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How Do Firms Cope with Losses from Extreme Weather Events?*

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Abstract

We document the investment and financing decisions of firms that experience monetary losses due to extreme weather events. Our sample covers firms operating in 41 economies, mainly emerging and developing markets. Consistent with the need to either replenish damaged capital or to adapt to climate change, firms hit by extreme weather are more likely to invest in long-term assets. In addition, they are more likely to integrate climate-friendly measures in their production processes. Although these firms have higher needs for bank credit, they are not more likely to be credit constrained than the average firm. Nonetheless, they face higher loan rejection rates and they are more leveraged than otherwise comparable firms. This suggests that climate change has the potential to erode the quality of firm balance sheets over time.

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1 Introduction

In a warming climate, weather extremes are becoming more frequent and severe. In its sixth assessment report, the Intergovernmental Panel for Climate Change (IPCC) considers it an established fact that greenhouse gas emissions have "led to an increased frequency and/or intensity of some weather and climate extremes since pre-industrial times" (IPCC, 2021).[1] The IPCC expects these trends to continue as the global average temperatures increases further (IPCC, 2021). The evidence is not limited to extreme heat but also concerns heavy rainfall, floods, storms and droughts. Extreme weather events have already exacted a heavy toll in recent decades, with the World Meteorological Organization attributing 2 million deaths and USD 3.6 trillion in losses to extreme weather events from 1970-2019 (WMO, 2021).

In this paper, we use comprehensive firm-level data to examine how firms cope with realizations of acute physical climate risk.[2] Specifically, we study how both investment and financing decisions relate to realizations of losses from extreme weather events, such as storms, foods, droughts or landslides. Our measure of losses due to extreme weather events comes from the 2019 wave of the EBRD-EIB-World Bank Enterprise Survey. The survey provides representative samples of the formal private sector of 41 countries in Central, Eastern and South-Eastern Europe, Central Asia, and the Middle East and North Africa. Crucially for our study, the 2019 wave includes the so-called Green Economy module, which has detailed questions one the relationship between the company and the environment. This enables us to identify firms that experience monetary losses from extreme weather. The focus on losses from extreme weather implies that we do not quantify the effects of extreme weather per se; however, the subset of firms that experience weather-induced losses is of particular interest from an economic perspective.

Our paper studies both the investment response and the financing decisions of firms suffering losses from extreme weather. The challenge that the empirical strategy needs to address comes from omitted variable bias. We alleviate this concern by saturating our model with country-industry-firm size fixed effects to absorb unobservables common to all firms located in the same country, that operate in the same business sector and that are of the same size category.[3]

Everything else equal, we find that firms suffering losses from extreme weather exhibit a 6 percentage point greater propensity to invest. The result is statistically and economically significant, as it corresponds to 15 percent of the sample mean. We also examine the intensive margin of investments in fixed assets and we find that investments per worker conditional on investing are approximately 25 percent

[1] While weather can be viewed as a draw from the climate distribution (Dell et al., 2014), extreme weather events are draws from the tail of the climate distribution. In general, climate change can be conceptualized as a shift in the location but also the variability of the climate distribution.

[2] Climate change affects economic activity through transition risks and physical risks. While the former refers to regulatory changes implemented to help the transition to a low carbon economy, the latter refers to risks induced by changes in average temperature over a longer time horizon (chronic risks) or risks induced by realizations of weather extremes (acute risks) (Ginglinger, 2020; EIB, 2021).

[3] This methodology has been proposed by Degryse et al. (2019) in the banking literature to absorb credit demand and estimate credit supply effects.

higher for firms experiencing losses due to extreme weather events. Two plausible mechanisms could be at play. Firms may seek to replenish their capital stock. However, it can also be that firms engage in adaptation investment to guard against future realizations of climate risk.

In a second stage, we study firms' propensity to increase investments in measures that decrease the establishment's footprint. We provide evidence that firms suffering losses from extreme weather display an 12 percentage point greater likelihood of adopting climate-friendly measures. Prima facie, this can be due to vintage effects: As the firm replenishes its capital stock, it installs more modern equipment that has a lower environmental footprint. Nonetheless, we also provide an alternative explanation whereby firms' increase green investments as a response to higher environmental awareness. The data suggest that firms exposed to climate risks can be more aware of the risks embedded in climate change, thus making them keener on adopting environmentally friendly modes of production.

Regarding the liability side of the balance sheet, we document that firms suffering from losses due to weather extremes are 12 percentage points more likely to need bank credit. Conditional on needing a loan, they are not more likely to be credit constrained than other firms. This is the result of two forces that partially offset each other. On the one hand, firms experiencing weather-related losses are 9 percentage points less likely to be discouraged from applying for a bank loan. On the other hand, they are 5 percentage points more likely to have their loan application rejected, suggesting that banks assess them as on average less creditworthy. We also find evidence that firms suffering losses from extreme weather are more levered than otherwise comparable firms. This holds after taking into account equity injections and government assistance. Overall, our findings suggest that climate change has the potential to erode the quality of firm balance sheets over time.

Finally, we investigate how our findings vary with firm size and managerial characteristics. We document that SMEs are more vulnerable to losses from extreme weather than large firms. Specifically, SMEs exhibit a comparatively weaker investment response than large firms. We also document that the on average greater need for bank credit following weather-related losses is concentrated in the SME segment. It may well be that large firms are geographically more diversified, and that the scale of weather related losses is smaller relative to overall company size. We also find evidence that old managers are reluctant to invest in green assets. This result is consistent with earlier work showing that older executives tend to be more risk-adverse, more conservative in their business strategy, and more reluctant to invest in new technologies (Barker III and Mueller, 2002; Kaplan et al., 2012; Huang and Kisgen, 2013; Faccio et al., 2016).

We also run a battery of robustness tests. First, we compare the behaviour of firms suffering weather-related losses to firms experiencing a negative liquidity shock due to bribe requests. This is akin to a placebo treatment as bribe payments drain company resources but typically do not involve the destruction

of physical capital. Second, we control for the quality of management at the individual firm. In addition, we use the longitudinal component of the Enterprise Survey and apply a falsification test to the 2013 sample —thus prior to the realisation of the extreme weather event— to assess whether incurring a weather related loss is correlated with unobserved firm-level characteristics. Our results are robust to all sensitivity tests.

Our paper contributes to the growing literature on climate finance. Climate finance studies how companies, banks, and investors respond to the realization of climate risks (Ginglinger, 2020; Furukawa et al., 2020; Giglio et al., 2020; Hong et al., 2020.). Our contribution to the existing literature is threefold.

First, our paper extends earlier work on realizations of physical climate risks showing that extreme weather events affect firm financing (Huang et al., 2018; Ginglinger and Moreau, 2019; Brown et al., 2020) and organizational structure (Bergmann et al., 2016). Indeed, while existing work has documented the growth effects of natural disasters (Cavallo et al., 2013, Felbermayr and Gröschl, 2014), we focus on the investment and financing strategies of firms experiencing losses from extreme weather events. Ginglinger and Moreau (2019) rely on a sample of firms included in the MSCI World Index —thus listed firms— to show that increasing climate risk reduces firm's debt ratios in the post-2015 period. We complement these findings by providing direct micro evidence on how the incidence of physical climate risks affects the assets and liabilities of predominantly unlisted firms operating in emerging and developing economies, many of which are SMEs.

Second, our paper contributes to the understanding of how firms cope with losses from realizations of physical climate risks by studying the investments in green measures. Earlier evidence finds that people learn and adapt only after weather extremes have materialized (Miao and Popp, 2014). De Haas et al. (2021) shows that low-quality firm management and credit constraints inhibit green investments. Our findings show that firms cope with losses from extreme weather by increasing expenditure in fixed assets and making their production processes greener. Moreover, we also document that the likelihood of investing in green measures is lower for firms suffering from losses due to weather extremes and having older managers, suggesting that older managers are less keen on investing in green measures. These results complement those by De Haas et al. (2021).

Finally, we examine the dynamics in the market for bank credit in the extreme weather post-event (Cortés, 2014; Cortés and Strahan, 2017; Koetter et al., 2020; Brown et al., 2020). Huang et al. (2018) shows that an increase in countries' physical climate risk influences the financing choices of publicly listed firms, whereby firms located in countries characterized by more extreme weather are more likely to hold cash and to have a negative financial performance.[4] Exploiting the exogenous variation of firms'

[4]Dessaint and Matray (2017) find similar results. The authors examine how managers of firms located in the neighbourhood of a disaster area take decisions. They find that firms increase corporate cash holdings only temporarily, as a response to perceived risk.

exposure to economic damage due to flooding of the River Elbe in Germany in 2013, Koetter et al. (2020) find that banks operating more globally, and not only locally, provide corporate recovery lending to firms affected by natural disasters. Brown et al. (2020) show that firms affected by unexpected winter weather draw on and increase the size of their credit lines, whilst banks charge borrowers for this liquidity via higher interest rates and less borrower-friendly loan provisions. Our findings complement the existing literature providing further evidence on access to credit in relationship to an extreme weather event.

The remainder of this paper is organized as follows. Section 2 describes the data and provides descriptive statistics of the sample. Section 3 lays out the empirical strategy. Section 4 presents a discussion of the results. Section 5 is dedicated to robustness checks. Section 6 concludes.

2 Data

Our data come from the 2019 wave of the Enterprise Surveys, implemented jointly by the European Investment Bank (EIB), the European Bank for Reconstruction and Development (EBRD) and the World Bank Group (WBG). The survey round covers 28,162 firms in 41 economies in Central, Eastern, South-East Europe, Central Asia, the Middle East, and North Africa., predominantly emerging and developing economies. The Enterprise Survey covers a representative sample of an economy's formal private sector. It includes a broad range of business environment topics, notably access to finance, corruption, infrastructure, crime, competition, investment decisions as well as firm performance. Enterprise Surveys involve face-to-face interviews with business owners and top managers and are designed to represent the business environment as experienced by firms. The samples are stratified by size, sector, and geography. Large firms are over-sampled to allow for inference at a reasonable sample size.[5] As the sampling probability differs across firms, we use sampling weights at every step of the analysis. We drop firm-level observations for which responses have been judged to be somewhat untruthful or completely untruthful, and for which we have missing information on the firm's geographic coordinates. This leaves us with 24,086 firms. Table 1 contains all variable definitions; Table 2 reports survey-weighted summary statistics.

2.1 Losses from extreme weather events

The last wave of the Enterprise Survey includes also a Green Economy Module. The Green Economy Module contains unique information on a firm's environmental footprint. More than 50 questions cover management practices related to the environment, the firm's compliance with environmental policy and regulation, as well as the firm's exposure to physical climate risk. Our explanatory variable of interest is given by an indicator equal to one if the firm responds affirmatively to survey question BMGB1: 'Over

[5]For more details, see https://www.enterprisesurveys.org/en/methodology.

the last three years, did this establishment experience monetary losses due to extreme weather events (such as storms, floods, droughts, or landslides)?' We refer to this variable as *Extreme weather loss*. It is important to note that the variable does not pick up exposure to extreme weather per se; instead, it captures the economic consequences of being exposed to an extreme weather event. The survey does not have information on the size of weather related losses, which limits the subsequent analysis to the extensive margin.

Physical climate risk is real. Table 2 shows that 9.3 percent of the surveyed firms experienced a monetary loss from extreme weather in the three years preceding the interview. Figure 2 shows that the percentage of firms experiencing weather-related losses varies widely across countries. Countries in South and South Eastern Europe have the highest share of firms with losses from extreme weather.

Losses from extreme weather are not distributed uniformly in space. Figure 1 displays the location of the firms in our sample. Firms with weather-related losses are highlighted in red, whereas the firms without losses are shown in grey. Figure 4 provides evidence on the spatial correlation of extreme weather losses. The left-hand-side plot presents the percentage of firms experiencing weather related losses conditional on the distance to a firm that is experiencing no such losses. The right-hand-side plot presents corresponding evidence in the vicinity of firm that do experience weather-related losses. The likelihood to experience weather-related losses for a firm located within 10km radius of a firm with weather-related losses are almost twice as high as that of a firm within 10km of a firm without such losses. The difference declines with distance, but does not vanish even at a distance of 100km.

The incidence of weather related losses varies with firm size and across business sectors. Figure 3 reports a breakdown of the percentage of firms suffering from losses due to extreme weather events conditional on size and business sector. Small firms are less likely to report monetary losses due to extreme weather than medium and large companies. Across sectors, construction firms are most likely to suffer losses from extreme weather events, followed by firms operating in the hotel or restaurant business.

2.2 Corporate investment

The 2019 wave of the Enterprise Surveys measures investment activities along several dimensions. First, firms are asked whether they invested in physical capital either by purchasing any new or used *Fixed assets*, by spending on the expansion or renovation of existing *Land and buildings*, or by acquiring used or new *Machinery and equipment*. The question refers to either purchases in the last complete fiscal year or purchases in the fiscal year prior to the last one. Table 2 reports that almost 39 percent of firms purchased new or used fixed assets in the fiscal year of reference. While only 10.6 percent of the surveyed firms spent money on land or buildings, 38 percent of firms invested in machinery and equipment. These investments are not mutually exclusive whereby some firms might have invested in

Machinery and equipment as well as *Land and buildings*. The Enterprise Surveys also collect information on the intensive margin of long-term investments for those firms that made any fixed assets purchases.

The Green Economy Module asks whether in the last three years firms adopted measures that make production processes more climate and environmentally friendly. The list of measures includes on-site generation of green energy and measures to control air pollution, but also improvements in both energy and water management, as well as measures to improve energy efficiency.[6] We follow De Haas et al. (2021) in defining *Green measures* as an indicator equal to one if the firm implemented at least one eco-friendly measure in the last three years. As Table 2 shows, this applies to 64.4 percent of firms in the sample.[7] In addition, the Green Economy Module asks whether firms have monitored their CO_2 emissions over the last three years. As Table 2 shows, this applies to 4 percent of firms.

2.3 Access to credit

The Enterprise Surveys contain a detailed set of questions to measure a firm's ability to access finance. For the purpose of studying firms' access to credit, we use the information on the firm's most recent experience when applying for a loan. To define credit constrained firms, we follow standard studies that rely on detailed questions as in the Enterprise Surveys (Cox and Jappelli, 1993; Popov and Udell, 2012; Gorodnichenko and Schnitzer, 2013; Ongena et al., 2013). First, we identify firms that desire bank loans with the variable *Need loan*. Formally, we start from the survey question K16: "Did the establishment apply for any loans or lines of credit in the last fiscal year?" For firms that answered "No", we move to question K17: "What was the main reason the establishment did not apply for any line of credit or loan in the last fiscal year?" We define all firms that answered to this question "No need for a loan - establishment had sufficient capital" or that did not apply for a loan as not desiring bank credit. For the subset of firms that need a loan, we classify as credit constrained firms that are discouraged from applying for a loan, or that have their loan application rejected. Specifically, we define the variable *Rejected* for all firms that replied "Yes" to question K16 and "Application was rejected" to question K20, and the variable *Discouraged* for all firms that answered "No" to question K16 and either "Interest rates are not favorable"; "Collateral requirements are too high"; "Size of loan and maturity are insufficient"; or "Did not think it would be approved" to question K17. In total, 42 percent of firms in our sample desire bank credit, and among these firms 48 percent are credit constrained. The vast majority of credit constrained firms is discouraged from applying for a loan whereas only 4 percent have their loan application rejected.

[6] Table 1 lists the eight items included in the questionnaire.

[7] At first glance, this may seem high in comparison to the percentage of firms engaging in capital expenditure. In this context, it is important to note that some of the measures, such as improved waste management, may not be capital intensive. Moreover, the question on *Green measures* covers a three year period, whereas the one on capital expenditure refers to the last financial year only.

3 Empirical strategy

The first part of our analysis explores the association between losses due to extreme weather events and corporate investments. The second part investigates firm's access to credit. To this end, we estimate the following linear probability (OLS) model:

$$y_{isc} = \beta_0 + \beta_1 \text{Extreme weather loss}_{isc} + \beta_2 \mathbf{X}_{isc} + \gamma_{sck} + \varepsilon_{isc} \quad (1)$$

where the dependent variable y_{isc} denotes one of the outcome variables we consider to study the association between losses due to extreme weather events and firms' investments and financing decisions. Specifically, to study corporate investments, we consider i) investment in fixed assets in fiscal year t, ii) investment in land and buildings, iii) investment in machinery and equipment, iv) investment in fixed assets in fiscal year t or t-1, and v) the intensive margin of investment in fixed assets as measured by logarithm of investment scaled by the number of employees. This variable is defined only for the subset of firms that did invest in the last financial year. In the analysis of access to credit, the dependent variable y_{isc} denotes four outcomes: i) the firm needs a loan, ii) the firm is discouraged from applying for a loan, iii) the loan application is rejected, and iv) the firm is credit constrained. Specifications (ii) - (iv) are estimated on the sub-sample of firms that need a loan.

The explanatory variable of interest is *Extreme weather loss*, an indicator for whether the firm declares that it experienced monetary losses due to extreme weather over the past three years. The variable does not pick up the effects of extreme weather per se; instead, it captures its economic consequences. From an economic perspective, the firms that experience losses are of particular interest, because these are the firms that should exhibit a response, both on the asset and the liability side of the balance sheet.

We control for firm-level observable heterogeneity via $\mathbf{X}_{isc}$, which comprises the following covariates: indicator variables for whether the firm is listed on a stock exchange, is a sole proprietorship, is in a partnership, sold the main product in the local market, has a website, has audited financial accounts, and the natural logarithm of firm age.[8] We also control for gender and work experience of the manager. The model specification that studies the propensity to adopt green measures controls also for three additional elements: i) payment of energy levies, ii) being subject to energy standards and iii) having a manger responsible for climate issues.[9]

The parameter γ_{sck} denotes the sector-location-size fixed effects. Specifically, we denote by k the size category of the firm (small, medium, large), by s the firm's sector (manufacturing, retail trade, wholesale

[8]The inclusion of *Has a website* in the set of control variables may seem not useful to alleviate omitted variables concerns. However, establishments included in our sample are located in countries and areas that are not always advanced in terms of innovation and usage of technology. Having a website may convey a signal of business sophistication and competitive advantage. This may affect both the ability to make a long-term investment and to access bank credit.

[9]Having a manager responsible for climate issues may itself be influenced by whether a firm decided to invest in green measures. When we exclude this variable in a robustness test, the results remain largely unchanged.

trade, construction, hotel or restaurant, and provision of other services), and by c the country where the firm is located. Given the sample structure, this results in more than 700 bins. The fixed effects absorb any unobserved factors common to firms in a country-, sector-, and size bin that affect investment and financing decisions. This approach does not account for possible within-country variation in economic activity. For instance, large-scale natural disasters could exert downward pressure on demand in the local economy. We absorb such effects by controlling for average real annual sales growth among sample firms in a circle with a radius of 50 km centered on firm i. In addition, the indicator for whether the firm caters mainly to the local market captures firms that are particularly prone to such local demand effects.

Finally, robust standard errors are clustered by Enterprise Survey region to allow for correlation in the error term among firms located in the same region within a country.[10]

4 Results

4.1 Losses due to extreme weather and capital expenditure

Firms experiencing losses from extreme weather events are more likely to invest in long-term assets. As column 1 of Table 3 shows, firms experiencing losses from extreme weather exhibit a 6 percentage point higher likelihood to invest in fixed assets. The coefficient is statistically significant and economically relevant, as it corresponds to 16.4 percent of the average value of the dependent variable. The higher propensity of investing applies to investments in both land and buildings (4 percentage points) as well as machinery and equipment (5.1 percentage points), as reported in columns 2 and 3 of Table 3. The survey question on investment in fixed assets has a reference period of one year, whereas the question on weather related losses has a reference period of three years. To reduce the mismatch, column 4 draws on additional information on investment activity in the year prior to the last financial year. Column 4 shows that firms exhibit a 4.5 percentage point higher likelihood to invest in fixed assets in the two years before the interview. We also examine the intensive margin of investments in fixed assets. As column 5 of Table 3 shows, the investments per worker conditional on investing are approx. 25 percent higher for firms with extreme weather losses.

The availability of location data allows us to proxy for the dynamism of the local economy, a potentially important confounding factor. It turns out that firms located in areas with higher sales growth are more likely to invest in fixed assets. As expected, the control variables suggest that more sophisticated firms are more likely to increase capital expenditure. Firms with audited financial statements and a website

[10] As explained in section 2, the Enterprise Surveys use stratified random sampling, and as such the probability of selection into the sample differs across observations. The estimation procedure takes the survey design into account.

are more likely to invest. The same applies to exporters. On the other hand, firms that cater primarily to the local market are less likely to invest. The effect of firm size is absorbed by the fixed effects. However, conditional on size, older firms exhibit a lower propensity to invest.

The positive relationship between losses from extreme weather events and the propensity to invest as well as the amount invested can arise from several mechanisms. One potential channel is that firms may seek to replenish the capital stock. Indeed, firms can be more likely to purchase new machinery or invest in new lands or buildings due to the physical destruction brought by extreme weather events. However, it can also be that firms invest to guard against future climate risks; firms might be hedging or getting more resilient in view of potential future events and therefore increase investment.[11] Both mechanisms provide a plausible explanation for the relationship between extreme weather losses and capital expenditure in a sample largely dominated by unlisted firms, mainly operating in developing and emerging markets.

4.2 Losses due to extreme weather and investment in green measures

So far, our results show that firms that experience losses due to extreme weather events are more likely to increase capital expenditure. In this section, we turn to adoption of green measures.

Firms experiencing losses from extreme weather are more likely to adopt measures that reduce the environmental footprint of their company. The results in column 1 of Table 4 indicate a positive and statistically significant relationship between extreme weather-related losses and the likelihood that the firm invests in climate-friendly measures. Our reduced-form results show that firms experiencing losses from extreme weather events have on average a 11.9 percentage points higher probability of adopting green measures. The coefficient is statistically significant at conventional levels and economically meaningful, since it corresponds to 19 percent of the mean of the dependent variable. Not surprisingly, firms that have a manager in charge of climate issues and firms that are subject to energy standards are significantly more likely to adopt greener modes of production.

As a next step to our analysis, we explore whether executives' years of work experience relate to the higher probability to invest in measures that reduce a firm's environmental footprint. Earlier work has shown that older executives tend to be more risk-adverse, more conservative in their business strategy, and more reluctant to invest in new technologies (Barker III and Mueller, 2002; Kaplan et al., 2012; Huang and Kisgen, 2013; Faccio et al., 2016). Specifically, columns 2 and 3 in Table 4 examine whether the manager's age, proxied by the years of the managers' work experience in the firm's sector plays a different role in the adoption of *Green measures* as opposed to investments in *Fixed assets*. Column

[11] As the Green Economy Module does not have information on climate adaptation investment, our data do not allow us to distinguish between these two mechanisms.

2 shows that the probability of investing in green measures conditional on suffering from losses due to extreme weather decreases with the work experience of the manager. On the other hand, in column 3, the coefficient on the interaction term is not statistically significant, confirming that the age of the executives does not relate to the probability of investing in fixed assets. This exercise complements recent work by De Haas et al. (2021), where the authors examine whether credit constraints and low-quality firm management inhibit corporate investment in green measures.

Why would firms that suffer losses from extreme weather events be more likely to adopt environmentally friendly modes of production? One potential explanation is based on vintage effects. As the firm replenishes its capital stock, it installs more modern equipment that has a lower environmental footprint. Alternatively, firms exposed to extreme weather events may be more aware of the risks embedded in climate change and, therefore, more likely to invest in climate-friendly assets. To investigate this possibility, column 4 of Table 4 looks at whether firms incurring losses from extreme weather are more likely to monitor their CO_2 emissions. We use emissions monitoring as a proxy for environmental awareness as for the firms in our sample, emitting CO_2 is free of charge. Therefore firms have no immediate interest in monitoring their emissions. Conditional on having generated greenhouse gas emissions, firms that experience losses due to extreme weather events have an approximately 5 percentage points greater propensity to monitor their CO_2 emission levels. The result is consistent with greater environmental awareness of firms that experience losses from extreme weather. While vintage effects and greater environmental awareness can both account for the higher propensity to adopt green measures, the data do not allow us to gauge the relative importance of the two channels.

4.3 Losses due to extreme weather and access to credit

In this section, we investigate the relationship between extreme weather-related losses and firms' access to credit. The analysis is based on Equation 1 and it proceeds in two stages. First, we study firms' need for bank credit. Then, we examine whether firms in need for a loan are able to obtain one.

Firms experiencing losses from extreme weather events have on average a 12 percentage points higher likelihood to desire a bank loan, as reported in specification 1 of Table 5. The coefficient is statistically significant at the one percent level and corresponds to almost 28 percent of the average value of the dependent variable. Conditional on needing a loan, firms suffering from weather-related losses are not more likely to be credit constrained. In column 2 of Table 5, the coefficient of *Extreme weather loss* on *Credit constrained* is not statistically significant different from zero.[12] This result reflects the findings on discouragement and rejections documented in columns 3 and 4 of the same regression table. It turns out that firms experiencing losses from extreme weather are less likely to be discouraged in applying for

[12] In the population, firms with losses from extreme weather events are more likely to be credit constrained. The difference amounts to 3.7 percentage points and results largely from their greater need for loans.

a loan by almost 9 percentage points on average, all else equal. This is a substantial effect given that 43 percent of all firms that need a loan in our data are classified as discouraged. However, conditional on applying for a loan, firms experiencing losses from extreme weather do face higher rejection rates, as shown in column 4. At 5.2 percentage points, the coefficient is large compared to the average rejection rate of 4 percent in the sample.

Together these results indicate that extreme weather events decrease the probability of being discouraged in applying for a loan, and that banks do not seem to constrain access to credit to firms experiencing weather-related losses. These results are broadly in line with findings in the literature on the role that local lenders have in aiding in the recovery after disasters (Cortés, 2014; Koetter et al., 2020). However, the results on loan rejection rates suggest that firms experiencing losses from extreme weather events might be perceived by banks on average less creditworthy.

4.4 Extensions

This section extends our analysis to financing instruments other than bank credit. In a second step, we investigate how the main results on investment and access to credit vary with firm size.

One of the advantage of the Enterprise Surveys data is that it contains information on the use of financial instruments other than bank credit. This enables us to study the composition of working capital and investment finance of firms in the aftermath of losses from extreme weather events. In addition to internal finance and bank credit, our exercise takes into account credit from non-bank institutions, which include microfinance institutions, credit cooperatives and credit unions, trade credit and government grants. The results are reported in Panel A and B of Table 6. Specifications 1-5 report results from a linear probability model used to investigate the extensive margin of firms financing instrument's choices. Given that all firms use internal finance to some degree, the dependent variable in these specifications is equal to one if the firm finances its working capital or its investments exclusively from internal sources. Firms that finance both working capital and investments from internal sources only can be considered zero-leverage firms (Strebulaev and Yang, 2013). The exercise therefore shows whether firms suffering losses from extreme weather are more likely to be levered. However, to obtain a more comprehensive picture of balance sheet strength, we proxy a firm's loss absorption capacity in specification 6 of Table 6 by the percentage of capital expenditure or working capital financed as the sum of retained earnings and new equity injections. This specification is estimated by a quasi-maximum likelihood estimator for fractional response models (Papke and Wooldridge, 1996) that is appropriate for continuous zero to one data.

Firms with weather related losses have a more levered composition of both investment and working capital finance. Panel A of Table 6 presents the results for investment finance. Firms suffering losses from

extreme weather are 9.7 percentage points less likely to finance their capital expenditure exclusively from internal sources, as reported in column 1. The results suggest that firms suffering losses from extreme weather are more likely to be levered.[13] As columns 2 and 4 show, firms resort to borrowing from banks and customers/suppliers instead. Higher recourse to trade credit signals that bank credit is insufficient to meet the financing needs of at least for some firms with weather-related losses, as Petersen and Rajan (1997) have shown that firms are more likely to resort to trade credit if institutional finance is not available. In addition, trade credit appears less than ideal to finance capital expenditure in particular, as such firms are unlikely to benefit from the early repayment discounts typically offered by sellers. In addition, reliance on trade credit may expose the firm to rollover risk. Column 6 presents results on ex-post balance sheet strength. The estimates indicate that firms experiencing monetary losses due to extreme weather events have a more leveraged composition of investment finance. The difference amounts to 5.2 percentage points, which corresponds to 6.7 percent of the sample mean.

Panel B1 of Table 6 presents results on the financing of working capital for the subset of firms that invested in fixed assets. Analogously to the results on investment finance, column 1 shows that firms suffering losses from extreme weather are less likely to finance 100 percent of their working capital from internal sources. Results in column 2 suggest that these firms turn to banks to make up their funding shortfalls. Firms that invest in fixed assets are also more likely to use non-bank credit to finance working capital needs, although the estimated coefficient is mildly statistically significant. Column 5 and 6 indicate that firms with weather-related losses are more likely to use funding provided as government interventions and that they are more leveraged.

Firms with weather-related losses that do not invest also use greater leverage to finance their working capital, as shown in Panel B2 of Table 6. With the exception of non-bank credit, the results closely resemble those for the subset of investing firms. This suggests a third motive for increased credit demand in addition to adaptation and replacement investment. Firms with weather-related losses may borrow to make up for disruptions to their operations.

Overall, the results in Table 6 are consistent with the notion that bank finance is the most important source of external finance for firms suffering losses from extreme weather. However, the results also indicate firms suffering losses from extreme weather are more leveraged than otherwise comparable firms. This holds after taking into account equity injections and government assistance. This result suggests that climate change has indeed the potential to erode the quality of firm balance sheets over time.

It is well known that SMEs, on account of their opaqueness, are more likely to be credit constrained (Stiglitz and Weiss, 1981). As a result, the investment response to extreme weather events may vary with firm size. Specifications in Panel A Table 7 test for possible size effects on investment activity by

[13] These firms can be considered zero-leverage firms, as they finance their operations via internal sources only (Strebulaev and Yang, 2013).

adding the interaction of an SME indicator with experiencing losses from extreme weather. In column 1, we find that the coefficient on the interaction term is negative and significant, indicating that SMEs are less likely to invest in fixed assets than large firms. This result is consistent with the notion that large firms have more resources at their disposal, which may enable them to rebuild their capital stock or engage in adaptation investments. Instead, the positive and statistically significant coefficient on the interaction term shows that the increase in the propensity to adopt green measures in Table 4 is driven by SMEs.

We also present the heterogeneous effects of firm size on access to credit for firms that experience monetary losses due to extreme weather in Panel B of Table 7. Specification 1 shows that SMEs have higher needs of bank credit compared to large firms.[14] Conditional on needing a loan, there is no significant difference in discouragement and rejection rates between SMEs and large firms. The lack of significant coefficients does not imply, however, that the results from Table 5 break down. The sum of the coefficients on extreme weather loss and the interaction term roughly equals the coefficient on extreme weather loss in Table Table 5. Instead, this suggests that the results in Table 5 are driven by small and medium-sized enterprises.

In sum, the results suggests that SMEs are more vulnerable to physical climate risk than large firms, on account of both their weaker investment response and their higher needs for bank credit.

5 Robustness checks

A potential concern in studying the relationship between extreme weather-related losses, corporate investment and access to credit is that the estimated coefficients on our variable of interest pick up factors other than the effects of extreme weather-related losses. This section presents results from a series of sensitivity tests that alleviate these concerns.

5.1 Alternative liquidity shock: Informal payments

The first robustness check exploits bribe requests as an alternative liquidity shock. Bribe payments should be irrelevant for the firm's decision to make a new investment, but as they drain the company of resources bribe payments should result in a greater need for credit.[15] We measure bribe requests with the variable *Informal payment*, which takes value one for firms that declare that an informal gift or payment was expected or requested to obtain a water or electricity connection, to obtain an import

[14] For large firms, extreme weather losses may be comparatively smaller relative to the scale of the enterprise. However, due to lack of data on the scale of weather-related losses we cannot empirically examine this conjecture.

[15] A possible question might be the relevance of informal payments compared to weather events losses in generating liquidity shortage. Firms in our sample declare to pay 7 percent of total annual sales paid as informal payment on average, which is a substantial number given the market where these firms operate.

license, to clear both imported or exported goods, or during inspections by tax officials. The results are based on Equation 1, where *Extreme weather loss* is replaced by *Informal payment*.

As Panel A of Table 8, shows the positive and statistically significant relation between informal payments and corporate investments is absent. [16] The lack of statistical significance increases our confidence that the results in Table 3 do indeed reflect the effects of losses from extreme weather events. We also examine firms' access to credit and report results in Panel B of Table 8. The bribe payments increase the likelihood that the firm needs bank credit. Indeed, payments of bribes can be costly for a firm, which is more likely to seek out external funds to repair the monetary damage induced by the experience of the bribery. There is no statistically significant relationship between informal payments and discouragement in applying for banks loans. At the same time, banks are more likely to reject the loan applications of firms exposed to bribery. The coefficient is significant only at the 10 percent level. This result is in line with Qi and Ongena (2019) who show that the more a firm is exposed to bribery, the higher the probability that it loses access to bank credit. The authors find that the effect is mainly driven by banks being less willing to lend to bribing firms. Overall, the results of the exercise are consistent with our baseline results.

5.2 Falsification test: Panel sub-sample

As a second robustness check, we conduct a falsification test of our baseline results. The Enterprise Surveys have a longitudinal component and this exercise is based on the panel sub-sample of the survey. Because the question on losses from extreme weather events was asked only in the 2018-2020 round of the survey, we cannot use the panel sub-sample in combination with firm fixed effects. However, we can use the 2013 wave for a falsification test. The test has two components. First, we examine whether the baseline results hold in the panel sub-sample of the 2018-2020 wave. The second component is a placebo exercise that assigns the realizations of *Extreme weather loss* to the 2013 wave of the survey. Significant coefficients in the placebo exercise would indicate that losses from extreme weather events are correlated with an unobserved characteristic of the firm that affects capital expenditure or access to credit. Table 9 presents the results of this exercise. In both Panel A on corporate investment and Panel B on access to credit show, the coefficients estimated on the panel sub-sample of the 2018-2020 wave are similar to those based on the representative sample in 3 and 5. At the same time, the results on the backward *Extreme weather loss* applied to the 2013 sampling year are statistically insignificant in all specifications. This alleviates concerns of omitted variable bias.

[16] With the exception of the coefficient in specification 2 that is significant at the 10 percent level, the estimates are not significant.

5.3 Management practices

So far, the analysis has not explicitly considered the quality of management in the sampled enterprises. Nevertheless, the management dimension can be relevant to both firms' investment opportunities and to their ability to access bank credit. In addition, "badly run" firms, or a firm with poor management practices, may be more likely to experience losses due to extreme weather events. For example, a firm with poor managerial quality may occupy substandard premises, which would leave the establishment more exposed to environmental impacts. If firms with poor quality of management have higher propensity to declare monetary losses due to weather extremes, our estimates would suffer from omitted variable bias.

To address this point, we use information from the module on management practices module included in the Enterprise Surveys and use an index of the quality of management as an additional control variable. The module covers managerial practices in the areas of operations, monitoring, targets, and incentives. Unfortunately, it is administered only to medium-sized and large enterprises. The exclusion of small firms results in the loss of almost 50 percent of the sample. We therefore present the results that control for management practices as a robustness check. Our variable *Management practices* is an overall management z-score as a normalised unweighted average of the four areas of the questionnaire.[17]

Table 10 presents the results of this analysis. Firms with better management practices are more likely to invest; the coefficients are statistically significant at 1 percent level (see Panel A). Estimated coefficients on *Extreme weather loss* remain statistically significant. The magnitude is somewhat higher, but this reflect the changing composition of the sample. Large firms account for a greater share of the sample in Table 10 and as Table 7 shows, large firms exhibit a higher propensity to invest in response to losses from extreme weather events. Panel B reports results on access to credit. This robustness exercise confirms main results shown in Table 5; however, we do not find any statistically significant association between experiencing monetary losses due to weather extreme and discouragement from applying for bank credit when accounting for managerial practices. This is consistent with the heterogeneity analysis shown in Panel B of Table 7 where we find that the lower likelihood to be discouraged applies to mainly to small-medium sized firms. As mentioned already, small firms are excluded from this robustness test due to unavailability of information on managerial practices for small firms.

5.4 Alternative clustering of standard errors

In the baseline regression, we estimated standard errors by clustering at the Enterprise Surveys within-country region. Clustering at the Enterprise Surveys regional level accounts for correlation between

[17] We create and normalize a score for each question such that they have a mean of 0 and a standard deviation of 1 in the sample. We then aggregate them to obtain average z-scores for each of the four question areas; we then create an overall z-score as a normalised unweighted average of the four areas.

observations that are located in the same region. Moreover, it models the presence of random common shocks to all firms in the same region that have been hit by extreme weather events (Abadie et al., 2017). In Table 11, we alternatively cluster standard errors accounting for spatial correlation of the errors for firms that are located within 10km of each other, following the methodology for arbitrary clustering proposed by Colella et al. (2019). Estimating standard errors by modeling the correlation, or neighborhood structure, of firms that are geographically close to each other reduces the size of the cluster, but it improves inference as extreme weather events are typically local shocks.

Panel A and Panel B of Table 11 shows that the main coefficients of interest on extreme weather losses remain statistically significant at conventional levels. These findings contribute to the robustness of our baseline results.

6 Conclusions

We study the investment and financing choices of firms that suffer from monetary losses due to extreme weather events. We find evidence that firms experiencing a loss due to extreme weather, such as floods, droughts, and landslides, have a greater likelihood to invest. This finding is consistent with either the need to replenish capital destroyed by the weather event or with adaptation investments to guard the firm against future climate risks.

Our reduced-form analysis also shows that firms experiencing losses due to weather extremes are more likely to adopt measures that reduce their environmental footprint. Prima facie, this can be due to vintage effects. Nonetheless we also provide an alternative explanation whereby firms exposed to climate risks can be more aware of the risks caused by climate change. However, we also find that older managers hamper the adoption of climate-friendly practices by firms, possibly due their conservatism and risk-aversion in investing in new technologies.

Firms suffering losses due to extreme weather are more likely to need bank credit. However, conditional on needing a loan, they are not more likely to be credit constrained. Our findings are broadly in line with the literature on the role that lenders have in aiding in the recovery after natural disasters (Cortés, 2014; Koetter et al., 2020). We also study the composition of working capital and investment finance of firms in the aftermath of losses from extreme weather event. Overall, the results are consistent with the notion that bank finance is the most important source of external finance for firms suffering losses from extreme weather.

Although we cannot conclude that banks constrain the access to credit to firms that experienced extreme weather-related losses, we find that these firms face higher rejection rates. This result suggests that these firms might be perceived by banks as on average less creditworthy. We also find that firms

suffering losses from extreme weather are more leveraged than otherwise comparable firms. This holds after taking into account equity injections and government assistance. Overall, these results suggest that climate change has the potential to erode the quality of firm balance sheets over time.

Finally yet importantly, we document that SMEs are more vulnerable to losses due to weather extremes as they have a weaker investment response than large firms and a higher need for bank credit.

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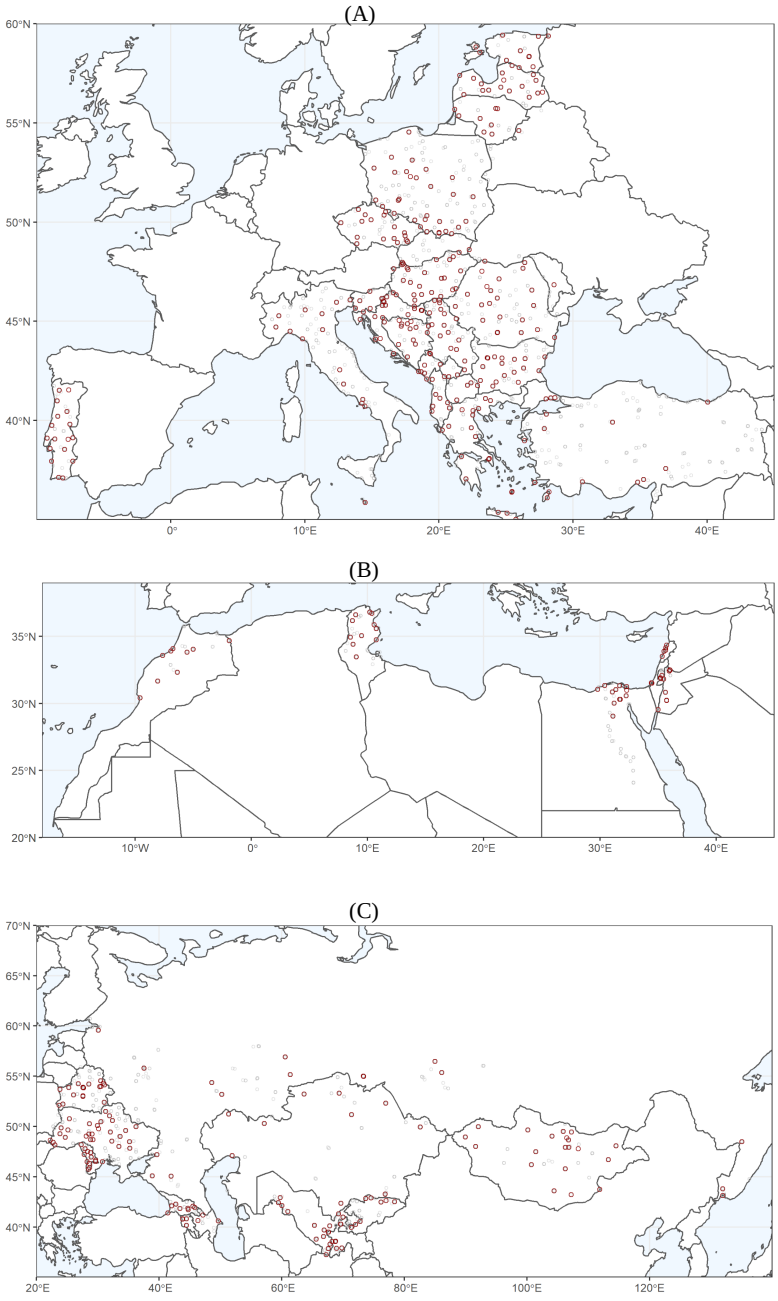
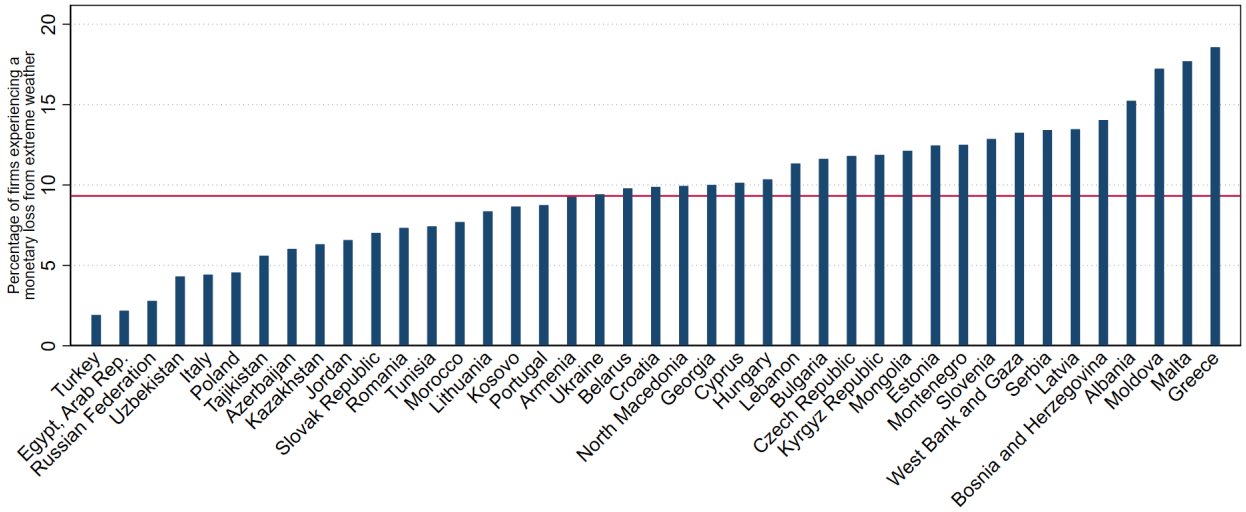
Figures and Tables

Figure 1: Geographical distribution of firms experiencing a monetary loss due to extreme weather



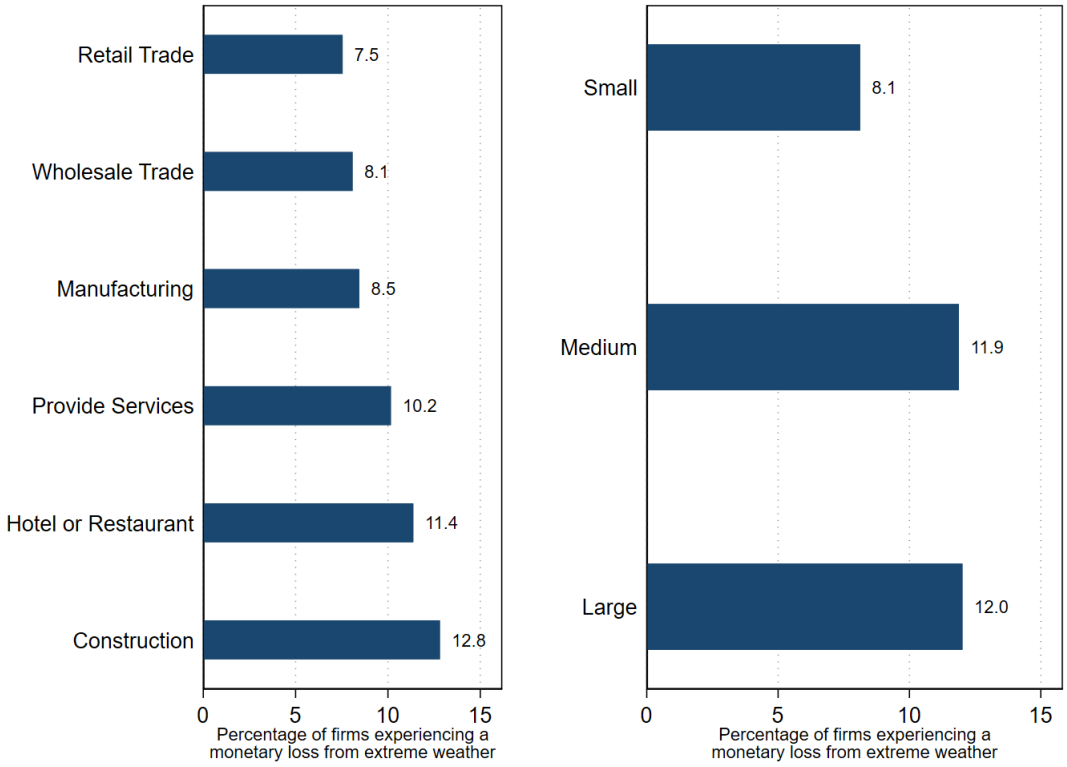
Notes: These maps show the geographical distribution of firms part of our sample across countries in Western Balkans, Central, Eastern and Southern Europe (Panel A), in the Middle East and North Africa (MENA) region (Panel B), and in Central Asia and the Eastern Neighbourhood area (Panel C). Each dot represents one or a cluster of firms in a country. Dark red dots are firms that have experienced a monetary loss due to extreme weather; light grey dots are firms that have not experienced a monetary loss due to extreme weather. The total number of firms making up our sample is 24,086. Figure 2 shows the countries included in our sample. Source: EBRD-EIB-WBG Enterprise Survey.

Figure 2: Sample breakdown of firms experiencing a monetary loss due to extreme weather by country



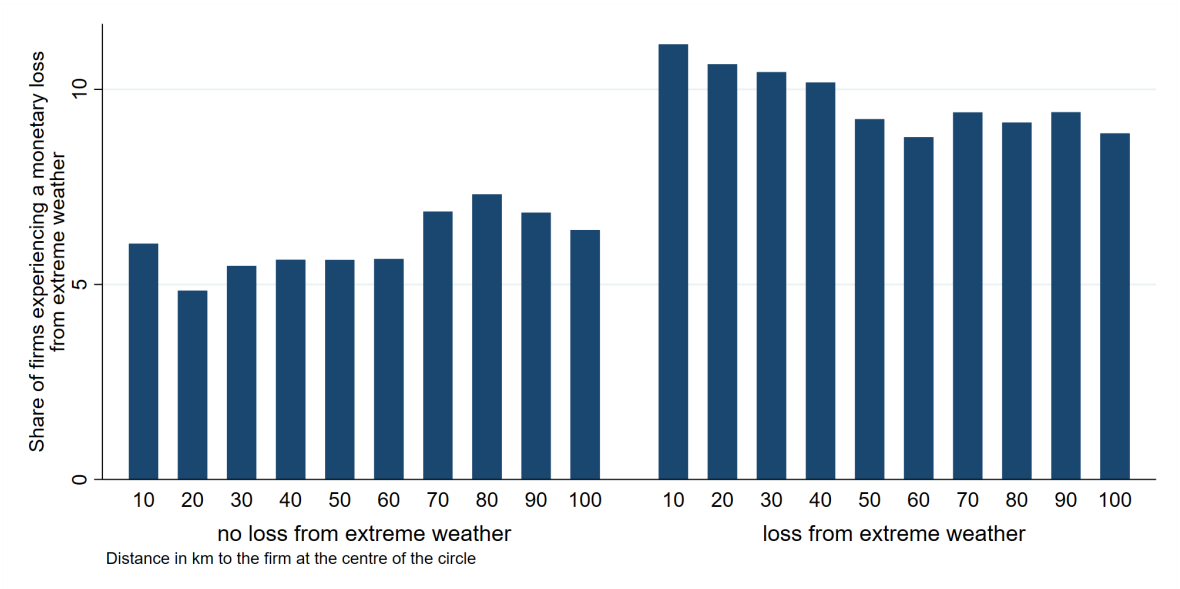
Notes: This graph shows the percentage of firms that declare to have experienced a monetary loss due to extreme weather events. Percentages are calculated out of total number of firms located in each country. The blue bar reports percentage of firms with monetary losses due to extreme weather per country; the red horizontal bar reports the average number of firms with a monetary loss due to extreme weather in the overall sample (9.319 percent). Calculations are survey-weighted. Countries are sorted in ascending order. Source: EBRD-EIB-WBG Enterprise Survey.

Figure 3: Sample breakdown of firms experiencing a monetary loss due to extreme weather by sector and size



Notes: These charts show the percentage of firms that declare to have experienced a monetary loss due to extreme weather events conditional on firm size and business sector. Sectors are defined under the Enterprise Surveys six sectors definition. Firm size is defined under the Enterprise Surveys as the number of the firms' employees (5-19, 20-99 and 100+ employees). Percentages are calculated out of total number of firms with the same size and working in the same business sector. Calculations are survey-weighted. Each category is sorted in ascending order of percentage value. Source: EBRD-EIB-WBG Enterprise Survey.

Figure 4: Spatial correlation of monetary losses due to extreme weather events



Notes: This figure shows the spatial correlation of firms that declare (right-hand chart) and do not declare (left-hand chart) to have experienced a monetary loss due to extreme weather events. The y-axis shows the share of firms that are neighbors within a given distance, while the x-axis shows the circles in kilometers (km) -10, 20, 30, 40, 50, 60, 70, 80, 90 and 100 km. Calculations are survey-weighted. Source: EBRD-EIB-WBG Enterprise Survey.

Table 1: Variable definitions

Variable name	Variable definition
Extreme weather loss	1 if the firm experienced monetary losses due to extreme weather events (such as storms, floods, droughts, and landslides) over the last three years; 0 otherwise.
Audited	1 if the firm has its annual financial statements checked and certified by an external auditor; 0 otherwise.
Sole proprietorship	1 if the firm's current legal status is a sole proprietorship; 0 otherwise.
Publicly listed	1 if the firm's current legal status is a shareholding company with shares trade in the stock market; 0 otherwise.
In partnership	1 if the firm's current legal status is partnership; 0 otherwise.
Main market: Local	1 if the firm sold its main product mostly in the municipality where it is located; 0 otherwise.
Exporter	1 if the firm directly exported at least 10 per cent of its sales in the last complete fiscal year; 0 otherwise.
log(Age)	Log of firm age based on the year in which the firm began operations.
Have a website	1 if the firm has its own website; 0 otherwise.
Female CEO	1 if the firm's top manager is female; 0 otherwise.
log(Years of experience)	Log of the top manager's years of working experience in the sector where the firm is operating.
Pay energy levy	1 if the firm was subject to an energy tax or levy; 0 otherwise.
Subject to energy standards	1 if the firm was subject to an energy performance standard in its operations; 0 otherwise.
Manager for climate issues	1 if the firm had a manager responsible for environmental and climate change issues; 0 otherwise.
Mean Δ sales	Average real annual sales growth (%) over the last three years of firms located within a circle with a radius of 50 km.
Small-medium sized enterprises	1 if the firm is a small-medium sized enterprises (5-19 or 20-99 employees); 0 otherwise.
Management practices	A z-score aggregated for each Enterprise Surveys management section in the areas of operations, monitoring, targets, and incentives.
Fixed assets_t	1 if the firm has purchased any new or used fixed assets over the last fiscal year; 0 otherwise.
Land and buildings	1 if the firm spent a strictly positive amount on land and buildings over the last fiscal year, including expansion and renovations of existing structures; 0 otherwise.
Machinery and equipment	1 if the firm spent a strictly positive amount on new or used machinery, vehicles, and equipment over the last fiscal year; 0 otherwise.

Table 1: Variable definitions - continued

Variable name	Variable definition
Fixed assets$_{(t \text{ or } t\text{-}1)}$	1 if the firm has purchased any new or used fixed assets either over the last fiscal year or over the fiscal year previous to the last one; 0 otherwise.
Log(Inv. amount/size)	Log of amount the firm spent of purchases of land, buildings, machinery, and equipment in US dollars scaled by firm's number of employees.
Green measures	1 if firm adopted at least one of the following measures over the last three years: heating and cooling improvements, more climate-friendly energy generation on site, machinery and equipment upgrades, energy management, waste minimisation, recycling and waste management, air pollution and control measures, water management, upgrade of vehicles, improvements to lighting systems, other pollution control measures, measures to enhance energy efficiency; 0 otherwise.
$C0_2$ monitoring	1 if the firm emitted and monitored its CO_2 emissions over the last three years; 0 otherwise.
Need loan	1 if the firm desires bank loans; 0 otherwise -it has sufficient capital.
Discouraged	1 if a firm have positive demand of bank credit (Need loan=1) and it did not apply for bank credit due to unfavorable loan terms (complex application procedures, too high collateral requirements, not favorable interest rates, not sufficient size and maturity of the loan, did not think would be approved); 0 otherwise.
Rejected	1 if a firm have positive demand of bank credit (Need loan=1) and the firm application for bank credit was rejected; 0 otherwise.
Credit constrained	1 if a firm have positive demand of bank credit (Need loan=1) and either it didn't apply because of adverse loan conditions or the application was rejected; 0 otherwise.
Ex-post internal funds	Fraction of internal finance that the firm use to purchase fixed assets or to fund working capital. Internal sources include internal funds or retained earnings, owners' contribution or issuance of new equity shares.
Internal funds	1 if the firm financed purchases of fixed assets or working capital with 100% of internal funds or retained earnings; 0 otherwise.
Bank credit	1 if the firm financed purchases of fixed assets or working capital with a strictly positive amount borrowed from banks (private and state-owned) as bank loans; 0 otherwise.
Non-bank credit	1 if the firm financed purchases of fixed assets or working capital with a strictly positive amount borrowed from non-banks financial institutions (microfinance institutions, credit cooperatives, credit unions, or finance companies); 0 otherwise.
Trade credit	1 if the firm financed purchases of fixed assets or working capital with a strictly positive amount obtained as advances from suppliers, or trade credit; 0 otherwise.
Gov. grants	1 if the firm financed purchases of fixed assets or working capital with with a strictly positive amount obtained as government grants; 0 otherwise.
Informal payment	1 if the firm declares that an informal gift or payment was expected or requested in relation to obtaining an electricity connection, a water connection, an import license, to inspections by tax officials, or to clear imported and/or exported goods; 0 otherwise.

Notes: This table reports variables definition. The data source is the 2018-2020 wave of the EBRD-EIB-WBG Enterprise Surveys.

Table 2: Summary statistics

	Obs.	Mean	Std. Dev.	Min.	Max.
Fixed assets_{t}	24,086	0.391	0.482	0	1
Land and buildings	24,086	0.106	0.313	0	1
Machinery and equipment	24,086	0.378	0.479	0	1
Fixed $\text{assets}_{\text{(t or t-1)}}$	17,097	0.772	0.493	0	1
Log(Inv. amount/size)	7,912	11.535	5.512	4.087	26.719
Green measures	24,086	0.644	0.480	0	1
$C0_2$ monitoring	23,844	0.040	0.243	0	1
Need loan	23,567	0.425	0.495	0	1
Discouraged	10,200	0.436	0.499	0	1
Rejected	10,200	0.039	0.175	0	1
Credit constrained	10,200	0.476	0.500	0	1
Extreme weather loss	24,086	0.093	0.267	0	1
Audited	24,086	0.351	0.491	0	1
Sole proprietorship	24,086	0.222	0.403	0	1
Publicly listed	24,086	0.039	0.243	0	1
In partnership	24,086	0.066	0.285	0	1
Main market: Local	24,086	0.460	0.495	0	1
Exporter	24,086	0.155	0.399	0	1
log(Age)	24,086	2.682	0.748	0	5.268
Have a website	24,086	0.608	0.487	0	1
Female CEO	24,086	0.178	0.365	0	1
log(Years of experience)	24,086	2.809	0.725	0	4.248
Pay energy levy	24,086	0.201	0.405	0	1
Subject to energy standards	24,086	0.101	0.330	0	1
Manager for climate issues	24,086	-.0165	0.299	0	1
Mean Δ sales	24,086	2.273	7.071	-73.389	98.155
Small-medium sized enterprises	24,086	0.942	0.396	0	1
Informal payment	15,518	0.099	0.284	0	1
Management practices	12,646	0.016	0.948	-7.874	1.817

Notes: This table reports survey-weighted summary statistics.

Table 3: Are firms experiencing losses due to extreme weather more likely to increase capital expenditure?

	(1) Fixed assets$_t$	(2) Land & buildings	(3) Machinery & equipment	(4) Fixed assets$_{(t \text{ or } t-1)}$	(5) Log(Inv. amount/size)
Extreme weather loss	0.060***	0.040***	0.051**	0.045***	0.254***
	[0.023]	[0.012]	[0.023]	[0.017]	[0.094]
Audited	0.042***	0.029***	0.038***	0.038***	0.082
	[0.015]	[0.010]	[0.015]	[0.012]	[0.094]
Sole proprietorship	-0.014	-0.006	-0.009	-0.046***	-0.198**
	[0.017]	[0.010]	[0.017]	[0.017]	[0.094]
Publicly listed	-0.015	-0.000	-0.016	-0.018	-0.170
	[0.032]	[0.016]	[0.032]	[0.033]	[0.128]
In partnership	-0.003	-0.005	-0.002	-0.029	0.040
	[0.024]	[0.015]	[0.023]	[0.028]	[0.117]
Main market: Local	-0.047***	-0.004	-0.049***	-0.049***	-0.172***
	[0.014]	[0.007]	[0.013]	[0.013]	[0.059]
log(Age)	-0.061***	-0.009	-0.057***	-0.044***	-0.134**
	[0.009]	[0.008]	[0.009]	[0.008]	[0.054]
Have a website	0.065***	0.041***	0.058***	0.054***	0.179**
	[0.015]	[0.010]	[0.015]	[0.012]	[0.071]
Female CEO	0.003	0.014	0.007	0.018	-0.358***
	[0.015]	[0.010]	[0.015]	[0.013]	[0.070]
log(Years of experience)	0.012	0.003	0.006	0.012	-0.012
	[0.010]	[0.006]	[0.010]	[0.008]	[0.047]
Exporter	0.057***	0.026**	0.057***	0.050***	0.362***
	[0.020]	[0.013]	[0.019]	[0.014]	[0.111]
Mean Δ sales	0.004**	0.002	0.005***	0.003**	0.003
	[0.002]	[0.001]	[0.002]	[0.001]	[0.007]
Obs.	24,086	24,086	24,086	17,097	7,912
Adj. R^2	0.218	0.148	0.215	0.423	0.926
Industry × Size × Country FE	✓	✓	✓	✓	✓
Mean(dep. var.)	0.391	0.106	0.378	0.772	11.535

Notes: This table reports estimates from survey-weighted linear probability models. The regressor of interest is the dummy variable *Extreme weather loss* that is equal to one if the firm experienced a monetary loss due to extreme weather; zero otherwise. In column 1, the dependent variable is a dummy that is one if the firm invested in fixed assets. In column 2, the dependent variable is a dummy equal to one if the firm spent a strictly positive amount of land and buildings, including expansion and renovations of existing structures. In column 3, the dependent variable is one if the firm spent a strictly positive amount of new or used machinery, vehicles, and equipment; 0 otherwise. In column 4, the dependent variable is a dummy equal to one if the firm made an investment in fixed assets either during last complete fiscal year or during the fiscal year before last. In column 5, the dependent variable is the natural logarithm of amount invested in purchases of fixed asset (USD adjusted) scaled by firm size (number of employees). All columns include firm-level controls, industry-size-country fixed effects. Omitted category in firm ownership is Limited partnership and Shareholding company with non-traded shares. Robust standard errors are clustered by Enterprise Surveys region and shown in parentheses. For variable definitions, see Table 1. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 4: Are firms experiencing losses due to extreme weather more likely to invest in green measures?

	(1) Green Measures	(2) Green Measures	(3) Fixed Assets	(4) $C0_2$ monitoring
Extreme weather loss	0.119***	0.338***	0.171**	0.047***
	[0.021]	[0.074]	[0.082]	[0.010]
log(Years of experience)	-0.002	0.008	0.017	0.000
	[0.012]	[0.012]	[0.011]	[0.003]
Extreme weather loss × log(Years of experience)		-0.078***	-0.039	
		[0.025]	[0.026]	
Obs.	24,086	24,086	24,086	23,844
Adj. R^2	0.217	0.219	0.219	0.144
Firm controls	✓	✓	✓	✓
Industry × Size × Country FE	✓	✓	✓	✓
Mean(dep. var.)	0.644	0.644	0.391	0.040

Notes: This table reports estimates from survey-weighted linear probability models. The regressor of interest is the dummy variable *Extreme weather loss* that is equal to one if the firm experienced a monetary loss due to extreme weather; zero otherwise. Specifically, columns (2) and (3) report estimates when running a specification with interaction term *Extreme weather loss×log(Years of experience)*. In columns (1) and (2), the dependent variable is a dummy equal to one if the firm invested in green measures; 0 otherwise. In column (3), the dependent variable is equal to one if the firm invested in fixed assets; 0 otherwise. In column (4), the dependent variable is a dummy equal to one if the firm declares to have emitted $C0_2$ during the last fiscal year and that have also monitored these emissions. All columns include firm-level controls, industry-size-country fixed effects. Omitted category in firm ownership is Limited partnership and Shareholding company with non-traded shares. Robust standard errors are clustered by Enterprise Surveys region and shown in parentheses. For variable definitions, see Table 1. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 5: Are firms experiencing losses due to extreme weather able to access bank credit?

	(1) Need loan	(2) Credit constrained	(3) Discouraged	(4) Rejected
Extreme weather loss	0.120***	-0.034	-0.087**	0.052**
	[0.023]	[0.031]	[0.042]	[0.022]
Audited	0.007	-0.064***	-0.050**	-0.014
	[0.016]	[0.020]	[0.022]	[0.011]
Sole proprietorship	-0.022	0.032	0.060*	-0.028***
	[0.020]	[0.030]	[0.030]	[0.010]
Publicly listed	-0.016	0.022	0.030	-0.008
	[0.035]	[0.048]	[0.040]	[0.015]
In partnership	0.000	-0.047	-0.025	-0.022**
	[0.030]	[0.041]	[0.043]	[0.010]
Main market: Local	-0.009	0.035*	0.021	0.014*
	[0.013]	[0.020]	[0.019]	[0.008]
log(Age)	-0.043***	0.014	0.017	-0.003
	[0.010]	[0.014]	[0.018]	[0.013]
Have a website	0.020	-0.069***	-0.060***	-0.009
	[0.014]	[0.020]	[0.019]	[0.007]
Female CEO	-0.015	0.006	-0.001	0.006
	[0.015]	[0.023]	[0.027]	[0.015]
log(Years of experience)	0.028***	-0.013	0.006	-0.019
	[0.010]	[0.014]	[0.019]	[0.018]
Exporter	0.043**	-0.074***	-0.092***	0.018
	[0.018]	[0.023]	[0.021]	[0.015]
Mean Δ sales	0.001	-0.003	-0.002	-0.001
	[0.002]	[0.002]	[0.002]	[0.001]
Obs.	23,567	10,200	10,200	10,200
Adj. R^2	0.155	0.262	0.243	0.157
Industry × Size × Country FE	✓	✓	✓	✓
Mean(dep. var.)	0.425	0.476	0.436	0.039

Notes: This table reports estimates from survey-weighted linear probability models. The regressor of interest is the dummy variable *Extreme weather loss* that is equal to one if the firm experienced monetary losses due to extreme weather events; zero otherwise. In column (1), the dependent variable is a dummy that is one if the firm declares positive demand of bank credit. In column (2), the dependent variable is a dummy equal to one if the firm is credit constrained. In column (3), the dependent variable is one if the firm is discouraged from applying for a loan due to adverse credit conditions. Finally, in column (4) the dependent variable is a dummy equal to one if the firm's bank loan application was rejected in the last fiscal year. Estimation results in columns 2 to 4 are based on the sample of firms that have a positive demand of bank credit. All columns include firm-level controls, industry-size-country fixed effects. Omitted category in firm ownership is Limited partnership and Shareholding company with non-traded shares. Robust standard errors are clustered by Enterprise Surveys region and shown in parentheses. For variable definitions, see Table 1. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 6: What is the role of financing instruments other than bank credit?

Panel A: Investment finance

	(1) Internal funds	(2) Bank Credit	(3) Non Bank Credit	(4) Trade Credit	(5) Gov. grants	(6) Ex-post internal funds
Extreme weather loss	-0.109***	0.069**	-0.005	0.065***	0.003	-0.052***
	[0.029]	[0.029]	[0.006]	[0.022]	[0.005]	[0.018]
Obs.	8,285	8,285	8,285	8,285	8,285	8,285
Adj. R^2	0.180	0.166	0.234	0.187	0.093	
Firm Controls	✓	✓	✓	✓	✓	✓
Industry × Size × Country FE	✓	✓	✓	✓	✓	✓
Mean(dep. var.)	0.633	0.254	0.028	0.089	0.012	0.779

Panel B: Working capital finance

	(1) Internal funds	(2) Bank Credit	(3) Non Bank Credit	(4) Trade Credit	(5) Gov. grants	(6) Ex-post internal funds
Panel B1. Sub-sample of firms with fixed investments						
Extreme weather loss	-0.079***	0.060**	0.022*	0.028	0.019**	-0.051***
	[0.027]	[0.029]	[0.013]	[0.027]	[0.009]	[0.014]
Obs.	8,665	8,803	8,803	8,803	8,803	8,665
Adj. R^2	0.222	0.182	0.218	0.229	0.111	
Mean(dep. var.)	0.470	0.368	0.037	0.241	0.016	0.742
Panel B2. Sub-sample of firms with no fixed investments						
Extreme weather loss	-0.082***	0.079**	0.008	0.027	0.011	-0.062***
	[0.030]	[0.034]	[0.012]	[0.025]	[0.009]	[0.019]
Obs.	14,722	15,283	15,283	15,283	15,283	14,722
Adj. R^2	0.183	0.161	0.099	0.215	0.118	
Mean(dep. var.)	0.539	0.251	0.023	0.226	0.009	0.771
Firm Controls	✓	✓	✓	✓	✓	✓
Industry × Size × Country FE	✓	✓	✓	✓	✓	✓

Notes: This table reports estimates from survey-weighted linear probability models in columns (1) to (5) and the marginal effects from quasi-maximum-likelihood estimation in column (6). Panel A reports estimates on investments finance, while Panel B reports estimates on working capital finance. Dependent variables in columns (1) to (5) are dummy variables; the dependent variable in column (6) is a variable reporting the fraction of internal sources used by the firm to finance either investments or working capital needs. The regressor of interest is the dummy variable *Extreme weather loss* that is equal to one if the firm experienced monetary losses due to extreme weather events; zero otherwise. All regressions include firm-level controls (indicators for exporter status, listed firm, sole proprietorship, in partnership, audited financial accounts, female top manager, natural logarithm of firm age, selling main product in the local market, having a website, average the real annual sales growth of firms located in 50 km radius, and the log of manager's experience), industry-size-country fixed effects. Omitted category in firm ownership is Limited partnership and Shareholding company with non-traded shares. Robust standard errors are clustered by Enterprise Surveys region and shown in parentheses. For variable definitions, see Table 1. *** p<0.01, ** p<0.05, * p<0.1.

Table 7: How do the results vary with firm size?

Panel A: Corporate investments

	(1) Fixed Assets	(2) Land & buildings	(3) Machinery & equipment	(4) Green measures
Extreme weather loss	0.146***	0.106***	0.143***	0.029
	[0.041]	[0.038]	[0.041]	[0.042]
Extreme weather loss × Small-medium sized enterprises	-0.092**	-0.071*	-0.098**	0.097**
	[0.044]	[0.041]	[0.044]	[0.045]
Obs.	24,086	24,086	24,086	24,086
Adj. R^2	0.218	0.149	0.215	0.217
Firm Controls	✓	✓	✓	✓
Industry × Size × Country FE	✓	✓	✓	✓
Mean(dep. var.)	0.365	0.110	0.356	0.641

Panel B: Access to credit

	(1) Need loan	(2) Credit constrained	(3) Discouraged	(4) Rejected
Extreme weather loss	0.036	-0.044	-0.056	0.012
	[0.035]	[0.047]	[0.047]	[0.013]
Extreme weather loss × Small-medium sized enterprises	0.091**	0.011	-0.033	0.043
	[0.038]	[0.052]	[0.062]	[0.028]
Obs.	23,567	10,200	10,200	10,200
Adj. R^2	0.155	0.262	0.243	0.157
Firm Controls	✓	✓	✓	✓
Industry × Size × Country FE	✓	✓	✓	✓
Mean(dep. var.)	0.433	0.493	0.461	0.032

Notes: This table reports estimates from survey-weighted linear probability models. Panel A shows results for the interaction between losses due to extreme weather events and firm size -a dummy variable if the firm is defined as a SME. Panel B shows results for the interaction between losses due to extreme weather events and firm size -a dummy variable if the firm is defined as a SME. Estimation results in columns (2) to (4) of Panel B are based on the sample of firms that have a positive demand of bank credit. All regressions include firm-level controls (indicators for exporter status, listed firm, sole proprietorship, in partnership, audited financial accounts, female top manager, natural logarithm of firm age, selling the main product in the local market, having a website, average the real annual sales growth of firms located in 50 km radius, and the log of manager's years of work experience), industry-size-country fixed effects. Column (4) of Panel A include additional firm-level controls (indicators for payment of an energy levy, for being subject to energy standards, and for having a manager responsible for climate issues). Omitted category in firm ownership is Limited partnership and Shareholding company with non-traded shares. Robust standard errors are clustered by Enterprise Surveys region and shown in parentheses. For variable definitions, see Table 1. For readability, omitted variables due to collinearity are left out. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 8: Informal payments, investment and access to credit

Panel A: Corporate investment

	(1) Fixed assets	(2) Land & buildings	(3) Machinery & equipment	(4) Green measures
Informal payment	0.041	0.033*	0.046	0.011
	[0.035]	[0.017]	[0.034]	[0.036]
Obs.	15,518	15,518	15,518	15,518
Adj. R^2	0.237	0.168	0.239	0.222
Firm Controls	✓	✓	✓	✓
Industry × Size × Country FE	✓	✓	✓	✓
Mean(dep. var.)	0.391	0.106	0.378	0.644

Panel B: Access to credit

	(1) Need loan	(2) Credit constrained	(3) Discouraged	(4) Rejected
Informal payment	0.069**	0.048	-0.014	0.062*
	[0.033]	[0.058]	[0.062]	[0.034]
Obs.	15,168	6,809	6,809	6,809
Adj. R^2	0.164	0.282	0.269	0.186
Firm Controls	✓	✓	✓	✓
Industry × Size × Country FE	✓	✓	✓	✓
Mean(dep. var.)	0.425	0.476	0.436	0.039

This table compares our baseline results in columns 1-4, as in Table 3 and Table 5, with results in columns 5-8 where the regressor of interest is *Informal payment*, which identifies firms that experienced a liquidity shock, or monetary losses due to payment of bribes. We run a survey-weighted linear probability model in all columns. Estimation results in Panel B are based on the sample of firms that have a positive demand of bank credit. All regressions include firm-level controls (indicators for exporter status, listed firm, sole proprietorship, in partnership, audited financial accounts, female top manager, natural logarithm of firm age, selling main product in the local market, having a website, average the real annual sales growth of firms located in 50 km radius, and the log of manager's years of work experience), industry-size-country fixed effects. Omitted category in firm ownership is Limited partnership and Shareholding company with non-traded shares. In Panel A, columns 4 and 8, we additionally include indicators for payment of an energy levy, for being subject to energy standards, and for having a manager responsible for climate issues. Robust standard errors are clustered by Enterprise Surveys region and shown in parentheses. For variable definitions, see Table 1. *** p<0.01, ** p<0.05, * p<0.1.

Table 9: Falsification test: Panel sub-sample

Panel A: Corporate investments

	Fixed Assets		Land & buildings		Machinery & equipment	
	(1)	(2)	(3)	(4)	(5)	(6)
Extreme weather loss	0.117***		0.057***		0.113***	
	[0.025]		[0.020]		[0.025]	
Extreme weather $loss_{2013}$		-0.004		0.007		-0.005
		[0.025]		[0.020]		[0.025]
Obs.	5,210	5,216	5,210	5,216	5,210	5,216
Adj. R^2	0.183	0.130	0.113	0.071	0.180	0.130
Firm Controls	✓	✓	✓	✓	✓	✓
Industry × Size × Country FE	✓	✓	✓	✓	✓	✓
Mean(dep. var.)	0.328	0.420	0.108	0.139	0.318	0.411

Panel B: Access to credit

	Need loan		Credit constrained		Discouraged		Rejected	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Extreme weather loss	0.106***		-0.048		-0.048		0.001	
	[0.027]		[0.037]		[0.037]		[0.016]	
Extreme weather $loss_{2013}$		0.020		-0.043		-0.043		0.006
		[0.027]		[0.034]		[0.034]		[0.016]
Obs.	5,097	5,092	2,393	2,506	2,393	2,503	2,353	2,422
Adj. R^2	0.099	0.063	0.115	0.145	0.115	0.145	-0.018	0.005
Firm Controls	✓	✓	✓	✓	✓	✓	✓	✓
Industry × Size × Country FE	✓	✓	✓	✓	✓	✓	✓	✓
Mean(dep. var.)	0.470	0.489	0.486	0.366	0.486	0.366	0.036	0.044

This table reports estimates from survey-weighted linear probability models. Extreme weather loss is a dummy variable equal to 1 if the firm experienced a monetary loss due to extreme weather events over the three years before the fiscal year of reference -Enterprise Surveys 2019 wave; Extreme weather $loss_{2013}$ is a dummy variable equal to 1 for all firm that declared to have experienced a monetary loss due to extreme weather events (such as storms, floods, droughts, and landslides) in the Enterprise Surveys 2019 wave and for which we have data from 2013 Enterprise Surveys wave. Panel A reports estimates when studying corporate investments; Panel B reports estimates when studying access to bank credit. Estimation results in columns (3) to (8) of Panel B are based on the sample of firms that have a positive demand of bank credit. All columns include firm-level controls (indicators for exporter status, listed firm, sole proprietorship, in partnership, audited financial accounts, female top manager, natural logarithm of firm age, selling main product in the local market, having a website, and the log of manager's years of work experience), industry-size-country fixed effects. Omitted category in firm ownership is Limited partnership and Shareholding company with non-traded shares. We estimate robust standard errors. For variable definitions, see Table 1. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 10: Controlling for management practices

Panel A: Corporate investments

	(1) Fixed assets	(2) Land & buildings	(3) Machinery & equipment	(4) Green measures
Extreme weather loss	0.093***	0.076***	0.084**	0.121***
	[0.033]	[0.021]	[0.033]	[0.021]
Management practices	0.058***	0.029***	0.058***	0.048***
	[0.010]	[0.010]	[0.010]	[0.010]
Obs.	12,254	12,254	12,254	12,254
Adj. R^2	0.268	0.192	0.265	0.248
Firm Controls	✓	✓	✓	✓
Industry × Size × Country FE	✓	✓	✓	✓
Mean(dep. var.)	0.528	0.170	0.516	0.758

Panel B: Access to credit

	(1) Need loan	(2) Credit constrained	(3) Discouraged	(4) Rejected
Extreme weather loss	0.077**	0.009	-0.026	0.035**
	[0.034]	[0.038]	[0.034]	[0.016]
Management practices	0.022**	-0.012	-0.005	-0.007*
	[0.010]	[0.019]	[0.019]	[0.004]
Obs.	11,906	5,401	5,401	5,401
Adj. R^2	0.175	0.316	0.323	0.204
Firm controls	✓	✓	✓	✓
Industry × Size × Country FE	✓	✓	✓	✓
Mean(dep. var.)	0.465	0.357	0.330	0.026

This table reports estimates from survey-weighted linear probability models. The regressor of interest is the dummy variable *Extreme weather loss* that is equal to one if the firm experienced monetary losses due to extreme weather events; zero otherwise. Panel A reports estimates when analysing corporate investments; Panel B reports estimates when analysing access to bank credit. Estimation results in columns 2 to 4 of Panel B are based on the sample of firms that have a positive demand of bank credit. All columns include firm-level controls (indicators for exporter status, listed firm, sole proprietorship, in partnership, audited financial accounts, female top manager, natural logarithm of firm age, selling main product in the local market, having a website, average the real annual sales growth of firms located in 50 km radius, and the log of manager's years of work experience), industry-size-country fixed effects. Omitted category in firm ownership is Limited partnership and Shareholding company with non-traded shares. Robust standard errors are clustered by Enterprise Surveys region and shown in parentheses. For variable definitions, see Table 1. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 11: Alternative clustering of standard errors

Panel A: Corporate investments

	(1) Fixed Assets	(2) Land & buildings	(3) Machinery & equipment	(4) Green measures
Extreme weather loss	0.060***	0.040***	0.051***	0.135***
	[0.019]	[0.013]	[0.018]	[0.023]
Obs.	24,085	24,085	24,085	24,085
R^2	0.022	0.010	0.020	0.027
Firm controls	✓	✓	✓	✓
Industry × Size × Country FE	✓	✓	✓	✓
Mean(dep. var.)	0.391	0.106	0.378	0.644

Panel B: Access to credit

	(1) Need loan	(2) Credit constrained	(3) Discouraged	(4) Rejected
Extreme weather loss	0.120***	-0.034	-0.087**	0.052**
	[0.021]	[0.028]	[0.036]	[0.021]
Obs.	23,564	10,139	10,139	10,139
R^2	0.010	0.017	0.019	0.019
Firm controls	✓	✓	✓	✓
Industry × Size × Country FE	✓	✓	✓	✓
Mean(dep. var.)	0.425	0.476	0.436	0.039

This table reports estimates from survey-weighted probability models but correcting standard errors for spatial correlation. We correct standard errors' estimation by using the acreg Stata command by following Colella et al. (2019). Standard errors are computed by correcting for arbitrary cluster correlation within 10 km radius of distance among firms. All regressions include firm-level controls (indicators for exporter status, listed firm, sole proprietorship, in partnership, audited financial accounts, female top manager, natural logarithm of firm age, selling main product in the local market, having a website, average the real annual sales growth of firms located in 50 km radius, and the log of manager's years of work experience), industry-size-country fixed effects. Omitted category in firm ownership is Limited partnership and Shareholding company with non-traded shares. In Panel A column (4), we additionally include indicators for payment of an energy levy, for being subject to energy standards, and for having a manager responsible for climate issues. For variable definitions, see Table 1. *** p<0.01, ** p<0.05, * p<0.1.

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How do firms cope with losses from extreme weather events?

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