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Thermal stress and financial distress: Extreme temperatures and firms' loan defaults in Mexico*

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Abstract

The frequency and intensity of extreme weather events are likely to increase with climate change. Although a growing body of literature shows that extreme weather has a negative impact on economic outcomes, there is lack of evidence about how it affects firm's credit delinquency and credit use. This question is relevant for Low and Middle Income Economies, where institutions are frequently less prepared to deal with informational asymmetries and credit market are frequently shallow. We fill this gap by exploiting an extraordinarily detailed data set with loan-level information for the universe of loans extended by commercial banks to private firms in Mexico. Exploiting differences across Mexican counties over time, we find that anomalous days of extreme temperature increase the rate of non-performing loans and that this result is mainly driven by extreme heat. The effect is concentrated in the agricultural sector but there is also a non-negligible impact on the non-agriculture industries that are more dependent on local demand. Our results are consistent with general equilibrium effects originated in agriculture that expand to non-agriculture sectors in agricultural regions.

JEL-codes: D25; Q54; Q14.
Keywords: Extreme temperatures, Default, Firm credit, Agriculture.

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1 Introduction

Global temperatures have registered the highest level in the last decade since the 1850s, and the frequency and intensity of extreme temperatures are likely to increase in the future with climate change (IPCC, 2021). This outlook has risen concerns about the potential impacts of extreme weather, particularly in low- and middle-income economies (LMIEs), where the equipment to cope with environmental insults is scarce and the resources to invest in adaptive technologies are few (Dell *et al.*, 2012; Oppenheimer *et al.*, 2014; Burke *et al.*, 2015; Carleton and Hsiang, 2016; Hsiang *et al.*, 2019). In the economic arena, recent studies suggest that extreme weather events increase firms costs and reduce local demand. There is evidence that these events diminish agricultural yields, reduce labor productivity, increase absenteeism, diminish local spending and, when they induce adaptation, they raise operational costs (Graff Zivin and Neidell, 2014; Blanc and Schlenker, 2017; Jessoe *et al.*, 2018; Zhang *et al.*, 2018; Colmer, 2021; Somanathan *et al.*, 2021; Addoum *et al.*, 2021).[1]

These impacts on costs and demand may create liquidity shortages for firms that may turn into solvency problems, especially for small and medium-sized enterprises (SMEs). SMEs have a more limited access to credit than large firms, and thus they find it more difficult to cope with liquidity shortages (Gourinchas *et al.*, 2020; Eggers, 2020). Furthermore, access to credit is more limited in LMIEs, where credit markets are shallow and institutions are less prepared to deal with informational asymmetries (Beck *et al.*, 2004; Djankov *et al.*, 2007; Calomiris *et al.*, 2017; Gutierrez *et al.*, 2021).[2] All in all, this suggests that SMEs may not obtain the financing they need to cope with the negative effects of extreme weather in LMIEs, and this impossibility may lead them to default on their loans.

Thus, in this paper we investigate the effects of extreme weather events on credit default and credit use of SMEs in Mexico, a middle-income economy. Finance is vital for SMEs growth in developing countries, where these enterprises are the primary source of employment and job creation (Ayyagari *et al.*, 2012; Beck *et al.*, 2004).[3]

[1]See Dell *et al.* (2014) for an earlier review of this literature.

[2]SMEs in these countries face higher interest rates and larger credit constraints. In Mexico, where we focus our study, 36.8 percent of SMEs needed external financing in 2018 but did not use banking credit because their applications were rejected or because the offered interest rate was too high, compared to only 3 percent of large firms (INEGI, 2019).

[3]Failure to timely repay debts denotes financial stress at the time of default. Delinquency can also deteriorate firms' future access to credit, for example, because credit scores are downloaded after a default. In Mexico, any default is part of the firm's credit history, and its record is kept in the credit bureau up to six years. All commercial banks have access to the same information independently of the institution that granted the defaulted loan. In our sample, only around 10% of SMEs that default a loan regain access to new credit in the following 12 months, as opposed to 70% of SMEs that do not default. For other countries, Bonfim *et al.* (2012) shows that after a default episode in Portugal, it is particularly difficult to regaining access to credit for small firms who borrow from only

To the best of our knowledge, this is the first paper to study the impact of extreme temperatures on credit performance of firms of any size, and therefore, the first one to study credit delinquency of SMEs in a middle-income economy.

To analyze these effects, we exploit an extraordinarily detailed dataset with loan-level information for the universe of loans extended by commercial banks to private firms in Mexico between 2010 and 2018. This dataset enables us to identify loans for which the borrower was not able to meet its loan obligations (i.e., non-performing loans), to distinguish between large and small and medium-sized firms, to classify loans by the firm's industry and to identify the municipality where each loan is used.[4]

To measure exposure to extremes, we follow Addoum *et al.* (2020) and Somanathan *et al.* (2021) and define absolute extreme temperature thresholds. In particular, our exposure variable is defined as the number of days in a quarter that minimum and maximum temperature are below 3°C and above 36°C, respectively, which correspond to the bottom 5 percent and the top 5 percent of daily minimum and maximum temperature distribution in the country. The use of absolute thresholds enables us to capture extremes that may be masked using average measures. In the robustness section we also test the sensibility of our results to the definition of alternative absolute thresholds as well as relative thresholds that depend on municipality-specific daily minimum and maximum temperature distribution.

We build delinquency rates as the ratio of non-performing loans to outstanding credit (the sum of performing and non-performing loans). We then construct quarterly delinquency rates at the municipality level and relate them to the number of anomalous days of extreme temperature that occurred in a given municipality and quarter. The identification strategy relies on the assumption that these extreme temperatures shocks (i.e., the number of anomalous days of extreme temperature) are exogenous after controlling for seasonality and smooth time trends specific to each municipality, as well as for national-level changes in credit delinquency rates over time.

The results show that extremely hot days increase the credit delinquency rates of SMEs but not those of large firms. Specifically, for every ten days of exposure to unusual extreme heat in a quarter, the delinquency rate of SMEs increases by 0.16 percentage points (8% of the sample mean). On the contrary, none of the specifications yields a statistically significant result for the case of large firms. This finding is consistent with the idea that extreme weather events have a negative impact on loan defaults of SMEs because these firms are less-equipped to deal with extreme

one bank. Likewise, de Roux (2021) finds that coffee farmers in Colombia that incur in default due to extreme precipitation are more often denied loan applications in the future, even when they have recovered their ability to repay.

[4]Municipalities are the second-level administrative units (after states) in Mexico.

temperatures and because they find it more difficult to access further credit in times of financial stress in LMIEs. The outcomes are robust to using different thresholds for the definition of extreme temperature events, as well as to including lagged shocks.

Since delinquency rates are constructed as the ratio of non-performing loans to outstanding credit, they may increase due to a rise in non-performing credit, a reduction in performing credit, or both. Thus, we further investigate the sources of increased default. The results show that credit delinquency rates increase because non-performing loans of SMEs (defaults) rise, that is, SMEs fail to honor their obligations. Extreme weather events have no statistically significant impact on performing loans that is consistent with the idea that total credit to SMEs does not increase to alleviate negative effects of extreme weather. In contrast with the evidence found for the US, according to which firms use credit lines to buffer against liquidity shortages during extreme weather (Brown *et al.*, 2021; Collier *et al.*, 2020), Mexican SMEs do not seem, then, to smooth their cash flows with new loans.

We also investigate potential heterogeneous impacts of extreme temperatures across industries and regions. Temperature shocks affect economic outcomes through several channels, some of which are stronger for some industries than for others, and have different implications for extreme heat and extreme cold. First, weather is used as direct input in the process of plant growth, and thus extreme heat has a particularly sizeable impact on agriculture (Mendelsohn *et al.*, 1994; Blanc and Schlenker, 2017). Second, extreme heat reduces task efficiency and hours worked because it creates fatigue and cognitive impairment. However, the evidence is less conclusive for extreme cold (Colmer, 2021; Graff Zivin and Neidell, 2014; Hsiang, 2010; Somanathan *et al.*, 2021). Finally, thermal stress creates discomfort and diminishes demand. These effects are larger for leisure and outdoor activities, such as shopping, dining, traveling and personal services (Addoum *et al.*, 2021; Chan and Wichman, 2021).

Consistent with these mechanisms, we find that the negative impacts of extreme heat are stronger in agriculture. Interestingly, however, in regions with a sufficiently large proportion of agricultural workers, extreme heat also has sizeable effects in non-agricultural industries. These effects are concentrated in services and retail, that is, non-tradable sectors that rely heavily on local demand. The results are, then, suggestive of spillovers effects originated in agriculture that expand to non-agriculture industries through reduced local spending. Hence, our outcomes suggest that extreme heat is damaging not only for agriculture but also for non-tradable industries.

For extreme cold, there is a relatively small effect on delinquency rates in non-tradable industries, which is consistent with the possibility that consumer discomfort reduces the demand for leisure activities during cold days. It is also consistent with existing evidence that outdoor leisure activities are more sensitive to extreme cold than extreme heat (Graff Zivin and Neidell, 2014; Chan and Wichman, 2021).

Mexico is an ideal setting for this type of study for several reasons. First, the high quality of the bank-loan level data covering the universe of firms with bank loans in Mexico provides information that is usually scarce. These data allow us to circumvent identification problems that are common in studies with survey data, such as measurement error, and external validity challenges that arise in studies with restricted samples of firms. Second, as in other LMIEs, employment and job creation in Mexico are disproportionately dependent on SMEs. Third, the service, retail and agricultural sectors are among the industries that hire more workers in Mexico, for example, the median share of employment in the agricultural sector is about a third of the total employment across Mexican municipalities. Finally, the variation in degrees of economic development across Mexican regions allows us to study effects in heterogeneous areas, so that our results shed light on the potential importance of extreme weather events for other countries.

This paper contributes to a growing literature studying the impact of weather shocks on economic outcomes. Closely linked to our study, Addoum *et al.* (2020) analyze the detrimental effect of extreme temperatures on firms' sales, Graff Zivin and Neidell (2014) and Colmer (2021) study labor allocation responses, Somanathan *et al.* (2021) analyzed the effect on labor productivity and Blanc and Schlenker (2017) discuss the literature analyzing impacts on agricultural yields. We show that the economic effects found in this literature affect firms' ability to meet their loan obligations. An additional contribution of this paper is that we exploit differences not only across locations but also across economic sectors. We believe that this additional dimension of analysis is relevant to inform about the heterogeneity of the effects and the corresponding design of climate adaptation policies in LMIEs (Davlasheridze and Geylani, 2017; Kousky, 2014).[5]

In addition, our study contributes to the emerging literature on the effect of climate on financial outcome. Following the increased interest of policy-makers (Bolton *et al.*, 2020; Semenenko and Yoo, 2019; Furukawa *et al.*, 2020; IMF, 2019), a number of studies have emphasized this effect. Brown *et al.* (2021) find that the loans obtained by small solvent firms in the aftermath of abnormal snow in the US had shorter maturities and higher interest rates. Collier *et al.* (2020) show that the loan applications of firms that were negatively affected by a hurricane were more likely to be denied or be

[5]A limitation of our study is the interpretation of our estimates in the context of long-term permanent changes in climate such as expected increases of warm days and nights across the globe (IPCC, 2021). To the extent that there exists a potential for long-run adaptation that can mitigate adverse effects from extreme temperature, our estimates would overstate the impact of future climate change. Although hybrid approaches that aim to assess both short and long-run consequences of extreme events are emerging (Kolstad and Moore, 2020), the results from our current empirical setting are best interpreted in the context of near-future occurrence of unexpected extreme events.

granted at a higher cost. Gallagher and Hartley (2017) show that homeowners in the most flooded areas of New Orleans used insurance payouts to pay off mortgages after hurricane Katrina. Inundated residents ten years after this hurricane had higher insolvency rates and lower home-ownership than their non-flooded neighbors (Bleemer and van der Klaauw, 2019). In the context of a LMIE, de Roux (2021) finds that the probability of defaulting loans among Colombian coffee farmers increases upon exposure to extreme precipitation. While the contribution of these studies to a better understanding of financial climate-related risks is indisputable, none of these papers investigated the effect of these temperatures on firms' loan defaults in a LMIE.[6]

The remainder of this paper is organized as follows: Section 2 describes the Mexican context and theoretical predictions based on previous literature. Section 3 describes the data used in our analysis. Section 4 lays out our empirical strategy. Section 5 presents the main results while Section 6 display heterogeneous effects by sector and region that shed light on the potential mechanisms driving our results. Section 7 shows a series of robustness checks. Section 8 concludes.

2 Background and theoretical predictions

2.1 The Mexican context

The climate of Mexico is highly diverse due to its sizeable territorial extension, seven mountain ranges, and 9,330-kilometer coastline. The Tropic of Cancer effectively divides the country into temperate and tropical zones. Land north of the twenty-fourth parallel experiences lower temperatures during the winter months. South of the twenty-fourth parallel, temperatures are relatively consistent all year round and vary solely as a function of elevation. Notably, due to its location in the Tropic of cancer, the variety of climatic conditions still ranges within what would be considered warm temperatures. As shown in Figure 1, minimum temperatures range between -10°C and 40°C, with 95% of daily minimum temperatures being higher than 3°C while virtually all the maximum temperatures reached in the period 2010-2018 were registered above 10°C.

[6]Another set of papers also analyze the impact of extreme climate events on financial intermediaries. Schüwer *et al.* (2019) found that small US banks increased risk-based capital ratios to buffer against future shocks, and this increase tightened credit constraints. Brei *et al.* (2019) found that it was a reduction in the capitalization of banks that drove credit crunches after hurricanes in Caribbean countries. Cortés and Strahan (2017) and Koetter *et al.* (2020) investigated the effect of floods on credit reallocation and mortgages' use and conditions. Bayangos *et al.* (2021) showed that extreme precipitation events increased banks' default rates in the Philippines, and Klomp (2014) found that natural disasters reduced a banking sector's distance to default. For the effects of climate phenomena on repricing of real estate and on firms' stock prices, see Bunten and Kahn (2014); Ortega and Taspinar (2018); Hallstrom and Smith (2005); Bakkensen and Barrage (2017); Bernstein *et al.* (2019); Baldauf *et al.* (2020); Hino and Burke (2020); Bansal *et al.* (2016); Hong *et al.* (2019).

Mexico is a desirable setting to study the effects of extreme temperatures on credit default and credit use. Being among the 15 largest countries globally regarding territorial extension, Mexico encompasses different regions that present diverging degrees of economic development and industrial composition. During 2013-2017, the contribution of industries highly sensitive to weather such as agriculture, fishing and agribusiness to the national GDP was 7.6 percent (SAGARPA, 2017). While this figure may not seem particularly large, the median share of employment in the agricultural sector is about a third of the total employment across Mexican municipalities which may ease the propagation of negative effects into other industries.

LMIEs have lower saving rates than rich countries and their institutions are less prepared to deal with informational asymmetries. Thus, SMEs face worse credit conditions and greater credit constraints than large firms in their own countries and than other SMEs in rich nations (Gutierrez *et al.*, 2021). According to a recent survey, 36.8 percent of Mexican SMEs needed external financing in 2018 but did not use banking credit because their applications were rejected or because the offered interest rate was too high, compared to only 3 percent of large firms (INEGI, 2019). In other Latin American countries, Eastern Europe and Central Asia, SMEs also report being credit constrained (Kuntchev *et al.*, 2013). Moreover, lack of credit access and inadequate credit conditions are an important obstacle for SMEs growth in LMIEs (Ayyagari *et al.*, 2012).

Thus, the relevance of looking at SMEs in LMIEs cannot be stressed enough. In Mexico, SMEs represent 99.8 percent of all firms and employ more than two-thirds of the labor force. Although not the focus of this study, it is noteworthy that loan defaults can affect future access to credit for SMEs (Bonfim *et al.*, 2012; de Roux, 2021). In Mexico, any default is part of a firm's credit history, and its record is kept in the credit bureau for up to six years. All commercial banks have access to the same information independently of the institution that granted the defaulted loan. In our sample, only around 10% of SMEs that default a loan regain access to new credit in the following 12 months, as opposed to 70% of SMEs that do not default.

2.2 Theoretical predictions

There is vast evidence that extreme temperatures can impose deleterious effects on economic outcomes increasing firms cost and reducing firms demand (Dell *et al.*, 2014). These channels can have heterogeneous impacts depending on firms' industry and local market where they operate, as well as on their size. In addition, hot and cold extremes may be more harmful for some industries than for others. In this section we summarize findings from the literature that are relevant to our research question and context to motivate the potential channels upon which temperatures may harm the financial performance of firms. Importantly, these findings inform about the relevant dimensions of heterogeneity that we explore in our results.

We begin this section by discussing a labor productivity channel that is common to all industries. It has been shown that thermal stress creates discomfort, fatigue and cognitive impairment and thus may reduce hours worked and task efficiency (Colmer, 2021; Graff Zivin and Neidell, 2014; Hsiang, 2010; Somanathan *et al.*, 2021). Negative effects of extreme temperatures on labor productivity and absenteeism are expected to be larger for workers that are more exposed to weather such as those in agriculture, mining, construction and transportation (Graff Zivin and Neidell, 2014).

In the case of manufacture and other industries that are in principle less exposed to ambient temperatures, actual exposure partially depends on climate control technologies in place. For instance, Somanathan *et al.* (2021) find that productivity declines and absenteeism rises in Indian manufacturing in weeks with more days of extreme heat. They also find mixed evidence regarding the alleviating effect of indoor climate control in the workplace. While climate control dampens the negative effect on productivity, it does not mitigate the adverse impact on absenteeism. They interpret this result as evidence that extreme heat creates discomfort and affects health at home and during commutes. Existing evidence is less conclusive about the effect of extreme cold on labor productivity and absenteeism, so that the labor productivity channel may emerge more clearly in our data for extreme heat.[7]

In the case of agriculture, productivity may decline when workers are highly exposed to ambient temperatures, as in other industries. Furthermore, due to the role of weather as a direct input into plant growth, yields in this sector can deteriorate through an additional channel. Therefore, it is not surprising that the sensitivity of agriculture to temperature has been long studied (Mendelsohn *et al.*, 1994; Blanc and Schlenker, 2017). For instance, Schlenker and Roberts (2009) find harmful effects on crop yields in the US and Cui (2020) finds, in addition, negative impacts on crop abandonment (areas not harvested). In these studies there is not evidence of detrimental effects of cold temperatures in the US growing season (Spring through Fall).[8] Hence, we hypothesize that in our data the agricultural yield channel may materialize more clearly upon exposure to extreme heat than extreme cold.

Extreme temperatures may also create consumer discomfort, reduce the appeal of outdoor leisure activities and thus also reduce their demand. Conversely to the

[7] Zhang *et al.* (2018) find that the output of Chinese manufacturing firms responds negatively to cold temperatures, but only at extremely low levels that are not typically observed in the Mexican territory.

[8] Because the number of days with low temperatures is not negligible in the relatively warmer season on which these studies concentrate, the lack of effects is unlikely to be driven by a loss of precision due to low level of exposure to cold days that could increase standard errors.

labor and land productivity channels, empirical evidence supports the idea that discretionary consumer demand is responsive to low temperatures. For example, in their study on earnings from 60 industries across four seasons Addoum *et al.* (2021) finds that unusually hot seasons do not reduce earnings of firms in the leisure and travel industries, but unusually cold seasons do, mainly due to revenue declines. This is in line with the results in Graff Zivin and Neidell (2014) and Chan and Wichman (2021) who find that time allocated to outdoor leisure tends to fall with low temperatures.[9] Based on this evidence, we hypothesize that the consumer discomfort channel may emerge emerge more clearly on days with extreme cold.

Another mechanism that is common to all industries is the increase in operating costs. While harmful effects of extreme temperatures, and heat in particular, may be partially contained by the implementation of protective measures such as air conditioning, this type of adaptation may require substantive investments and may significantly increase costs. Indeed, indirect evidence from the US shows that sales from the energy sector increase during unusually cold and hot seasons (Addoum *et al.*, 2021; Auffhammer *et al.*, 2017). In the case of agriculture, protective measures such as irrigation and crop substitution may limit the negative effects of extreme heat as Cui (2020) finds. These adaptation strategies are also costly to put in place and operate. In the case of extreme cold, restaurants, hotels and other leisure related activities may also increase heating expenditures to ameliorate its impact on customers' thermal discomfort. We hypothesize that the operating cost channel could affect all industries and could activate upon exposure to either heat or cold extremes.

In addition to the direct effects of extreme temperatures on productivity and demand, indirect effects can emerge from spillover effects originated in a particular sector. Extreme temperatures may reduce wages and employment in agriculture, and these reductions may diminish local spending in other industries (Jessoe *et al.*, 2018). These spillover effects are expected to be larger for non-tradable activities that depend strongly on local income, such as retail, services, and construction. Conversely, non-agricultural tradable industries, mainly manufacturing, may be more resilient.[10]

Finally, firm size matters since SMEs tend to lack risk management systems (Asgary *et al.*, 2020), lack internal resources (Eggers, 2020) and are typically more credit constrained, particularly in LMIEs (Gourinchas *et al.*, 2020; Chodorow-Reich

[9] Chan and Wichman (2021) finds that among eight outdoor recreation categories, only time allocated to boating, fishing and hiking falls with higher temperatures. In another study for cities in Canada, Unites States and Mexico, these authors find that cold temperatures reduce cycling time but that bikers respond to days with heat extremes only through modification of their intraday scheduling of cycling towards cooler times (Chan and Wichman, 2020).

[10] The tradable sector might even benefit slightly from a decline in agricultural employment. (Colmer, 2021) finds that manufacturing benefited by absorbing excess labor in the agricultural sector in India after a temperature shock, but only in regions with more flexible labor markets.

et al., 2021). Thus, SMEs are less likely to be equipped with costly protective measures that can mitigate the negative impacts of extreme temperatures such as irrigation and indoor climate control. Indeed, as mentioned earlier, days with extreme heat have a smaller negative effect on the productivity of industries that use air conditioning more intensively compared to industries in which climate control equipment is uncommon (Somanathan *et al.*, 2021). Hence, we hypothesize that small firms may suffer more from extreme temperature shocks than large firms, and that the main driver of changes in delinquency rates upon extreme temperature shocks will be an increase in non-performing loans.

3 Data and descriptive statistics

To evaluate the relationship between extreme temperature and delinquency rates in Mexico, we use a proprietary data set from the country's central bank (Banco de Mexico, Banxico). This data contains detailed information on the universe of credit lines issued by private banks to firms in the country during the period January 2010-December 2018. All commercial banks are mandated to submit monthly reports to the regulator, the National Banking and Values Commission (Comisión Nacional Bancaria y de Valores, CNBV), with detailed information about all new and existent loans extended to firms in the country, regardless of firm and loan size. .

For each loan, a large set of characteristics is reported. Importantly for the purpose of this study, for each loan we observe the firm's location (municipality) and economic sector, the loan size and whether the loan is non-performing or not. Non-performing loans refer to loans in which the borrower is unable to meet its obligations for a specific period.[11]

In our main specifications, non-performing loans are normalized by total outstanding credit that includes both performing and non-performing loans. This normalization results in a ratio that is equivalent to the delinquency rate, an indicator that is widely used for monitoring financial systems around the globe (also known as default rate or non-performing loans to total gross loans ratio).[12]

[11] Banks self-report if a loan is non-performing. According to regulatory norms, a loan should be classified as non-performing if its payment date has been past due for a certain period of time, which is defined between 1 to 90 days depending on loan's characteristics (e.g., amount and repayment time).

[12] The ratio of nonperforming loans to total gross loans is part of the International Monetary Fund Financial soundness indicators. It is calculated by using the value of nonperforming loans (NPLs) as the numerator and the total value of the loan portfolio (including NPLs, and before the deduction of specific loan- loss provisions) as the denominator. Our classification of NPLs is in accordance to that from IMF (2019) that defines them "...as those loans for which (1) payments of interest or principal are past due by 90 days or more; or (2) interest payments equal to 90 days or more have been capitalized (reinvested into the principal amount), refinanced, or rolled over (payment delayed

We define small firms based on their credit history. A firm is considered SME if it has never obtained a credit for more than 100 million pesos at 2018 constant prices (approximately 5 million USD in 2018). The central bank commonly uses this definition of SMEs in its flagship reports. Since the municipality is the most granular level for which we can identify firms' location in the loan database, we aggregate these data at the quarterly municipality-level to construct delinquency rates for subsamples of the data based on firms' size, economic sector and type of region.

To measure local exposure to extreme temperature, we use data from NASA's Oak Ridge National Laboratory (ORNL). The Daymet data product is derived from a collection of algorithms designed to interpolate and extrapolate daily meteorological observations to produce gridded estimates of daily weather indicators. Daymet data includes daily minimum and maximum temperature measures on a 1km x 1km gridded surface. We process this information and construct municipality-level variables by obtaining the average maximum and minimum temperature for the municipality surface. Additionally, daily data on precipitation is obtained from the ERA5 dataset, a data product from the European Centre for Medium-Range Weather Forecasts. The data covers the surface of interest on a 30km grid. Monthly total rainfall at the municipality level was calculated by overlaying the municipality polygons to the gridded data.

Figure 1 shows the distribution of maximum and minimum daily temperatures at the municipality level in Mexico. The figure reveals some general aspects of temperature extremes in the country: First, both minimum and maximum temperatures are centered at relatively mild levels (at about 12°C and 30°C, respectively). Second, minimum temperatures seem to be more variable compared to maximum temperatures. Third, extreme cold temperatures, defined by those below the 5% percentile of the minimum daily temperature distribution or 3°C, may not represent a threat to economic activity (especially as these temperatures typically occur during the early morning). Fourth, extreme hot temperatures, defined by those above the 95% percentile of the maximum daily temperature distribution or 36°C, exceed the temperature at which detrimental effects on health, labor, and land productivity have been documented. In general, the figure shows that Mexico tends to be more exposed to harmful extreme heat than to extreme cold temperatures.[13]

by agreement); or (3) evidence exists to reclassify them as nonperforming even in the absence of a 90-day past due payment, such as when the debtor files for bankruptcy. The amount of loans recorded as non-performing should be the gross value of the loan as recorded on the balance sheet, not just the overdue amount."

[13]Extreme hot temperatures lie within a range for which there are negative impacts through the channels discussed in Section 2.2. In particular, agricultural yields (34 C) (Schlenker and Roberts, 2009), labor productivity (33 C) (Somanathan *et al.*, 2021), labor supply (37 C) (Graff Zivin and Neidell, 2014; Somanathan *et al.*, 2021), and electricity consumption (27 C) (Auffhammer *et al.*, 2017) are all negatively affected by extreme heat. For extreme cold, the threshold lies within a range for

Finally, to distinguish between agricultural and non-agricultural municipalities, we use individual-level occupation data from the Mexican Census conducted in 2010 by the Mexican Statistics and Geography Institute (Instituto Nacional de Estadística, Geografía e Informática, INEGI). This information corresponding to the first year for which we have data on credit at the local level. From this Census, we define agricultural municipalities as those for which employment in agriculture is above our sample's median (28 percent).

Table 1 shows sample means and standard deviations of the variables used for all municipalities in our sample, and for two sub-samples distinguished by the percentage of agricultural employment in the municipality. Mean temperatures also indicate the presence of relatively mild weather across the territory. However, the number of days with extreme temperatures is non-negligible and highly variant. This pattern is also present in the two sub-samples. However, mean temperature is slightly higher and the mean number of days with extreme temperature is slightly smaller in municipalities with a large share of agricultural employment. Abstracting from any other differences between the two sub-samples, this characterization suggests that slightly warmer and more stable regions are more suitable for agricultural activity.

The table also shows that delinquency rates in all sectors are about 2% in both groups of municipalities, but they are larger for agricultural firms that hold an economically relevant share of the credit (12.6%). Looking at differences across groups of municipalities, delinquency rates in agricultural (non-agricultural) sectors are more extensive in municipalities with higher (smaller) agricultural employment shares. This difference may suggest that in municipalities specialized in industries different from that of borrowers', relatively less risky firms have access to credit. As it would be expected, the percentage of credit in agricultural sectors is larger in municipalities with more agricultural employment.

4 Empirical Framework

The goal of our empirical strategy is to quantify the impact of days of extreme temperature on credit delinquency. To define days of extreme temperature, we first obtain the daily distribution of minimum and maximum temperatures of all municipalities

which there are negative impacts over some dimensions but not all. There is no consistent evidence of an effect of cold extremes on agricultural yields (Schlenker and Roberts, 2009), labor productivity (Somanathan *et al.*, 2021) and labor supply (Graff Zivin and Neidell, 2014). Conversely, there is indication that outdoor leisure (10 C) (Chan and Wichman, 2021; Graff Zivin and Neidell, 2014) and electricity consumption (4 C) (Auffhammer *et al.*, 2017) are responsive to cold extremes. This tendency of extreme heat to negatively affect economic outcomes through more channels compared to extreme cold is consistent with findings from studies that find no effect of cold temperatures on aggregate economic output (Burke *et al.*, 2015; Burke and Tanutama, 2019).

in Mexico during 2010-2018. Then, following Addoum *et al.* (2020) and Somanathan *et al.* (2021) we use absolute thresholds for daily minimum and maximum temperatures, that is, thresholds that are common to all municipalities.[14] In particular, we consider that a municipality was exposed to extreme cold if the minimum temperature during the day dropped below the fifth percentile of the minimum temperature distribution, equal to 3°C. Similarly, we consider that a municipality was exposed to extreme heat if the maximum temperature rose above the 95th percentile of the maximum temperature distribution, equal to 36°C. Section 6 shows that our results are robust to defining different absolute thresholds (e.g., 2.5 -97.5th percentiles and 1-99th percentiles of the minimum-maximum daily temperature distribution) and to defining municipality-specific thresholds based on the distribution of daily temperature within municipalities, known as relative temperature shocks.[15]

Our main empirical specification is defined as follows:

$$Delinquency_{mqy} = \beta_1 * DaysExtremeTemp_{mqy} + \gamma_{my} + \delta_{mq} + \theta_{qy} + \epsilon_{mqy}, \quad (1)$$

where $Delinquency_{mqy}$ is the delinquency rate of municipality m in the last month of quarter q of year y, $DaysExtremeTemp_{mqy}$ is the number of days of extreme temperature of municipality m during quarter q of year y; γ_{my} are municipality by year fixed effects; δ_{mq} are municipality by quarter fixed effects; and θ_{qy} are quarter by year fixed effects.

The municipality by year fixed effects are included to flexibly control for trends at the municipality level. For instance, time-trending variables such as migration, technological changes and public safety at the municipality level, which may be correlated with both delinquency rates and extreme temperature, are captured by these fixed effects. In addition, the municipality by quarter fixed effects control for municipality-specific seasonality in the exposure to extreme days, which could be important for municipalities with a larger share of firms in seasonal sectors like those related to tourism or agriculture. Finally, the quarter by year fixed effects control for national-level variations over time (common shocks across municipalities). In all

[14] A subset of the literature uses a flexible function of temperature bins to characterize the impacts of weather on relevant economic outcomes. For instance, (Deryugina and Hsiang, 2014) use 3°C bins to estimate the effect of daily temperature on annual income in United States, and Schlenker and Roberts (2009) use 1°C bins to calculate the climate-agricultural production relation. The goal of our paper is qualitatively different to that line of work: while such studies seek to characterize the temperature-outcome relationship, we seek to estimate how firms deal with the cumulative impact of extreme temperatures, hence we count the days per quarter that they are exposed to extreme heat and cold.

[15] The robustness of our results when using relative temperature shocks is reassuring. Our main results are based on specifications that use the definition of days with extreme temperatures obtained from absolute thresholds to facilitate comparability to other research considering different periods and regions of analysis.

the regressions presented in the paper we also control for average precipitation at the municipality level in each quarter.

The coefficient of interest is β_1, which measures the percentage point change in delinquency rates for each day of anomalous extreme temperature. Note that the variation exploited is the difference in the number of days with extreme temperature with respect to the municipality-quarter-specific historical averages, after controlling for yearly changes.

In order to investigate whether the impact of extreme temperatures differ between extreme hot and extreme cold days, we run regressions of the following form:

$$\begin{aligned} Delinquency_{mqy} =& \beta_1 * DaysExtremeHeat_{mqy} + \beta_2 * DaysExtremeCold_{mqy} \\ &+ \gamma_{my} + \delta_{mq} + \theta_{qy} + \varepsilon_{mqy}, \end{aligned} \tag{2}$$

where β_1 and β_2 measure the effect of each additional anomalous day of extreme heat and cold on firms' delinquency rate, respectively.

Further, in order to explore whether the impact of the number of days with extreme temperatures on our outcomes of interest is non-linear, we run regressions of the following form:

$$\begin{aligned} Delinquency_{mqy} =& \gamma_{my} + \delta_{mq} + \theta_{qy} + \beta_1 * (1 < DaysExtreme <= 10)_{mqy} + \\ & \beta_2 * (10 < DaysExtreme <= 20)_{mqy+} \\ & \beta_3 * (DaysExtreme > 20)_{mqy+} + \varepsilon_{mqy}, \end{aligned} \tag{3}$$

where the three explanatory variables included take value of one if the number of extreme temperature days a municipality-quarter is between 2 and ten, between eleven and twenty, and higher than twenty, respectively. Each of the point estimate is interpreted in relation to the omitted category, that is 0 or 1 day of exposure to extreme temperature.

5 Main Results

We start by presenting the results of the main specifications for all firms and for large and small firms separately. Table 2 shows combined results for any extreme temperature and distinguishing between extreme heat and extreme cold. Specifically, the first line shows the outcomes for equation 1 and the second and third lines show the outcomes for equation 2. The table shows a statistically significant negative effect of extreme temperatures on SMEs firms, and that none of the specifications we consider yield a statistically significant result for the case of large firms. As discussed earlier, these results are consistent with SMEs being more vulnerable to temporary shocks. SMEs have low internal resources and limited access to credit, implying that the liquidity shortages may easily turn into solvency problems for them and these problems may risk their survival or their ability to repay existent debt (Gourinchas *et al.*, 2020; Eggers, 2020). Nonetheless, some caution is encouraged when comparing the results from large and SMEs given that the number of observations drops significantly for the sample of large firms, which are present in a fewer number of municipalities.

In terms of its magnitude, one unusual day of extreme temperature per quarter increases the delinquency rate of SMEs by 0.012 percentage points. These results imply that ten days of extreme weather per quarter cause an increase in delinquency rate of 0.12 percentage points representing 6% of the sample mean (1.99%). When distinguishing between extreme heat and cold (Columns 4 through 6), we find that the increase in delinquency is driven by days of extreme heat which is consistent with harmful effects upon exposure to our definition of extreme heat being transmitted through more channels than those from extreme cold as discussed in Section 3. Specifically, for every ten days of exposure to unusual extreme heat in a quarter, the delinquency rate of SMEs increases by 0.16 percentage points (8% of the sample mean).[16]

Under the standard definition of the delinquency rate as the ratio between non-performing credit to total outstanding credit (performing plus non-performing credit), its increase can arise from a rise in non-performing credit, a reduction in performing loan volume, or both. The implications for both financial outcomes and future access to credit for SMEs are different, depending on whether the increases in delinquency rates stem from the fact that firms are not paying their current loans or from a decrease in outstanding loan volume.

Table 3 shows the estimation of equations (1) and (2) replacing delinquency rates by the log of performing and non-performing credit to examine the source of the increased default rates found for SMEs. The results from this exercise show that the increase in delinquency rates is entirely driven by defaults of current loans, which increases the stock of non-performing credit. Moreover, we find that in the event of a temporary negative shock produced by extreme temperatures, there is no increase in performing loans. This points to striking differences between conditions faced by firms in LMIEs and those in developed economies. In particular, contrary to the case of US firms that use credit lines to buffer against liquidity shortages during

[16]Results are robust to allowing for spatial correlation in error terms applying Conley (1999) approach using different values of the reference distance (see Appendix Table A1).

extreme weather events (Brown *et al.*, 2021; Collier *et al.*, 2020), Mexican SMEs are not smoothing their cash flows by taking new loans but by defaulting on their current ones. Hence, these episodes might have long run consequences if default hinder future access to credit. Bonfim *et al.* (2012) shows that after a default episode in Portugal, only a small fraction of firms have access to new loans in the following quarters, and it is particularly difficult to regaining access to credit for small firms who borrow from only one bank. Likewise, de Roux (2021) finds that coffee farmers in Colombia that incur in default due to extreme precipitation are more often denied loan applications in the future, even when they have recovered their ability to repay.

To the best of our knowledge, there are no studies showing to effects of firm default in future access to credit in Mexico. However, banks use credit scores to determine access and interest rate of new loans, which automatically decline with defaults. Moreover, the regulatory framework establishes that for each new loan, the banks have to keep a proportion of it as reserves. These reserve requirements increase with previous defaults generating higher costs for the bank, and likely translating into less approval rates or higher interest rates for firms that have recently defaulted a loan. Consistent with that idea, in our sample only a small fraction of SMEs that default a loan regain access to new credit in the following 12 months (10%), as opposed to the majority of of firms that do not default (70%). In the following, we restrict our analysis to delinquency rates which normalize the non-performing portfolio in a municipality by its corresponding total outstanding credit and that are equivalent to one of the leading indicators used to monitor the health of financial systems around the world.

Results from exploring whether the impacts on delinquency rates are linear (equation 3) are presented graphically in Figure 2. The figure shows that the only coefficient that is statistically distinguishable from zero at a high significance level is the one associated with the indicator of whether there were more than twenty days with extreme temperatures in a quarter. This result suggests that extreme temperatures only affect delinquency rates once they accumulate. As before, only extreme days of heat have an impact on delinquency rates. The accumulation of more than 20 days within the same quarter increases this rate by about 0.6 percentage points (about 24% of the mean). These findings highlight that the baseline results obtained from estimation of equations (1) and (2) represent the average effects of temperature extremes, and that the effects of shorter exposure may be different from that of longer exposure. However, to facilitate interpretation and increase the precision of our estimates, we focus on average effects in the remainder of the paper.

6 Heterogeneous effects by economic sector and region

To further explore the outcomes displayed in the previous section, Table 4 shows the results of equations (1) and (2) separating delinquency rates in each municipality for firms in the agriculture sector and the non-agriculture sector. We find effects in both sectors, although the point estimate for extreme heat is almost three times as large in agriculture compared to that in non-agriculture. This is consistent with extreme temperature directly affecting crop-yields in the agriculture sector as a large body of literature has documented (Blanc and Schlenker, 2017). It is also consistent with extreme temperatures directly affecting non-agricultural firms through the labor productivity, operating costs and consumer discomfort channels, and indirectly affecting these firms through general equilibrium effects from a reduction in local aggregated demand.

Table 5 presents additional evidence suggesting that non-agricultural firms may suffer from extreme temperature days through general equilibrium effects. In particular, it presents the results of our main specifications further splitting the sample between municipalities above and below the median fraction of the population working in agriculture. The impact of days of extreme heat on non-agricultural firms' delinquency rates is concentrated in municipalities with an above-median share of the population working in agriculture.[17] Moreover, we also find that there is a small albeit statistically significant effect of extreme cold in the non-agriculture sector in municipalities that do not depend heavily on agriculture. This latter result is explained in more detailed below.

The local general equilibrium effects are likely to be stronger for sectors that are highly dependant on local demand, such as retail and services. To explore this, Table 6 divides the non-agriculture sectors into tradables (manufacturing) and non tradables (construction, retail and services). Consistent with changes in demand being partly responsible for the effects found, the effects of extreme heat are concentrated in the non-tradable sector in high agricultural regions. These results are consistent with these shocks directly affecting agriculture in agricultural regions, generating negative spillovers to the rest of the economy. This finding is in line with the detrimental effects of extreme heat on local rural employment previously found for Mexico (Jessoe *et al.*, 2018). In contrast, recent literature for developed countries find a null effect of extreme heat on sales and earnings of large US retail and services firms (Addoum *et al.*, 2020, 2021), highlighting the diverging impacts that extreme heat can have on

[17] Municipalities with a larger fraction of workers in agriculture also tend to be poorer and less developed than non-agriculture regions and may have less resources to cope with extreme temperature shocks.

firms depending on their size and socioeconomic context.

Additionally, we do not find evidence that the potential negative effects of heat on the tradable sector translate into higher delinquency rates in the Mexican case. The lack of effect is consistent with two opposite effects operating in the tradable sector, potentially offsetting each other. Previous literature has found adverse effects in labor productivity in manufacturing in other developing countries (Somanathan *et al.*, 2021), which should increase delinquency rate. On the contrary, other recent papers have found that firms in the tradable sector might benefit from a negative local economic shock to agriculture by taking advantage of the decline in agricultural employment demand and the consequential detriment in local wages for all sectors (Colmer, 2021). If this is the case, there is a reduction in labor cost for firms in the manufacturing sector that should reduce delinquency rates.

Finally, we also find an effect of extreme cold temperature on delinquency rates in the non-tradable sector in low agricultural regions. The result is consistent with the consumer discomfort channel, which reduces demand for leisure activities during cold days. For instance, Graff Zivin and Neidell (2014) and Chan and Wichman (2021) find that people spend less time outdoors on colder days, and Addoum *et al.* (2021) finds that colder springs reduce earnings of consumer discretionary industries such as those related to travel, shopping and dining. The economic importance of these leisure-related activities tend to increase with the level of disposable income and leisure time that increase with economic development (Beauregard, 1998) and are thus more important in low agricultural regions that tend to be richer than high agricultural ones. However, this result could also be driven by low agriculture regions being more exposed to extreme cold than high agriculture regions, allowing for more precise estimates in the former regions. Table 1 shows that low agriculture regions are exposed, on average, to 5.7 days of extreme cold each quarter as opposed to 4.26 in high agriculture regions. The lack of precision is observed in Table 6, where the standard deviation of extreme cold in high agricultural regions in the non-tradable sector (column (3) is twice as large compared to that of low agricultural regions (column 5).

7 Robustness

Our main definition of extreme temperature is based on a threshold that is somehow arbitrary. Table 7 shows the sensitivity of our main results for SMEs to different definitions of days of extreme temperature based on the temperature distribution. In particular, we show that results are similar when considering thresholds based on the percentiles 7.5-92.5, 5-95, 2.5-97.5 of the distribution of daily minimum-maximum temperature. In addition, Appendix Table A2 shows results using municipality-specific thresholds to define extreme temperature days. Our main findings are robust to this alternative definition of temperature shocks. In particular, the point estimate for days of extreme temperature is equal to 0.014 compared to 0.012 in our main specification, and it is also driven by days of extreme heat. As expected, our estimates' precision declines given that some municipalities in Mexico have mild temperatures, introducing some noise to the definition of days of extreme weather.

Table 8 tests if our results hold when defining days of extreme temperature based on mean temperature instead of the distribution of minimum and maximum temperature. To this end, we first estimate the 5-95 percent thresholds for the distribution of daily mean temperature, and then count the number of days in a quarter that mean temperature was below or above this threshold in each municipality. The Table shows that results hold for this alternative definition: we obtained the same point estimate for total days of extreme temperature and a slightly larger coefficient for extreme heat.

Finally, it could be possible that shocks of extreme temperature have dynamic effects by anticipating default rates that would otherwise occur anyway or affecting delinquency rates in a longer horizon than a quarter. We test this by adding three lags to our main specifications in equations (1) and (2), and the results are presented in Table 9. We find that our point estimate and significance on the contemporary effect is maintained when lags are included, and that these lags are not statistically significant in any case. These results combined suggest that the dynamic effects, if they exist, are not large.

8 Discussion

To the best of our knowledge, this is the first study that estimates the effect of extreme temperatures on firm delinquency rates. Our results are particularly relevant in LMIEs, where small and medium-sized firms are more likely to lack the necessary resources to adapt to extreme temperatures and may have insufficient access to credit to shelter from adverse climate shocks. These findings have additional importance in the context of climate change projections and the underlying increase in the frequency and intensity of extreme weather events.

We combine an extraordinarily detailed data set containing loan-level information for the universe of loans extended by commercial banks to private firms in Mexico with satellite weather data to build a quarterly county-level panel that links cumulative exposure to extreme heat and firms' credit outcomes. We find evidence of a detrimental effect of extreme temperature shocks on delinquency rates. In particular, we find that one day of extreme temperature per quarter increases the delinquency rate, measured as the ratio between non-performing credit to total credit, by 0.012 percentage points. This effect is concentrated in SMEs and driven by hot extremes. The results for SMEs imply that ten days of extreme weather per quarter cause an 8% increase in the local delinquency rate. Importantly, the increase in delinquency rates is entirely driven by defaults of current loans, which increases the stock of non-performing credit. The flip side of this result is that there is no increase in performing loans, which means that firms are not smoothing their cash flows by taking new loans but by defaulting on their current ones. Hence, these episodes might have long-run consequences if they hinder future access to credit.

Our results also reflect important differences across economic sectors and regions. We find effects in both the agricultural and non-agricultural sectors. The point estimate for extreme heat is larger in agriculture compared to non-agriculture. The impact of extreme heat on non-agricultural sectors is concentrated in municipalities with an above-median share of the working population in agriculture. Within these municipalities, we find detrimental effects of extreme heat on delinquency rate in industries that depend on local demand such as construction, retail and services. Taken together, these findings are consistent with extreme temperature directly affecting crop yields and labor productivity in the agriculture sector and indirectly affecting non-agricultural firms through general equilibrium effects from local income contractions. In addition, we find a negative effect of extreme cold in non-tradable industries. This is in line with findings from previous literature in which outdoor leisure activities are more sensitive to extreme cold compared to extreme heat.

The findings in this paper provide empirical support to concerns regarding the potential effects of extreme weather on the financial system (Bolton *et al.*, 2020). Regulatory authorities and central banks across the world are considering the inclusion of climate risks in the design of policies that can contribute to reducing banks' exposures to those risks (Litterman *et al.*, 2020; PRA, 2021). While these policies may effectively reduce direct exposure of banks' balance sheets to these risks, they can also generate unintended consequences by further restricting SMEs' financial access upon realizations of weather shocks. These firms may not access financing precisely when they most need it as an extreme weather event hits or in the future when they had already recovered their solvency after a default episode. Thus, our results suggest that financial climate risk policies would ideally be complemented with other policies that deepen SMEs' access to credit.

References

Addoum, J. M., Ng, D. T. and Ortiz-Bobea, A. (2020). Temperature shocks and establishment sales. *The Review of Financial Studies*, **33** (3), 1331–1366.

—, — and — (2021). Temperature shocks and industry earnings news. *Available at SSRN 3480695*.

Asgary, A., Ozdemir, A. I. and Özyürek, H. (2020). Small and medium enterprises and global risks: evidence from manufacturing smes in turkey. *International Journal of Disaster Risk Science*, **11** (1), 59–73.

Auffhammer, M., Baylis, P. and Hausman, C. H. (2017). Climate change is projected to have severe impacts on the frequency and intensity of peak electricity demand across the united states. *Proceedings of the National Academy of Sciences*, **114** (8), 1886–1891.

Ayyagari, M., Demirgüç-Kunt, A. and Maksimovic, V. (2012). Financing of firms in developing countries: lessons from research. *World Bank Policy Research Working Paper*, (6036).

Bakkensen, L. A. and Barrage, L. (2017). *Flood risk belief heterogeneity and coastal home price dynamics: Going under water?* Tech. rep., National Bureau of Economic Research.

Baldauf, M., Garlappi, L. and Yannelis, C. (2020). Does climate change affect real estate prices? only if you believe in it. *The Review of Financial Studies*, **33** (3), 1256–1295.

Bansal, R., Kiku, D. and Ochoa, M. (2016). *Price of long-run temperature shifts in capital markets*. Tech. rep., National Bureau of Economic Research.

Bayangos, V. B., Cachuela, R. A. D. and Del Prado, F. L. E. (2021). Impact of extreme weather episodes on the philippine banking sector–evidence using branch-level supervisory data. *Latin American Journal of Central Banking*, **2** (1), 100023.

Beauregard, R. (1998). Tourism and economic development policies in urban areas. In D. Ioannides and K. Debagge (eds.), *The economic geography of the tourist industry: A supply-side analysis*, Routledge.

Beck, T., Demirgüç-Kunt, A. and Maksimovic, V. (2004). Bank competition and access to finance: International evidence. *Journal of Money, Credit and Banking*, pp. 627–648.

Bernstein, A., Gustafson, M. T. and Lewis, R. (2019). Disaster on the horizon: The price effect of sea level rise. *Journal of financial economics*, **134** (2), 253–272.

Blanc, E. and Schlenker, W. (2017). The use of panel models in assessments of climate impacts on agriculture. *Review of Environmental Economics and Policy*, **11** (2), 258–279.

Bleemer, Z. and van der Klaauw, W. (2019). Long-run net distributionary effects of federal disaster insurance: The case of hurricane katrina. *Journal of urban economics*, **110**, 70–88.

Bolton, P., Després, M., da Silva, L. A. P., Samama, F. and Svartzman, R. (2020). The green swan.

Bonfim, D., Dias, D. A. and Richmond, C. (2012). What happens after corporate default? stylized facts on access to credit. *Journal of Banking & Finance*, **36** (7), 2007–2025.

Brei, M., Mohan, P. and Strobl, E. (2019). The impact of natural disasters on the banking sector: Evidence from hurricane strikes in the caribbean. *The Quarterly Review of Economics and Finance*, **72**, 232–239.

Brown, J. R., Gustafson, M. and Ivanov, I. (2021). Weathering cash flow shocks. *The Journal of Finance*.

Bunten, D. M. and Kahn, M. E. (2014). *The impact of emerging climate risks on urban real estate price dynamics*. Tech. rep., National Bureau of Economic Research.

Burke, M., Hsiang, S. M. and Miguel, E. (2015). Global non-linear effect of temperature on economic production. *Nature*, **527** (7577), 235–239.

— and Tanutama, V. (2019). *Climatic constraints on aggregate economic output*. Tech. rep., National Bureau of Economic Research.

Calomiris, C. W., Larrain, M., Liberti, J. and Sturgess, J. (2017). How collateral laws shape lending and sectoral activity. *Journal of Financial Economics*, **123** (1), 163–188.

Carleton, T. A. and Hsiang, S. M. (2016). Social and economic impacts of climate. *Science*, **353** (6304).

Chan, N. W. and Wichman, C. J. (2020). Climate change and recreation: evidence from north american cycling. *Environmental and Resource Economics*, **76** (1), 119–151.

— and — (2021). Valuing nonmarket impacts of climate change on recreation: From reduced form to welfare. *Environmental and Resource Economics*, pp. 1–35.

Chodorow-Reich, G., Darmouni, O., Luck, S. and Plosser, M. (2021). Bank liquidity provision across the firm size distribution. *Journal of Financial Economics*.

Collier, B. L., Haughwout, A. F., Kunreuther, H. C. and Michel-Kerjan, E. O. (2020). Firmsâ management of infrequent shocks. *Journal of Money, Credit and Banking*, **52** (6), 1329–1359.

Colmer, J. (2021). Temperature, labor reallocation, and industrial production: Evidence from india. *American Economic Journal: Applied Economics*, **13** (4).

Conley, T. G. (1999). Gmm estimation with cross sectional dependence. *Journal of econometrics*, **92** (1), 1–45.

Cortés, K. R. and Strahan, P. E. (2017). Tracing out capital flows: How financially integrated banks respond to natural disasters. *Journal of Financial Economics*, **125** (1), 182–199.

Cui, X. (2020). Beyond yield response: Weather shocks and crop abandonment. *Journal of the Association of Environmental and Resource Economists*, **7** (5), 901–932.

Davlasheridze, M. and Geylani, P. C. (2017). Small business vulnerability to floods and the effects of disaster loans. *Small Business Economics*, **49** (4), 865–888.

de Roux, N. (2021). Exogenous shocks, credit reports and access to credit: Evidence from colombian coffee producers. *Documento CEDE*, (57).

Dell, M., Jones, B. F. and Olken, B. A. (2012). Temperature shocks and economic growth: Evidence from the last half century. *American Economic Journal: Macroeconomics*, **4** (3), 66–95.

—, — and — (2014). What do we learn from the weather? the new climate-economy literature. *Journal of Economic Literature*, **52** (3), 740–98.

Deryugina, T. and Hsiang, S. M. (2014). *Does the environment still matter? Daily temperature and income in the United States*. Tech. rep., National Bureau of

Economic Research.
Djankov, S., McLiesh, C. and Shleifer, A. (2007). Private credit in 129 countries. *Journal of financial Economics*, **84** (2), 299–329.
Eggers, F. (2020). Masters of disasters? challenges and opportunities for smes in times of crisis. *Journal of Business Research*, **116**, 199–208.
Furukawa, K., Ichiue, H., Shiraki, N. *et al.* (2020). *How Does Climate Change Interact with the Financial System? A Survey*. Tech. rep., Bank of Japan.
Gallagher, J. and Hartley, D. (2017). Household finance after a natural disaster: The case of hurricane katrina. *American Economic Journal: Economic Policy*, **9** (3), 199–228.
Gourinchas, P.-O., Kalemli-Özcan, á., Penciakova, V. and Sander, N. (2020). *Covid-19 and SME failures*. Tech. rep., National Bureau of Economic Research.
Graff Zivin, J. and Neidell, M. (2014). Temperature and the allocation of time: Implications for climate change. *Journal of Labor Economics*, **32** (1), 1–26.
Gutierrez, E., Jaume, D. and Tobal, M. (2021). Do credit supply shocks affect employment in middle-income countries?
Hallstrom, D. G. and Smith, V. K. (2005). Market responses to hurricanes. *Journal of Environmental Economics and Management*, **50** (3), 541–561.
Hino, M. and Burke, M. (2020). *Does Information About Climate Risk Affect Property Values?* Tech. rep., National Bureau of Economic Research.
Hong, H., Li, F. W. and Xu, J. (2019). Climate risks and market efficiency. *Journal of econometrics*, **208** (1), 265–281.
Hsiang, S., Oliva, P. and Walker, R. (2019). The distribution of environmental damages. *Review of Environmental Economics and Policy*, **13** (1), 83–103.
Hsiang, S. M. (2010). Temperatures and cyclones strongly associated with economic production in the caribbean and central america. *Proceedings of the National Academy of sciences*, **107** (35), 15367–15372.
IMF (2019). *Building Resilience in Developing Countries Vulnerable to Large Natural Disasters*. Tech. rep., IMF Policy Paper.
IMF (2019). Financial soundness indicators compilation guide. *International Monetary Fund*.
INEGI, C. E. (2019). Instituto nacional de estadística y geografía. *Censo Económico*.
IPCC (2021). *2021: Climate Change 2021: The Physical Science Basis*. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte.
Jessoe, K., Manning, D. T. and Taylor, J. E. (2018). Climate change and labour allocation in rural mexico: Evidence from annual fluctuations in weather. *The Economic Journal*, **128** (608), 230–261.
Klomp, J. (2014). Financial fragility and natural disasters: An empirical analysis. *Journal of Financial Stability*, **13**, 180–192.
Koetter, M., Noth, F. and Rehbein, O. (2020). Borrowers under water! rare disasters, regional banks, and recovery lending. *Journal of Financial Intermediation*, **43**, 100811.
Kolstad, C. D. and Moore, F. C. (2020). Estimating the economic impacts of climate change using weather observations. *Review of Environmental Economics and Policy*, **14** (1), 1–24.

Kousky, C. (2014). Informing climate adaptation: A review of the economic costs of natural disasters. *Energy economics*, **46**, 576–592.

Kuntchev, V., Ramalho, R., Rodríguez-Meza, J. and Yang, J. S. (2013). What have we learned from the enterprise surveys regarding access to credit by smes? *World Bank Policy Research Working Paper*, (6670).

Litterman, R., Anderson, C. E., Bullard, N., Caldecott, B., Cheung, M. L., Colas, J. T., Coviello, R., Davidson, P. W., Dukes, J., Duteil, H. P. *et al.* (2020). Managing climate risk in the us financial system.

Mendelsohn, R., Nordhaus, W. D. and Shaw, D. (1994). The impact of global warming on agriculture: a ricardian analysis. *The American economic review*, pp. 753–771.

Oppenheimer, M., Campos, M., Warren, R., Birkmann, J., Luber, G., O'Neill, B. and Takahashi, K. (2014). Climate change impacts, adaptation, and vulnerability. part a: Global and sectoral aspects. *Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.*

Ortega, F. and Taspinar, S. (2018). Rising sea levels and sinking property values: Hurricane sandy and new yorkâs housing market. *Journal of Urban Economics*, **106**, 81–100.

PRA (2021). *Climate-related financial risk management and the role of capital requirements*. Tech. rep., Bank of England Prudential Regulation Authority.

SAGARPA (2017). *Compendio de Indicadores de Gestion y Resultados 2017*. The Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food of Mexico.

Schlenker, W. and Roberts, M. J. (2009). Nonlinear temperature effects indicate severe damages to us crop yields under climate change. *Proceedings of the National Academy of sciences*, **106** (37), 15594–15598.

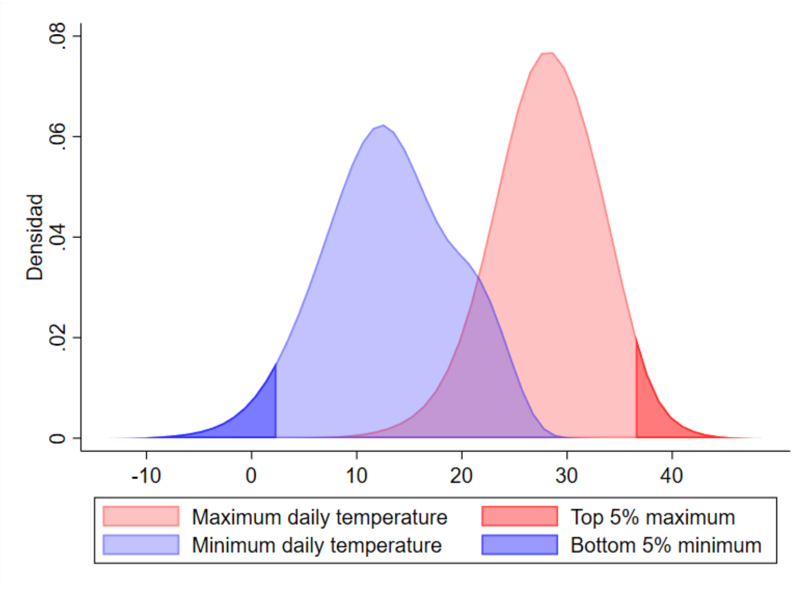
Schüwer, U., Lambert, C. and Noth, F. (2019). How do banks react to catastrophic events? evidence from hurricane katrina. *Review of Finance*, **23** (1), 75–116.

Semenenko, I. and Yoo, J. (2019). Climate change and real estate prices. *International Journal of Economics and Finance*, **11** (11).

Somanathan, E., Somanathan, R., Sudarshan, A. and Tewari, M. (2021). The impact of temperature on productivity and labor supply: Evidence from indian manufacturing. *Journal of Political Economy*, **129** (6), 1797–1827.

Zhang, P., Deschenes, O., Meng, K. and Zhang, J. (2018). Temperature effects on productivity and factor reallocation: Evidence from a half million chinese manufacturing plants. *Journal of Environmental Economics and Management*, **88**, 1–17.

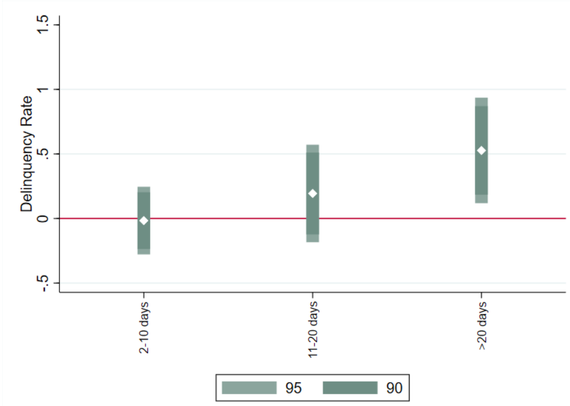
Figure 1: Distribution of maximum and minimum daily temperature in Mexico 2010-2018



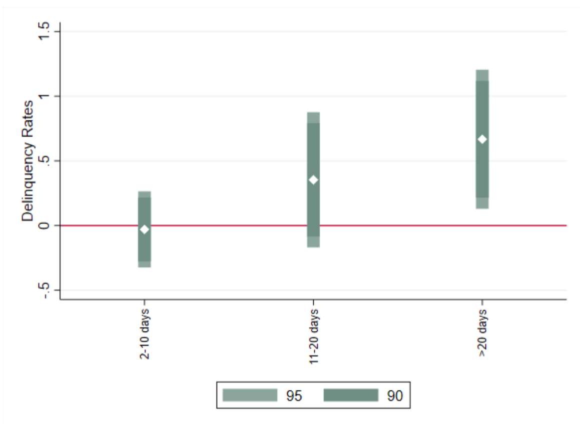
Notes: The figure shows the distribution of minimum (blue) and maximum (red) daily temperature for Mexican municipalities. Bottom 5% of minimum temperature (less than 3°C) and top 5% of maximum temperature (more than 36°C) are highlighted.

Figure 2: Non-linear effects of extreme temperatures on delinquency rates

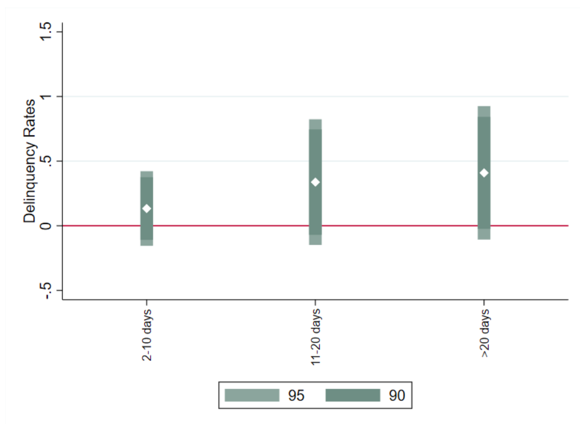
(a) Total days of extreme temperature



(b) Days of extreme heat



(c) Days of extreme cold



Notes: The figure shows the results of equation (3) separating the quarterly days of exposure to extreme temperature into four bins: 0-1 days, 2-10 days, 11-20 days and more than 11 days. Panel (a) aggregates days of exposure to extreme cold and heat temperature, while panels (b) and (c) present results for separate regressions distinguishing between extreme hot and cold days, respectively. The point estimates measure the effect of exposure to certain number days of extreme temperature with respect to the base category (0-1 days). The 90 and 95 percent confidence intervals are presented. Standard errors are clustered at the municipality level.

Table 1: Descriptive statistics

	All municipalities	High agricultural municipalities	Low agricultural municipalities
Panel A: Temperature			
Mean temperature	20.5	21.13	19.86
	(4.10)	(4.04)	(4.05)
Days of extreme temperature	9.24	8.36	10.13
	(16.48)	(15.87)	(17.03)
Days of extreme heat	4.26	4.09	4.44
	(12.30)	(11.67)	(12.90)
Days of extreme cold	4.98	4.26	5.69
	(12.46)	(12.01)	(12.85)
Panel B: Credit			
Delinquency rate-all sectors	1.99	1.98	2.00
	(8.88)	(9.69)	(7.98)
Delinquency rate - agricultural	2.91	3.53	2.38
	(14.03)	(16.03)	(12.01)
Delinquency rate-non agricultural	1.93	1.83	2.03
	(8.88)	(9.48)	(8.25)
Percentage of credit in agriculture	12.64	17.72	7.56
	(23.71)	(23.24)	(16.61)
Non-performing credit*	5.24	2.83	7.65
	(7.11)	(5.54)	(7.67)
Outstanding credit*	17	15.90	18.11
	(2.84)	(2.33)	(2.87)
Panel C: Agricultural intensity			
Employment in agriculture (%)	0.29	0.45	0.13
	(0.19)	(0.12)	(0.08)
Municipalities	1,604	851	753
Observations	50,248	25,129	25,119

Notes: Authors' calculation using quarterly credit data on small firms (2010-2018), quarterly temperature data (2010-2018), and census data for employment in agriculture (2010). The table shows sample averages with standard deviations in parenthesis. High agricultural regions are municipalities with employment in agriculture above the median of the sample (28 percent).* Inverse hyperbolic sine transformation.

Table 2: Effect of extreme temperatures on delinquency rates by firms' size

	All (1)	Small firms (2)	Large firms (3)	All (4)	Small firms (5)	Large firms (6)
Days of extreme temperature	0.012*** (0.005)	0.012*** (0.004)	0.001 (0.015)			
Days of extreme heat				0.017** (0.007)	0.016** (0.007)	-0.021 (0.015)
Days of extreme cold				0.008 (0.006)	0.008 (0.006)	0.028 (0.026)
Observations	50,270	50,248	864	50,270	50,248	864

Notes: Authors' estimation using 2010-2018 credit data. The point estimate measures the effect of one day of unusual exposure to extreme temperature in a quarter on firm credit delinquency rates. All regressions include municipality by quarter fixed effects, municipality by year fixed effects, quarter by year fixed effects, and average precipitation at the municipality level in each quarter. Columns (1)-(3) display results for equation (1). Columns (4)-(6) estimate equation (2) distinguishing between exposure to extreme hot and cold days. Small firms are defined based on the largest credit during the sample period (less than 100 million pesos). Standard errors are clustered at the municipality level. *** indicates significance at the 1% level, ** indicates significance at the 5% level and * indicates significance at the 10% level.

Table 3: Effect of extreme temperatures on the log of total non-performing and performing loans

	Non-performing (1)	Performing (2)	Non-performing (3)	Performing (4)
Days of extreme temperature	0.009*** (0.003)	-0.001 (0.001)		
Days of extreme heat			0.012*** (0.004)	-0.001 (0.001)
Days of extreme cold			0.007* (0.004)	0.001 (0.001)
Observations	50,248	50,248	50,248	50,248
R-squared	0.810	0.966	0.810	0.966

Notes: Authors' estimation using 2010-2018 credit data on small firms. The point estimate measures the percentage change the total non-performing and performing loans at the municipality level of one day of unusual exposure to extreme temperature.All regressions include municipality by quarter fixed effects, municipality by year fixed effects, quarter by year fixed effects, and average precipitation at the municipality level in each quarter. Columns (1)-(2) display results for equation (1) changing the dependent variable to the logarithm of non-performing and outstanding loans. Columns (3)-(4) further distinguish between exposure to extreme hot and cold days. Standard errors are clustered at the municipality level.*** indicates significance at the 1% level, ** indicates significance at the 5% level and * indicates significance at the 10% level.

Table 4: Effect of extreme temperatures on delinquency rates by firm's sector

	Agriculture (1)	Non-Agriculture (2)	Agriculture (3)	Non-Agriculture (4)
Days of extreme temperature	0.014 (0.010)	0.010** (0.004)		
Days of extreme heat			0.034** (0.014)	0.012** (0.006)
Days of extreme cold			-0.015 (0.015)	0.008 (0.007)
Observations	23,534	48,923	23,534	48,923
R-squared	0.726	0.653	0.726	0.653

Notes: Authors' estimation using 2010-2018 credit data on small firms. The point estimate measures the effect of one day of unusual exposure to extreme temperature in a quarter on firm credit delinquency rates. All regressions include municipality by quarter fixed effects, municipality by year fixed effects, quarter by year fixed effects, and average precipitation at the municipality level in each quarter. Columns (1)-(2) display results for equation (1). Columns (3)-(4) estimate equation (2) by distinguishing between exposure to extreme hot and cold days. Non-agriculture includes commerce, construction, industrial, transportation and services. Standard errors are clustered at the municipality level. *** indicates significance at the 1% level, ** indicates significance at the 5% level and * indicates significance at the 10% level.

Table 5: Effect of extreme temperatures on delinquency rates by region and sector

	All Sectors		Credit to firms in agriculture		Credit to firms in non-agriculture	
	High agricultural regions	Low agricultural regions	High agricultural regions	Low agricultural regions	High agricultural regions	Low agricultural regions
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Total days of extreme temperature						
Days of extreme temperature	0.013	0.011**	0.029	0.005	0.012	0.008
	(0.008)	(0.004)	(0.018)	(0.011)	(0.008)	(0.005)
Panel B: Separating heat and cold						
Days of extreme heat	0.025**	0.006	0.052**	0.019	0.022**	-0.000
	(0.011)	(0.006)	(0.022)	(0.017)	(0.009)	(0.007)
Days of extreme cold	-0.003	0.015**	-0.016	-0.011	-0.002	0.014**
	(0.012)	(0.007)	(0.028)	(0.018)	(0.013)	(0.007)
Observations	24,792	25,456	10,577	12,957	23,572	25,351

Notes: Authors' estimation using 2010-2018 credit data on small firms. The point estimate measures the effect of one day of unusual exposure to extreme temperature in a quarter on firm credit delinquency rates. All regressions include municipality by quarter fixed effects, municipality by year fixed effects, quarter by year fixed effects, and average precipitation at the municipality level in each quarter. Panel (A) display results for equation (1) with different controls for trends at the municipality level. Panel (B) estimate equation (2) distinguishing between exposure to extreme hot and cold days. Credit to firms in non-agriculture includes commerce, construction, industrial, transportation and services. High agricultural regions are municipalities with employment in agriculture above the median of the sample (28 percent). Standard errors are clustered at the municipality level. *** indicates significance at the 1% level, ** indicates significance at the 5% level and * indicates significance at the 10% level.

Table 6: Effect of extreme temperatures on delinquency rates in the non-agriculture sector

	All municipalities		High agricultural regions		Low agricultural regions	
	Non-agriculture & non-tradable (1)	Non-agriculture & tradable (2)	Non-agriculture & non-tradable (3)	Non-agriculture & tradable (4)	Non-agriculture & non-tradable (5)	Non-agriculture & tradable (6)
Days of extreme heat	0.011*	0.006	0.024**	0.005	-0.003	0.006
	(0.006)	(0.007)	(0.009)	(0.010)	(0.007)	(0.009)
Days of extreme cold	0.006	0.012	-0.004	0.021	0.013**	0.006
	(0.006)	(0.008)	(0.012)	(0.013)	(0.006)	(0.010)
Observations	48,923	48,923	23,572	23,572	25,351	25,351
R-squared	0.641	0.627	0.633	0.548	0.653	0.665

Notes: Authors' estimation of equation (2) using 2010-2018 credit data on small firms distinguishing between exposure to extreme hot and cold days. The point estimate measures the effect of one day of unusual exposure to extreme temperature in a quarter on firm credit delinquency rates. All regressions include municipality by quarter fixed effects, municipality by year fixed effects, quarter by year fixed effects, and average precipitation at the municipality level in each quarter. Non-tradable sectors include: commerce, construction and services. tradable sector refers to manufacturing. High agricultural regions are municipalities with employment in agriculture above the median of the sample (28 percent). Standard errors are clustered at the municipality level. *** indicates significance at the 1% level, ** indicates significance at the 5% level and * indicates significance at the 10% level.

Table 7: Robustness to using different percentiles to define extreme temperature days

	10-90 Min 5°, Max 34° (1)	7.5-92.5 Min 4°, Max 35° (2)	5-95 Min 3°, Max 36° (3)	2.5-97.5 Min 1°, Max 37° (4)	1-99 Min -2°, Max 39° (5)
Panel A: Total days of extreme temperature					
Days of extreme temperature	0.007*	0.009**	0.012***	0.015**	0.011
	(0.004)	(0.004)	(0.004)	(0.006)	(0.010)
Panel B: Separating heat and cold					
Days of extreme heat	0.005	0.010*	0.016**	0.022***	0.017*
	(0.005)	(0.006)	(0.007)	(0.008)	(0.010)
Days of extreme cold	0.010*	0.008	0.008	0.007	0.004
	(0.005)	(0.006)	(0.006)	(0.009)	(0.016)

Notes: Authors' estimation using 2010-2018 credit data on small firms. The point estimate measures the effect of one day of unusual exposure to extreme temperature in a quarter on firm credit delinquency rates for alternative definitions of extreme temperatures based on different percentiles of the minimum and maximum daily temperature distribution displayed in Figure 1. All regressions include municipality by quarter fixed effects, municipality by year fixed effects, quarter by year fixed effects, and average precipitation at the municipality level in each quarter. Panel (A) display results for equation (1) and Panel (B) distinguishes between exposure to extreme hot and cold days. Column (3) contains the main results from Table 2. Standard errors are clustered at the municipality level. *** indicates significance at the 1% level, ** indicates significance at the 5% level and * indicates significance at the 10% level.

Table 8: Alternative definition of extreme temperature days by using the mean temperature distribution

	(1)	(2)
Days of extreme temperature	0.012**	
	(0.005)	
Days of extreme heat		0.021**
		(0.008)
		0.008
Days of extreme cold		(0.006)
Observations	50,248	50,248

Notes: Authors' estimation using 2010-2018 credit data on small firms. The point estimate measures the effect of one day of unusual exposure to extreme temperature in a quarter on firm credit delinquency rates. All regressions include municipality by quarter fixed effects, municipality by year fixed effects, quarter by year fixed effects, and average precipitation at the municipality level in each quarter. Extreme cold/hot temperature days are defined by days with mean temperature below/above the 5th/95th percentile of the mean temperature distribution for the period 2010-2018 (13° and 30°, respectively) . Column (1) display results for aggregating extreme hot and cold days and Panel (B) distinguishes between exposure to extreme hot and cold days. Standard errors are clustered at the municipality level. *** indicates significance at the 1% level, ** indicates significance at the 5% level and * indicates significance at the 10% level.

Table 9: Dynamic effects of extreme temperatures on delinquency rates

	(1)	(2)	(3)
Panel A: Total days of extreme temperature			
Days of extreme temperature in t	0.011**	0.014**	0.015**
	(0.005)	(0.006)	(0.006)
Days of extreme temperature in t-1	-0.006	-0.006	-0.007
	(0.005)	(0.005)	(0.005)
Days of extreme temperature in t-2		0.005	0.006
		(0.005)	(0.005)
Days of extreme temperature in t-3			0.001
			(0.005)
Panel B: Separating heat and cold			
Days of extreme heat in t	0.016**	0.017**	0.018**
	(0.007)	(0.008)	(0.009)
Days of extreme heat in t-1	0.000	-0.002	-0.003
	(0.007)	(0.007)	(0.007)
Days of extreme heat in t-2		0.002	0.003
		(0.007)	(0.007)
Days of extreme heat in t-3			0.004
			(0.007)
Days of extreme cold in t	0.006	0.011	0.011
	(0.007)	(0.008)	(0.009)
Days of extreme cold in t-1	-0.010	-0.008	-0.011
	(0.006)	(0.007)	(0.008)
Days of extreme cold in t-2		0.008	0.008
		(0.007)	(0.009)
Days of extreme cold in t-3			-0.003
			(0.008)
Observations	50,248	48,931	46,303

Notes: Authors' estimation using 2010-2018 credit data on small firms. The point estimate measures the effect of one day of unusual exposure to extreme temperature present and past quarters on firm credit delinquency rates. All regressions include municipality by quarter fixed effects, municipality by year fixed effects, quarter by year fixed effects, and average precipitation at the municipality level in each quarter. Panel (A) display results for equation (1) and Panel (B) distinguishes between exposure to extreme hot and cold days. Columns (1) to (3) add lags to the main specification in column (3) of Table 2. *** indicates significance at the 1% level, ** indicates significance at the 5% level and * indicates significance at the 10% level.

Online Appendix

Table A1: Robustness allowing spatially-correlated standard errors

	(1)	(2)	(3)	(4)	(5)	(6)
Days of extreme temperature	0.012***	0.012***	0.012***			
	(0.000375)	(0.00366)	(0.00389)			
Days of extreme heat				0.016***	0.016***	0.016***
				(0.00507)	(0.00509)	(0.00517)
Days of extreme				0.008	0.008	0.008
				(0.00551)	(0.00529)	(0.00594)
Observations	50,248	50,248	50,248	50,248	50,248	50,248
Distance cut-off	25km	50km	100km	25km	50km	100km

Notes: Authors' estimation using 2010-2018 credit data on small firms. The point estimate measures the effect of one day of unusual exposure to extreme temperature in a quarter on firm credit delinquency rates for alternative definitions of extreme temperatures based on different percentiles of municipality-specific distribution of minimum and maximum daily temperature. All regressions include municipality by quarter fixed effects, municipality by year fixed effects, quarter by year fixed effects, and average precipitation at the municipality level in each quarter. Standard errors are estimated allowing for spatial correlation in error terms applying Conley (1999) approach and using different values of the reference distance. Columns (1) to (3) are comparable to column (3) from Table 2. Columns (4) to (6) are comparable to column (6) from Table 2. *** indicates significance at the 1% level, ** indicates significance at the 5% level and * indicates significance at the 10% level.

Table A2: Robustness to using different municipality-specific percentiles to define extreme temperature days

	10-90 (1)	7.5-92.5 (2)	5-95 (1)	2.5-97.5 (2)	1-99 (1)
Panel A: Total days of extreme temperature					
Days of extreme	0.005	0.005	0.014*	0.030**	0.064**
temperature	(0.005)	(0.006)	(0.008)	(0.014)	(0.031)
Panel B: Separating heat and cold					
Days of extreme heat	0.010	0.012	0.021*	0.043**	0.064
	(0.007)	(0.008)	(0.012)	(0.021)	(0.047)
	0.001	-0.001	0.007	0.016	0.065
Days of extreme cold	(0.006)	(0.007)	(0.009)	(0.017)	(0.040)

Notes: Authors' estimation using 2010-2018 credit data on small firms. The point estimate measures the effect of one day of unusual exposure to extreme temperature in a quarter on firm credit delinquency rates for alternative definitions of extreme temperatures based on different percentiles of municipality-specific distribution of minimum and maximum daily temperature. All regressions include municipality by quarter fixed effects, municipality by year fixed effects, quarter by year fixed effects, and average precipitation at the municipality level in each quarter. Panel (A) display results for equation (1) and Panel (B) distinguishes between exposure to extreme hot and cold days. Standard errors are clustered at the municipality level. *** indicates significance at the 1% level, ** indicates significance at the 5% level and * indicates significance at the 10% level.