1532	0.0024	0.7013
Greece	0.0785	0.0982	0.0197***	3.2844	0.0775	0.0850	0.0075*	1.8596
India	0.0791	0.0798	0.0007	0.2472	0.0793	0.0853	0.0060***	3.1686
Indonesia	0.1203	0.1183	-0.0020	-0.3241	0.1134	0.1171	0.0037	0.9056
Ireland	0.1620	0.1930	0.0310**	2.1671	0.1689	0.1754	0.0065	0.9611
Israel	0.2492	0.2414	-0.0078	-0.6703	0.2517	0.2493	-0.0024	-0.2912
Italy	0.1068	0.1236	0.0168***	2.8169	0.1118	0.1186	0.0068	1.5510
Japan	0.1958	0.1778	-0.0180	-11.5816	0.1787	0.1710	-0.0077***	-7.1904
Luxembourg	0.1568	0.1029	-0.0539**	-2.5375	0.1579	0.1086	-0.0493***	-3.5191
Malaysia	0.1559	0.1070	-0.0489***	-14.3462	0.1461	0.1125	-0.0336***	-13.5422
Mexico	0.0752	0.0999	0.0247***	3.7135	0.0844	0.0968	0.0124**	2.5841
Netherlands	0.1181	0.0917	-0.0264***	-3.6569	0.1202	0.1059	-0.0143***	-2.6437
New_Zealand	0.0810	0.1045	0.0235*	1.7936	0.0903	0.1108	0.0205**	2.2600
Norway	0.1591	0.1665	0.0074	0.7361	0.1632	0.1690	0.0058	0.7962
Peru	0.0626	0.0823	0.0197**	2.1333	0.0757	0.0856	0.0099	1.1442
Philippines	0.1549	0.1072	-0.0477***	-4.3030	0.1464	0.1111	-0.0353***	-4.6021
Poland	0.1044	0.1081	0.0037	0.5463	0.1024	0.1024	0.0000	-0.0027
Portugal	0.0550	0.0653	0.0103	1.3715	0.0569	0.0688	0.0119**	2.2447
Russia	0.0995	0.1002	0.0007	0.3791	0.0988	0.1049	0.0061	0.6139
Saudi_Arabia	0.1345	0.1071	-0.0274*	-1.8920	0.1180	0.1050	-0.0130	-1.4118
South_Africa	0.1212	0.1222	0.0010	0.1637	0.1288	0.1306	0.0018	0.9376
South_Korea	0.1344	0.1590	0.0246***	6.6240	0.1411	0.1540	0.0129***	5.3310
Spain	0.0926	0.0987	0.0061	0.8312	0.0908	0.0998	0.0090*	1.7538
Sweden	0.1506	0.1627	0.0121	1.6114	0.1516	0.1656	0.0140**	2.6149
Switzerland	0.1582	0.1824	0.0242***	2.9376	0.1583	0.1800	0.0217***	3.8889
Taiwan	-	-	-	-	0.2553	0.2637	0.0084	0.2128
Thailand	0.1138	0.0893	-0.0245***	-5.5639	0.1094	0.0937	-0.0157***	-5.0445
Turkey	0.0949	0.1101	0.0152**	2.3109	0.0989	0.1043	0.0054	1.1275
UK	0.1444	0.1373	-0.0071**	-2.2470	0.1534	0.1446	-0.0088***	-2.9328
US	0.1565	0.1972	0.0407***	23.9911	0.1664	0.1904	0.0240***	19.7197

In this table panel A presents mean t-tests of our dependent variable (CASH) in terms of key independent variable (TREND) grouped into the first and fourth quartiles and upper and lower medians. We look for both overall (groups are made using all data) scenario and country-wise (groups are made for each country separately) scenario. ***, **, and * indicate statistical significance at 1%, 5%, and 10% respectively. Panel B presents country-wise breakdown of mean t-tests. ***, **, and * indicate statistical significance at 1%, 5%, and 10% respectively.

Table 3: Baseline Results

VARIABLES	(1) CASH	(2) CASH	(3) FCASH	(4) FCASH	(5) Δ CASH	(6) Δ CASH
TREND	0.076*** (6.07)	0.031** (2.37)	0.059*** (4.51)	0.024* (1.76)	2.079** (2.06)	5.785*** (3.15)
SIZE	-0.005*** (-13.44)	-0.005*** (-13.52)	-0.005*** (-13.39)	-0.005*** (-13.52)	0.022 (0.91)	0.044* (1.85)
MB	0.004*** (15.46)	0.004*** (13.77)	0.003*** (10.48)	0.003*** (9.21)	-0.258*** (-4.80)	-0.223*** (-4.87)
LEV	-0.311*** (-92.81)	-0.311*** (-91.80)	-0.283*** (-81.09)	-0.283*** (-80.27)	0.575** (2.41)	0.595** (2.56)
RD	0.461*** (37.38)	0.471*** (37.62)	0.483*** (35.08)	0.492*** (35.14)	2.782*** (2.79)	1.934*** (2.75)
CASH_FLOW	-0.010*** (-3.96)	-0.006** (-2.21)	-0.009*** (-2.77)	-0.004 (-1.31)	0.445 (1.54)	0.208 (0.82)
NWC	-0.087*** (-30.34)	-0.090*** (-30.98)	-0.093*** (-28.47)	-0.095*** (-28.90)	0.007 (0.05)	-0.066 (-0.46)
CAPEX	-0.202*** (-35.43)	-0.197*** (-33.89)	-0.216*** (-35.73)	-0.212*** (-34.51)	-0.913 (-1.34)	-0.906 (-1.24)
ACQ	-0.286*** (-33.81)	-0.291*** (-33.95)	-0.273*** (-30.33)	-0.277*** (-30.49)	-0.404** (-2.10)	-0.336 (-1.61)
DIV_DUM	-0.013*** (-11.36)	-0.013*** (-11.30)	-0.011*** (-9.40)	-0.011*** (-9.43)	-0.079 (-0.93)	-0.052 (-0.58)
INDUSTRY_SIGMA	0.316*** (20.73)	0.316*** (20.05)	0.303*** (18.91)	0.297*** (18.02)	-2.325** (-2.22)	-0.841 (-1.23)
GDP_PERCAPITA		0.000*** (5.87)		0.000*** (6.04)		-0.000*** (-6.73)
PRIVATECREDIT_GDP		0.000*** (2.58)		0.000* (1.66)		0.001 (0.27)
CPI		-0.023*** (-4.27)		-0.039*** (-6.56)		3.732*** (2.78)
STOCKMARKET_CAP		0.000*** (11.05)		0.000*** (9.23)		-0.002*** (-2.83)
CONSTANT	0.238*** (77.91)	0.172*** (15.47)	0.234*** (71.63)	0.183*** (15.83)	0.141 (0.68)	7.278*** (7.65)
OBSERVATIONS	384,966	373,344	327,261	319,363	327,261	317,164
ADJUSTED R-SQUARED	0.337	0.340	0.315	0.318	0.010	0.014
YEAR FE	Yes	Yes	Yes	Yes	Yes	Yes
INDUSTRY FE	Yes	Yes	Yes	Yes	Yes	Yes
COUNTRY FE	Yes	Yes	Yes	Yes	Yes	Yes
FIRM CLUSTERING	Yes	Yes	Yes	Yes	Yes	Yes

This table presents our baseline results. The dependent variable for models (1) and (2) is CASH (sum of cash and marketable securities scaled by total asset). In models (3) and (4) we use FCASH (lead CASH) and in models (5) and (6) we use Δ CASH (change in CASH) as dependent variable. Our key independent variable (TREND) is constructed by following Hong et al. (2019) but we flip the sign and multiply it by 1,000 for the sake of an easier interpretation of the results. The higher value of TREND indicates higher climate change exposure. We follow Bates et al. (2009) to set control variables in models (1), (3) and (5). Models (2), (4) and (6) include several country-level macroeconomic factors as additional controls to models (1), (3) and (5). All variables are defined in Appendix-Table-1.1 (A 1.1). Every model considers year fixed effects, industry (two-digit SIC) fixed effects, and country fixed effects. The standard errors are clustered by firms. We report t-statistics in the parenthesis. ***, **, and * indicate statistical significance at 1%, 5%, and 10% respectively.

Table 4: Baseline Results excluding U.S. firms

VARIABLES	(1) CASH	(2) CASH	(3) FCASH	(4) FCASH	(5) ΔCASH	(6) ΔCASH
TREND	0.082*** (6.03)	0.059*** (4.09)	0.056*** (4.00)	0.056*** (3.82)	2.210* (1.85)	6.554*** (3.26)
SIZE	-0.006*** (-14.55)	-0.005*** (-13.77)	-0.006*** (-13.48)	-0.005*** (-13.02)	0.064* (1.78)	0.089** (2.45)
MB	0.005*** (15.01)	0.004*** (13.27)	0.004*** (12.27)	0.004*** (11.06)	-0.367*** (-4.22)	-0.308*** (-4.40)
LEV	-0.292*** (-74.18)	-0.292*** (-73.38)	-0.265*** (-65.38)	-0.264*** (-64.67)	0.195 (0.86)	0.206 (1.16)
RD	0.420*** (20.87)	0.434*** (20.77)	0.437*** (19.72)	0.445*** (19.39)	3.161* (1.77)	1.274* (1.71)
CASH_FLOW	-0.051*** (-14.72)	-0.050*** (-13.40)	-0.058*** (-14.05)	-0.058*** (-12.88)	0.495 (0.82)	-0.160 (-0.51)
NWC	-0.082*** (-23.27)	-0.087*** (-24.54)	-0.078*** (-20.71)	-0.082*** (-21.46)	0.003 (0.01)	-0.216* (-1.74)
CAPEX	-0.163*** (-22.93)	-0.159*** (-21.79)	-0.176*** (-23.83)	-0.174*** (-23.12)	-1.100 (-1.24)	-0.832 (-0.85)
ACQ	-0.244*** (-20.26)	-0.244*** (-19.94)	-0.224*** (-17.14)	-0.220*** (-16.61)	0.517 (1.17)	0.476 (1.14)
DIV_DUM	-0.001 (-0.66)	-0.000 (-0.23)	-0.000 (-0.16)	-0.000 (-0.07)	-0.186 (-1.40)	-0.084 (-0.67)
INDUSTRY_SIGMA	0.200*** (12.34)	0.200*** (12.28)	0.194*** (11.35)	0.190*** (11.19)	-2.795* (-1.75)	-0.618 (-0.81)
GDP_PERCAPITA		0.000** (2.28)		0.000 (1.52)		-0.000*** (-6.68)
PRIVATECREDIT_GDP		0.000 (0.42)		-0.000 (-1.45)		0.002 (0.49)
CPI		-0.023*** (-4.34)		-0.040*** (-6.81)		3.988*** (2.98)
STOCKMARKET_CAP		0.000*** (6.98)		0.000*** (4.04)		-0.006*** (-5.75)
CONSTANT	0.242*** (66.34)	0.230*** (20.96)	0.235*** (60.54)	0.256*** (22.33)	-0.024 (-0.08)	5.344*** (7.46)
OBSERVATIONS	260,233	248,611	221,727	213,829	221,727	211,630
ADJUSTED R-SQUARED	0.308	0.310	0.286	0.288	0.012	0.018
YEAR FE	Yes	Yes	Yes	Yes	Yes	Yes
INDUSTRY FE	Yes	Yes	Yes	Yes	Yes	Yes
COUNTRY FE	Yes	Yes	Yes	Yes	Yes	Yes
FIRM CLUSTERING	Yes	Yes	Yes	Yes	Yes	Yes

This table presents our baseline results excluding U.S. firms. The dependent variable for models (1) and (2) is CASH (sum of cash and marketable securities scaled by total asset). In models (3) and (4) we use FCASH (lead CASH) and in models (5) and (6) we use ΔCASH (change in CASH) as dependent variable. Our key independent variable (TREND) is constructed by following Hong et al. (2019) but we flip the sign and multiply it by 1,000 for the sake of an easier interpretation of the results. The higher value of TREND indicates higher climate change exposure. We follow Bates et al. (2009) to set control variables in models (1), (3) and (5). Models (2), (4) and (6) include several country-level macroeconomic factors as additional controls to models (1), (3) and (5). All variables are defined in Appendix-Table-1.1 (A 1.1). Every model considers year fixed effects, industry (two-digit SIC) fixed effects, and country fixed effects. The standard errors are clustered by firms. We report t-statistics in the parenthesis. ***, **, and * indicate statistical significance at 1%, 5%, and 10% respectively.

Table 5: Alternative proxies for climate change risk – limited sample

VARIABLES	(1) CASH	(2) CASH
WT_STTREND	0.121*** (2.75)	
LOG_ENRISK		0.002*** (2.98)
SIZE	-0.002*** (-2.59)	-0.010*** (-8.48)
MB	0.005*** (7.43)	0.010*** (7.08)
LEV	-0.340*** (-42.48)	-0.260*** (-25.32)
RD	0.464*** (21.67)	0.714*** (21.32)
CASH_FLOW	0.018*** (2.96)	0.061*** (4.66)
NWC	-0.111*** (-15.77)	-0.199*** (-15.16)
CAPEX	-0.306*** (-18.20)	-0.419*** (-16.00)
ACQ	-0.352*** (-22.24)	-0.433*** (-23.98)
DIV_DUM	-0.045*** (-12.43)	-0.030*** (-8.98)
INDUSTRY_SIGMA	0.275*** (5.38)	0.229*** (6.30)
GDP_PERCAPITA		0.000 (0.36)
PRIVATECREDIT_GDP		-0.000*** (-3.76)
CPI		-0.026 (-0.66)
STOCKMARKET_CAP		0.000 (0.72)
CONSTANT	0.253*** (27.73)	0.322*** (3.81)
OBSERVATIONS	53,414	34,093
ADJUSTED R-SQUARED	0.448	0.528
YEAR FE	Yes	Yes
INDUSTRY FE	Yes	Yes
COUNTRY FE	Yes	Yes
FIRM CLUSTERING	Yes	Yes

This table presents results for alternative climate risk proxies (firm-level). Model (1) considers Weighted State TREND (WT_STTREND) as the key independent variable. Here, we consider two important facts: 1. a significant number of our observations are from the U.S., and 2. state-level PDSI data for 48 U.S. mainland-states are also available. Applying the same methodology from Hong et al. (2019) we first construct state-level-TREND. We further alleviate the potential concern that Head Quarter (HQ) state of a firm and its' operational location can be different. We multiply firms' geographic concentration in different states (Garcia and Norli, 2012) with its state-level-TREND from those states to create an overall weighted-state-TREND that becomes a firm-specific measure. In model (2), we consider another firm-level proxy as the key independent variable developed by Hassan et al. (2019). This proxy (hereby log_enrisk = log (1+ env. risk)), largely measures firms' political risk due to climate/environmental legislation. The dependent variable for models (1) and (2) is CASH (sum of cash and marketable securities scaled by total asset). We follow Bates et al. (2009) to set control variables in model (1). Model (2) includes several country-level macroeconomic factors as additional controls to model (1). However, the sample period is limited (1992-2008 for model (1) and 2002-2014 for model (2)) due to unavailability of data. All variables are defined in Appendix-Table-1 (A1). Both models consider year fixed effects, industry (two-digit SIC) fixed effects, and country fixed effects. The standard errors are clustered by firms. We report t-statistics in the parenthesis. ***, **, and * indicate statistical significance at 1%, 5%, and 10% respectively.

Table 6: Impact of Stern Review (2006)

VARIABLES	(1) No Fixed Window	(2)	(3) 6 Years (2004-2009)	(4)	(5) 10 Years (2002-2011)	(6)
	CASH	CASH	CASH	CASH	CASH	CASH
TREND*SERN	0.019*** (2.97)	0.041*** (5.34)	0.046*** (6.98)	0.034*** (4.18)	0.049*** (7.35)	0.043*** (5.45)
TREND	0.073*** (5.75)	0.017 (1.24)	-0.003 (-0.10)	-0.025 (-0.90)	0.040** (2.04)	0.029 (1.48)
SIZE	-0.005*** (-13.35)	-0.005*** (-13.42)	-0.008*** (-15.64)	-0.008*** (-15.52)	-0.007*** (-15.31)	-0.007*** (-14.99)
MB	0.004*** (15.50)	0.004*** (13.87)	0.004*** (8.80)	0.004*** (8.45)	0.004*** (10.47)	0.003*** (9.72)
LEV	-0.311*** (-92.80)	-0.311*** (-91.81)	-0.317*** (-61.62)	-0.317*** (-61.29)	-0.316*** (-70.55)	-0.316*** (-70.08)
RD	0.460*** (37.37)	0.471*** (37.62)	0.522*** (27.93)	0.526*** (27.97)	0.504*** (31.20)	0.512*** (31.34)
CASH_FLOW	-0.010*** (-3.97)	-0.006** (-2.18)	-0.009** (-2.03)	-0.008* (-1.74)	-0.009** (-2.49)	-0.007** (-2.01)
NWC	-0.087*** (-30.35)	-0.090*** (-30.97)	-0.072*** (-15.23)	-0.073*** (-15.43)	-0.071*** (-17.99)	-0.073*** (-18.39)
CAPEX	-0.204*** (-35.50)	-0.197*** (-33.82)	-0.218*** (-20.87)	-0.216*** (-20.55)	-0.219*** (-24.25)	-0.213*** (-23.35)
ACQ	-0.286*** (-33.83)	-0.291*** (-34.01)	-0.362*** (-24.90)	-0.364*** (-24.89)	-0.359*** (-28.53)	-0.359*** (-28.29)
DIV_DUM	-0.013*** (-11.42)	-0.013*** (-11.33)	-0.009*** (-5.24)	-0.008*** (-4.98)	-0.009*** (-6.16)	-0.009*** (-5.97)
INDUSTRY_SIGMA	0.319*** (20.91)	0.317*** (20.12)	0.302*** (14.04)	0.304*** (14.08)	0.306*** (16.35)	0.306*** (16.17)
GDP_PERCAPITA		0.000*** (6.91)		0.000 (1.21)		0.000*** (2.65)
PRIVATECREDIT_GDP		0.000*** (3.57)		-0.000 (-1.38)		-0.000 (-0.21)
CPI		-0.008 (-1.31)		-0.042** (-2.09)		-0.025** (-2.45)
STOCKMARKET_CAP		0.000*** (10.61)		0.000*** (3.52)		0.000*** (2.52)
CONSTANT	0.238*** (77.71)	0.145*** (12.31)	0.269*** (55.02)	0.276*** (10.42)	0.259*** (61.67)	0.228*** (11.07)
OBSERVATIONS	384,966	373,344	106,065	104,995	177,292	174,064
ADJUSTED R-SQUARED	0.337	0.340	0.364	0.365	0.352	0.353
YEAR FE	Yes	Yes	Yes	Yes	Yes	Yes
INDUSTRY FE	Yes	Yes	Yes	Yes	Yes	Yes
COUNTRY FE	Yes	Yes	Yes	Yes	Yes	Yes
FIRM CLUSTERING	Yes	Yes	Yes	Yes	Yes	Yes

This table presents results of CASH around the Stern Review (an extensive report detailing pros and cons of climate change on economic and business policies published in 2006). We look for the impacts under three different sample settings (i.e., no fixed window, 6 years window, and 10 years window). We follow Bates et al. (2009) to set control variables in models (1), (3), and (5). Models (2), (4), and (6) include several country-level macroeconomic factors as additional controls to models (1), (3), and (5). All variables are defined in Appendix-Table-1 (A1). Every model considers year fixed effects, industry (two-digit SIC) fixed effects, and country fixed effects. The dummy Stern (if observation year is later than 2006) drops out from the models due to year fixed effects. The standard errors are clustered by firms. We report t-statistics in the parenthesis. ***, **, and * indicate statistical significance at 1%, 5%, and 10% respectively.

Table 7: Customer segmentation analysis - limited sample

VARIABLES	(1) CASH	(2) CASH	(3) CASH
CSTMR_TREND	0.109* (1.76)	0.121** (1.96)	0.113* (1.91)
SIZE	-0.005*** (-3.15)	-0.005*** (-2.99)	-0.004** (-2.43)
MB	0.004** (2.42)	0.003** (2.10)	0.003** (2.27)
LEV	-0.324*** (-18.50)	-0.327*** (-18.41)	-0.334*** (-19.00)
RD	0.448*** (9.33)	0.462*** (9.86)	0.460*** (9.78)
CASH_FLOW	0.051*** (3.52)	0.053*** (3.63)	0.051*** (3.49)
NWC	-0.105*** (-7.40)	-0.106*** (-7.41)	-0.108*** (-7.64)
CAPEX	-0.300*** (-5.91)	-0.311*** (-6.38)	-0.332*** (-6.87)
ACQ	-0.364*** (-10.65)	-0.367*** (-10.44)	-0.353*** (-10.65)
DIV_DUM	-0.039*** (-6.34)	-0.038*** (-6.17)	-0.039*** (-6.34)
INDUSTRY_SIGMA	0.121** (2.23)	0.215*** (3.61)	0.211*** (3.53)
GDP_PERCAPITA		-0.000 (-0.92)	-0.000 (-0.20)
PRIVATECREDIT_GDP		-0.000 (-1.12)	-0.000 (-0.84)
CPI		-0.081 (-1.38)	-0.054 (-0.97)
STOCKMARKET_CAP		-0.000 (-1.22)	-0.000 (-0.27)
CONSTANT	0.273*** (18.53)	0.387*** (6.85)	0.369** (2.44)
OBSERVATIONS	25,755	24,948	24,948
ADJUSTED R-SQUARED	0.416	0.418	0.426
YEAR FE	Yes	Yes	Yes
INDUSTRY FE	Yes	Yes	Yes
COUNTRY (of CSTMR) FE	Yes	Yes	Yes
COUNTRY (of FIRMS) FE	No	No	Yes
FIRM CLUSTERING	Yes	Yes	Yes

This table presents results for TREND at customers' geographic end (CSTMR_TREND) rather than firms' end as key independent variable since businesses are run on customers' need and ultimate products/services need to be supplied at customers' geographic locations. The dependent variable for models (1), (2), and (3) is CASH (sum of cash and marketable securities scaled by total asset). We follow Bates et al. (2009) to set control variables in model (1). Models (2), and (3) include several country-level macroeconomic factors (from firms' country) as additional controls to model (1). However, the sample is limited (based on the availability at COMPUSTAT Capital IQ Customer Segmentation database). All variables are defined in Appendix-Table-1 (A1). While models (1), and (2) consider year fixed effects, industry (two-digit SIC) fixed effects, and country (of customers) fixed effects, model (3) additionally considers country (of firms) fixed effects. The standard errors are clustered by firms. We report t-statistics in the parenthesis. ***, **, and * indicate statistical significance at 1%, 5%, and 10% respectively.

Table 8: Placebo test using propensity score match

VARIABLES	Q1 and Q4		Q12 and Q34	
	(1) CASH	(2) CASH	(3) CASH	(4) CASH
PLACEBO_TREND	0.001 (0.30)	-0.001 (-0.39)	0.002 (0.94)	-0.001 (-0.35)
SIZE	-0.004*** (-12.30)	-0.005*** (-12.61)	-0.004*** (-13.16)	-0.005*** (-13.46)
MB	0.004*** (12.06)	0.003*** (10.57)	0.004*** (15.50)	0.004*** (13.76)
LEV	-0.310*** (-84.04)	-0.309*** (-83.26)	-0.311*** (-92.89)	-0.311*** (-91.84)
RD	0.479*** (34.81)	0.488*** (35.00)	0.460*** (37.35)	0.471*** (37.61)
CASH_FLOW	-0.012*** (-3.88)	-0.008** (-2.53)	-0.011*** (-4.04)	-0.006** (-2.23)
NWC	-0.092*** (-27.73)	-0.094*** (-28.19)	-0.087*** (-30.38)	-0.090*** (-30.98)
CAPEX	-0.182*** (-28.68)	-0.184*** (-28.43)	-0.203*** (-35.44)	-0.197*** (-33.85)
ACQ	-0.280*** (-27.20)	-0.290*** (-27.87)	-0.286*** (-33.90)	-0.291*** (-34.02)
DIV_DUM	-0.013*** (-10.45)	-0.013*** (-10.31)	-0.013*** (-11.52)	-0.013*** (-11.38)
INDUSTRY_SIGMA	0.311*** (17.97)	0.325*** (17.89)	0.322*** (21.28)	0.317*** (20.18)
GDP_PERCAPITA		0.000*** (3.74)		0.000*** (6.33)
PRIVATECREDIT_GDP		0.000 (0.23)		0.000*** (3.01)
CPI		-0.026*** (-4.38)		-0.025*** (-4.58)
STOCKMARKET_CAP		0.000*** (11.87)		0.000*** (11.43)
CONSTANT	0.240*** (71.78)	0.195*** (15.82)	0.239*** (78.22)	0.168*** (15.17)
OBSERVATIONS	191,832	188,366	384,966	373,344
ADJUSTED R-SQUARED	0.347	0.350	0.337	0.340
YEAR FE	Yes	Yes	Yes	Yes
INDUSTRY FE	Yes	Yes	Yes	Yes
COUNTRY FE	Yes	Yes	Yes	Yes
FIRM CLUSTERING	Yes	Yes	Yes	Yes

This table presents placebo test results using propensity score match technique. The dependent variable is CASH (sum of cash and marketable securities scaled by total asset). The key independent variable (TREND) comes from the opposite group of propensity score matched sample. While matching, we also care for industry along with the usual controls in Bates et al. (2009). Regarding sample size: models (1), and (2) cover first and fourth quartiles (Q1 and Q4), while models (3), and (4) cover lower-median (Q12) and upper-median (Q34) of country-wise TREND from matched opposite group. We follow Bates et al. (2009) to set control variables in models (1) and (3). Models (2) and (4) include several country-level macroeconomic factors as additional controls to models (1) and (3). All variables are defined in Appendix-Table-1 (A1). Every model considers year fixed effects, industry (two-digit SIC) fixed effects, and country fixed effects. The standard errors are clustered by firms. We report t-statistics in the parenthesis. ***, **, and * indicate statistical significance at 1%, 5%, and 10% respectively.

Table 9: Subsample: financially constrained vs. unconstrained firms (Base Model)

VARIABLES	KZ Index		WW Index		SA Index	
	Constrained ΔCASH	Unconstrained ΔCASH	Constrained ΔCASH	Unconstrained ΔCASH	Constrained ΔCASH	Unconstrained ΔCASH
TREND	18.603*** (3.07)	0.249 (0.71)	36.577*** (3.29)	-0.003 (-0.20)	1.422* (1.93)	-0.071 (-0.20)
SIZE	0.023 (0.33)	0.039** (2.06)	-0.909*** (-5.55)	-0.000* (-1.72)	-0.012 (-0.35)	0.179*** (2.81)
MB	-0.237*** (-4.80)	-0.166 (-0.94)	-0.370*** (-3.20)	-0.002 (-0.83)	-0.095*** (-3.04)	-0.091 (-1.36)
LEV	1.477** (2.31)	0.099 (0.54)	1.374*** (4.03)	-0.015*** (-6.53)	1.610*** (2.58)	-0.201 (-1.59)
RD	2.989** (2.13)	1.560 (0.97)	0.893 (1.64)	-0.018 (-1.02)	2.151** (2.30)	-1.047 (-1.48)
CASH_FLOW	-0.022 (-0.06)	1.277 (1.46)	0.401 (1.42)	0.132*** (8.48)	0.883*** (4.76)	-0.020 (-0.08)
NWC	0.223 (0.73)	-0.110 (-1.12)	0.048 (0.25)	-0.036*** (-15.82)	0.531* (1.95)	0.147 (1.20)
CAPEX	-2.069 (-1.15)	-1.315 (-1.03)	-1.647 (-1.00)	-0.116*** (-10.12)	-2.099 (-1.41)	-1.240 (-1.48)
ACQ	1.066** (2.10)	-0.758*** (-6.06)	3.485*** (3.07)	-0.180*** (-15.30)	-0.544* (-1.92)	0.299 (1.42)
DIV_DUM	-0.349 (-1.35)	-0.072 (-1.03)	-2.673*** (-5.13)	0.006*** (4.42)	-0.290* (-1.70)	-0.299*** (-2.66)
INDUSTRY_SIGMA	-1.820 (-0.85)	0.261 (0.68)	-5.957*** (-3.17)	0.003 (0.29)	-0.678 (-0.67)	0.754** (2.28)
GDP_PERCAPITA	-0.001*** (-5.50)	-0.000 (-0.93)	-0.002*** (-6.36)	-0.000*** (-6.10)	-0.000*** (-3.02)	-0.000*** (-4.21)
PRIVATECREDIT_GDP	-0.018* (-1.70)	0.002 (1.08)	-0.077*** (-2.78)	0.000** (2.25)	0.002 (0.99)	0.006** (2.18)
CPI	10.665*** (2.99)	-0.084** (-2.18)	68.716*** (3.44)	-0.037*** (-5.91)	0.093 (0.14)	0.744 (1.07)
STOCKMARKET_CAP	-0.002 (-1.14)	-0.001 (-0.83)	-0.025*** (-2.93)	0.000*** (3.99)	-0.004** (-2.10)	-0.000 (-0.44)
CONSTANT	11.234*** (6.33)	1.011 (1.08)	51.509*** (6.09)	0.076*** (10.68)	12.542*** (3.07)	2.645*** (3.55)
OBSERVATIONS	95,846	94,886	86,754	94,407	84,005	108,090
ADJUSTED R-SQUARED	0.019	0.006	0.112	0.028	0.011	0.014
YEAR FE	Yes	Yes	Yes	Yes	Yes	Yes
INDUSTRY FE	Yes	Yes	Yes	Yes	Yes	Yes
COUNTRY FE	Yes	Yes	Yes	Yes	Yes	Yes
FIRM CLUSTERING	Yes	Yes	Yes	Yes	Yes	Yes

DIFF. IN COEFFICIENTS: 9.17 (0.0025) 11.48 (0.0007) 3.33 (0.0681)
 χ^2 (P-VALUE)

This table presents subsample analysis results for financially constrained vs. unconstrained firms differentiated through three popular measures: Kaplan-Zingales (KZ) index (1997), Whited and Wu (WW) Index (2006), and Hadlock and Pierce (SA) Index (2010). The dependent variable is ΔCASH (change in cash scaled by total asset). For the model set-up we largely follow Bates et al. (2009). Since our study is global, we additionally control for a set of country-specific macroeconomic factors. Every model considers year fixed effects, industry (two-digit SIC) fixed effects, and country fixed effects. The standard errors are clustered by firms. We report t-statistics in the parenthesis. ***, **, and * indicate statistical significance at 1%, 5%, and 10% respectively.

Table 10: Subsample: financially constrained vs. unconstrained firms (Almeida et al., 2004 Model)

VARIABLES	<u>KZ Index</u>		<u>WW Index</u>		<u>SA Index</u>	
	Constrained Δ CASH	Unconstrained Δ CASH	Constrained Δ CASH	Unconstrained Δ CASH	Constrained Δ CASH	Unconstrained Δ CASH
TREND	12.626** (2.57)	0.308 (0.84)	23.797*** (2.63)	0.004 (0.40)	1.601** (2.09)	0.297 (1.21)
CASH_FLOW_SEN	0.018 (0.84)	0.454*** (6.61)	0.181** (2.01)	0.030 (1.32)	0.028 (0.98)	0.067 (1.28)
TOBINQ	-0.026*** (-3.02)	-0.105 (-0.89)	-0.049 (-1.30)	-0.000 (-0.57)	-0.020 (-1.61)	-0.002 (-0.45)
SIZE	-0.074 (-1.43)	0.003 (0.26)	-0.583*** (-4.41)	-0.000 (-0.64)	-0.086 (-1.23)	0.069* (1.73)
CAPEX	-0.134 (-0.10)	0.192 (0.53)	-0.661 (-0.48)	-0.109*** (-9.16)	-0.370 (-0.39)	-1.038 (-1.22)
ACQ	0.781* (1.80)	-0.841*** (-3.87)	2.680*** (2.87)	-0.216*** (-13.15)	0.107 (0.29)	-0.378*** (-2.64)
DELTA_NWC	0.355** (2.32)	0.729 (0.90)	0.132 (0.78)	-108.001*** (-3.47)	0.376** (2.42)	170.301*** (3.15)
DELTA_ST_DEBT	0.121*** (3.92)	1.296 (1.34)	0.117*** (3.49)	0.118*** (2.93)	0.070** (2.41)	0.516*** (4.92)
GDP_PERCAPITA	-0.000*** (-3.21)	-0.000* (-1.81)	-0.002*** (-4.83)	-0.000*** (-6.29)	-0.000*** (-2.80)	-0.000** (-2.13)
PRIVATECREDIT_GDP	-0.016* (-1.76)	0.003** (2.08)	-0.047** (-2.06)	0.000* (1.90)	-0.000 (-0.05)	-0.001 (-0.48)
CPI	7.489** (2.54)	0.016 (0.25)	46.185*** (2.72)	-0.040*** (-7.18)	0.182 (0.27)	0.552 (1.17)
STOCKMARKET_CAP	-0.003** (-2.37)	0.000 (0.03)	-0.015** (-2.46)	0.000*** (4.48)	-0.005*** (-2.84)	-0.000 (-0.89)
CONSTANT	5.888*** (3.42)	1.178* (1.74)	36.174*** (4.44)	0.085*** (10.22)	12.383*** (2.98)	0.118 (0.22)
OBSERVATIONS	95,848	94,886	88,759	93,192	84,005	108,090
ADJUSTED R-SQUARED	0.241	0.430	0.222	0.112	0.179	0.387
YEAR FE	Yes	Yes	Yes	Yes	Yes	Yes
INDUSTRY FE	Yes	Yes	Yes	Yes	Yes	Yes
COUNTRY FE	Yes	Yes	Yes	Yes	Yes	Yes
FIRM CLUSTERING	Yes	Yes	Yes	Yes	Yes	Yes
DIFF. IN COEFFICIENTS: χ^2 (P-VALUE)	6.27 (0.0123)		6.95 (0.0084)		2.62 (0.1055)	

This table presents subsample analysis results for financially constrained vs. unconstrained firms differentiated through three popular measures: Kaplan-Zingales (KZ) index (1997), Whited and Wu (WW) Index (2006), and Hadlock and Pierce (SA) Index (2010). The dependent variable is Δ CASH (change in cash scaled by total asset). For the model set-up we largely follow Almeida et al. (2004). Since our study is global, we additionally control for a set of country-specific macroeconomic factors. Every model considers year fixed effects, industry (two-digit SIC) fixed effects, and country fixed effects. The standard errors are clustered by firms. We report t-statistics in the parenthesis. ***, **, and * indicate statistical significance at 1%, 5%, and 10% respectively.

Table 11: Subsample: cash shortfall vs. excess cash (Base Model)

VARIABLES	Cash Shortfall		Excess Cash	
	(1) ΔCASH	(2) ΔCASH	(3) ΔCASH	(4) ΔCASH
TREND	2.536** (2.51)	7.068*** (3.27)	1.234 (0.55)	3.847 (1.15)
SIZE	-0.022 (-1.19)	0.001 (0.05)	0.113** (2.00)	0.132** (2.28)
MB	-0.267*** (-4.10)	-0.218*** (-4.75)	-0.247** (-2.38)	-0.237** (-2.16)
LEV	0.241 (0.71)	0.370 (1.22)	0.855** (2.30)	0.759** (2.00)
RD	2.944* (1.85)	1.639* (1.88)	2.430** (2.14)	2.213* (1.80)
CASH_FLOW	0.368 (0.89)	0.033 (0.12)	0.566 (1.25)	0.460 (0.90)
NWC	-0.261* (-1.69)	-0.262* (-1.67)	0.580 (1.61)	0.474 (1.30)
CAPEX	-0.640 (-0.68)	-0.859 (-0.85)	-1.332 (-1.41)	-1.061 (-1.05)
ACQ	-0.120 (-0.71)	-0.095 (-0.50)	-0.600 (-1.43)	-0.423 (-0.96)
DIV_DUM	0.075 (1.14)	0.101 (1.55)	-0.277 (-1.53)	-0.256 (-1.30)
INDUSTRY_SIGMA	-2.929** (-2.14)	-1.062* (-1.90)	-0.413 (-0.22)	0.246 (0.13)
GDP_PERCAPITA		-0.000*** (-5.43)		-0.000*** (-4.37)
PRIVATECREDIT_GDP		-0.005 (-1.21)		0.010 (1.26)
CPI		4.080*** (2.77)		3.040 (1.16)
STOCKMARKET_CAP		-0.004*** (-3.97)		-0.000 (-0.08)
CONSTANT	0.573** (2.21)	7.203*** (6.41)	-0.718* (-1.83)	8.037*** (5.08)
OBSERVATIONS	194,047	186,910	133,214	130,254
ADJUSTED R-SQUARED	0.008	0.018	0.015	0.016
YEAR FE	Yes	Yes	Yes	Yes
INDUSTRY FE	Yes	Yes	Yes	Yes
COUNTRY FE	Yes	Yes	Yes	Yes
FIRM CLUSTERING	Yes	Yes	Yes	Yes

DIFF IN COEFFS (MODELS (2) AND (4)):

0.64 (0.4243)

 χ^2 (P-VALUE)

This table presents subsample analysis results for *Cash Shortfall* vs. *Excess Cash*. We determine the two sub-groups (*Cash Shortfall* and *Excess Cash*) based on the predicted value (of *CASH*) following Bates et al. (2009). If the actual level of *CASH* of an observation is smaller (larger) than the predicted value, it falls into the *Cash Shortfall* (*Excess Cash*) sub-group. The dependent variable is ΔCASH (change in cash scaled by total asset). Since our study is global, in addition to models (1), and (3), we control for a set of country-specific macroeconomic factors in models (2), and (4). Every model considers year fixed effects, industry (two-digit SIC) fixed effects, and country fixed effects. The standard errors are clustered by firms. We report t-statistics in the parenthesis. ***, **, and * indicate statistical significance at 1%, 5%, and 10% respectively.

Table 12: Subsample: cash shortfall vs. excess cash (Almeida et al., 2004 Model)

VARIABLES	Cash Shortfall		Excess Cash	
	(1) $\Delta CASH$	(2) $\Delta CASH$	(3) $\Delta CASH$	(4) $\Delta CASH$
TREND	1.353** (2.00)	4.193*** (2.60)	1.740 (0.96)	3.480 (1.49)
CASH_FLOW_SEN	0.024 (0.89)	0.027 (0.94)	0.027 (0.34)	0.081 (0.50)
TOBINQ	-0.028*** (-2.83)	-0.023*** (-2.69)	-0.029* (-1.72)	-0.026 (-1.30)
SIZE	-0.025 (-1.26)	-0.029* (-1.74)	0.080 (1.53)	0.048 (0.96)
CAPEX	0.048 (0.08)	-0.235 (-0.40)	-0.054 (-0.05)	1.002 (0.92)
ACQ	-0.151 (-1.29)	-0.166 (-1.32)	-0.121 (-0.28)	-0.066 (-0.14)
DELTA_NWC	0.484** (2.40)	0.410** (1.97)	0.184 (0.95)	0.252 (1.26)
DELTA_ST_DEBT	0.096*** (4.05)	0.099*** (4.09)	0.221** (2.32)	0.374*** (3.34)
GDP_PERCAPITA		-0.000*** (-3.49)		-0.000*** (-4.25)
PRIVATECREDIT_GDP		-0.003 (-1.00)		0.006 (0.85)
CPI		2.333** (2.12)		2.652 (1.42)
STOCKMARKET_CAP		-0.003*** (-3.47)		-0.001* (-1.71)
CONSTANT	0.145 (0.98)	4.217*** (4.10)	-0.773** (-2.06)	4.731*** (4.08)
OBSERVATIONS	194,047	186,910	133,214	130,254
ADJUSTED R-SQUARED	0.149	0.330	0.144	0.213
YEAR FE	Yes	Yes	Yes	Yes
INDUSTRY FE	Yes	Yes	Yes	Yes
COUNTRY FE	Yes	Yes	Yes	Yes
FIRM CLUSTERING	Yes	Yes	Yes	Yes
DIFF IN COEFFS (MODELS (2) AND (4)): χ^2 (P-VALUE)		0.01 (0.9266)		

This table presents subsample analysis results for *Cash Shortfall* vs. *Excess Cash*. We determine the two sub-groups (*Cash Shortfall* and *Excess Cash*) based on the predicted value (of *CASH*) following Bates et al. (2009). If the actual level of *CASH* of an observation is smaller (larger) than the predicted value, it falls into the *Cash Shortfall* (*Excess Cash*) sub-group. The dependent variable is $\Delta CASH$ (change in cash scaled by total asset). For the model set-up we largely follow Almeida et al. (2004). Since our study is global, in addition to models (1), and (3), we control for a set of country-specific macroeconomic factors in models (2), and (4). Every model considers year fixed effects, industry (two-digit SIC) fixed effects, and country fixed effects. The standard errors are clustered by firms. We report t-statistics in the parenthesis. ***, **, and * indicate statistical significance at 1%, 5%, and 10% respectively.

Table A1: Variable description

Dependent Variables	
CASH	Cash scaled by total assets. Source: Compustat
FCASH	Lead (forward) value of CASH. Source: Compustat
ΔCASH	Change in cash scaled by total assets. Source: Compustat
Key Independent Variable	
TREND	Yearly average of time-coefficient (times -1,000) from an augmented AR(1) model using country-level monthly frequency historical Palmer Drought Severity Index (PDSI) data extending back to 1900 from a point of time following Hong et al. (2019). Source: NOAA's NCDC
Control Variables	
SIZE	Natural logarithm of the deflated total assets [$\log(at/cpi)$]. We use the exchange rate data available in the Compustat Global database to convert a firm's total asset to U.S. dollars.
MB (TOBINQ)	Market to book ratio is the ratio of total assets plus market value of equity minus book value of equity scaled by total assets. Source: Compustat
LEV	Total debt over total assets. Source: Compustat
RD	Ratio of Research and Development expenditure over the sales. We replace missing values of R&D expenditure by zeros. Source: Compustat
CASH_FLOW	Earnings before interest and taxes, but before depreciation and amortization, less interest, taxes, and common dividends, over total assets. Source: Compustat
NWC	Net working capital minus cash over total assets. Source: Compustat
CAPEX	Capital expenditures over total assets. Source: Compustat
ACQ	Acquisitions over total assets. Source: Compustat
DIV_DUM	An indicator variable that is equal to one if common dividends are non-zero. We replace the missing values of dividends by zero. Source: Compustat
CASH_FLOW_SEN	Sum of cash income before extraordinary items (ibc), plus depreciation and amortization (dp), minus common dividends (dvc) over total assets (at). Source: Compustat
INDUSTRY_SIGMA	Mean of the standard deviation of the cash flows over the past 10 years by year and two-digit industry (SIC) code. Source: Compustat
GDP_PERCAPITA	Gross Development Product per capita. Source: World Bank
PRIVATECREDIT_GDP	Private credit by deposit money banks and other financial institutions to GDP. Source: World Bank
CPI	Consumer Price Index. Source: U.S. Bureau of Labor Statistics
STOCKMARKET_CAP	Stock market capitalization to GDP. Source: World Bank

Figure 1: Corporate cash holding following the Stern Review (2006)

This figure presents the difference in corporate cash holding following the Stern Review (2006). The group-1 (red line) takes the value of 1 if the observation belongs to the subsample with highest climate risk exposure quartile (Q1) and zero otherwise (blue line). We use the residual values to plot the graph.