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by Michele Cascarano, Filippo Natoli and Andrea Petrella

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ENTRY, EXIT, AND MARKET STRUCTURE IN A CHANGING CLIMATE

by Michele Cascarano*, Filippo Natoli** and Andrea Petrella**

Abstract

Climate change has long-term effects on the size and composition of a country's business sector. Using administrative data on the universe of Italian firms, we find that an increase in the number of very hot days per year persistently reduces the growth rate of active firms in the market in the medium run. This is due to a drop in firm entry and an increase in firm exit, with relocation playing a minor role. A firm-level investigation reveals a dichotomy between firms that persistently suffer as a result of higher temperatures and those that improve their profitability by adapting to a hotter climate: a combination of size and age best identifies the two groups, where older, smaller-sized firms lie at one extreme and younger, larger firms at the other. According to an average climate scenario, the projected evolution of local temperatures will impact firm demography further, also exacerbating the divergent effects across warmer and colder areas over the current decade.

JEL Classification: D22, R12, Q54.

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1 Introduction¹

The literature on the economic effects of climate change actively debates on whether fluctuations in temperatures and extreme events such as heat waves affect firms' output. Performance over the year can drop because workers in heat-exposed occupations can be less productive or more absent in hot days or, more generally, because hot temperatures increase overall production costs. These effects might exist for a large set of firms. However, on a longer time span, they may vanish and stimulate adaptation and technological advancement for some firms while, at the opposite, they can accumulate and become persistent for others. This divergence might not be inconsequential for market structure.

While the question of whether firms adapt to a changing climate is central to understand its longer run economic effects, the evidence is still scant. Recent contributions focus on impacts and adaptation policies of large, listed firms with complex supply chains and multiple local units. No evidence is available, to our knowledge, on the scope of temperature effects on the entire business sector, which can ultimately be shaped by climate-related entry-exit choices or by defaults of the most vulnerable entities. Using administrative data for the universe of Italian firms (excluding sole proprietorships) between 2005 and 2019, we take a broader perspective and explore medium-run implications of climate change on firm demography. In particular, we estimate the effect of the increasing incidence of high temperatures over a multiyear period on the number of active firms in the market, disentangling the effects on entry, exit and relocation rates at local level.

We find that an increase in the number of hot days within the year at local level reduces, in the medium run, the growth rate of active firms in that geographic area. These effects are strikingly persistent, with enduring impacts extending up to at least 12 years ahead. Decomposing this effect, results turn out to be driven by a significant reduction in entry rates of new firms and, to

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a lower extent, by an increase in exit rates; relocation instead plays a minor role. Implications on entry and exit prove to be heterogeneous across geographic areas: entries fall and exits rise in Mediterranean (warmer) areas while effects are milder —if anything, of opposite sign— in temperate (colder) ones, confirming that areas with high average temperature levels are those suffering the most from climate change. We show that these effects are not driven by pre-existing differences between Northern and Southern regions. At sector level, manufacturing, construction and retail are impacted almost as agriculture, both in terms of lower entries and higher exits. The fact that there is no clear correspondence at sector level between exits (or missing entries) in Mediterranean areas and entry in temperate ones is another evidence that any form of climate-induced firm mobility is at least of secondary importance. In the near future, climatic developments will exacerbate the trends highlighted by our results: based on an average scenario on the evolution of local temperatures until 2030, we show that the cumulative reduction in the growth rate of active firms between 2020 and 2031 would add to 0.2 percentage points, quite a sizable impact with respect to an average annual increase in the size of the business sector by 1.5%. Moreover, additional calculations show that these effects would be substantially magnified for warmer areas.

To investigate how extreme temperatures affect firm’s activity, we rely on detailed balance sheet data from the Company Account Database of Cerved Group: by encompassing almost 10 million firm-year observations from 2005 to 2019, our firm-level analysis rests on one of the largest single-country data set in the literature. Such data source, which comprehends all publicly listed firms as well as all non-listed limited liability companies, including single worker and micro firms (with less than 10 employees) that file their balance sheet at the Italian Business Registry, is ideal to identify differentiated temperature effects across various firm dimensions.

By exploring firm-level effects, a substantial dichotomy between “successful” and “unsuccessful” firms emerges. This dichotomy, related to the extent to which firms adapt to hotter temperatures, is best identified by the joint analysis of firms by age and size: at one extreme,

hotter temperatures have a persistently negative impact on the profitability of older, small-sized firms, who end up reducing investments in the medium run; on the other hand, instead, they have a positive effect on younger, larger firms, which instead are able to adapt and increase their profitability. This finding marks a stark difference in the resilience to climate change across firms, suggesting that global warming might be stimulating a reallocation of production shares within the business sector. All in all, our results of a negative medium-run effect of hot temperatures on firm demography, and of a climate-induced divergence both across areas with different temperatures and across firms with different age-size, stand out in the literature.

Our results on firm demography and on the enduring balance sheet effects of hot temperatures contribute to the literature by shedding light on the aggregate market dynamics in an increasingly hot world, previously disregarded, in which adaptation to climate change and lack thereof can play a pivotal role.

This paper is organized as follows. Section 2 documents the contribution of the paper in the literature. Section 3 describes the data used in the empirical analyses. Section 4 details the empirical strategy to assess long run effects of temperatures on firm demography and comments on the obtained results. Section 5 presents firm-level estimates. Section 6 concludes.

2 Related literature

The effects of climate change on the global economy are multifaceted. High temperatures substantially reduce activity and growth, especially —but not exclusively— in poor countries (Dell et al., 2012; Burke et al., 2015; Acevedo et al., 2020), entailing multiple effects, including migration (Hornbeck, 2012 and Peri and Sasahara, 2019, among others; see Dell et al., 2014 for a review of the literature). Effects on advanced economies have been analyzed mainly with regard to the United States, where sizable effects have first been found in agriculture (Burke and Emerick, 2016) and, more recently, in a wider range of industries (Colacito et al., 2019), with income per capita losses being concentrated during business days (Deryugina and Hsiang,

2014). The economic consequences of high temperatures are mainly channeled through reduced hours worked in climate-exposed industries and time allocated to outdoor leisure in hot days (Graff Zivin and Neidell, 2014) and through a reduction in labor productivity and an increase in absenteeism (Somanathan et al., 2021).

The literature on the long-run effects of climate change is emerging, but it is still scant. At firm level, while most of the analysis is focused on short-run impacts —where results are still mixed— one strand of literature investigates how firms implement medium-run adaptation policies to fight climate change.² For example, large firms are found to reduce the number of employees and firm establishments in the medium run because of high temperatures (Jin et al., 2021), and downstream firms in the supply chain terminate existing relationships with their suppliers if the latter underperform due to high temperatures (Pankratz and Schiller, 2021). These papers focus on large, publicly listed firms, with complex firm structures and supply chain relationships. While specific adaptation mechanisms are uncovered, these papers do not allow to draw conclusions on the longer run effects of temperature on the whole country’s business sector because the most vulnerable entities, which are also the least able to adapt to high temperatures, are for sure out of those selected firm samples. Moreover, limiting the analyses to the pool of incumbent firms in the market does not allow to consider extreme adaptation mechanisms — missing entry or premature exit— which is possible only with comprehensive firm demography data. Because of our focus on aggregate dynamics, our paper displays similarities with Barreca et al. (2016), who analyze the relationship between temperatures, mortality and household demography.

Another strand of literature explores long-run implications of climate change by focusing on the geographic dimension of global warming. Some papers carry out multi-country level analyses (Hsiang and Narita, 2012; Kahn et al., 2021, among others), suggesting that adaptation

²Regarding short-run effects, some papers do not find any consequence of high temperatures on firm sales and labor productivity (Addoum et al., 2020), while others document negative effects on sales of upstream firms in the supply chain (Custódio et al., 2021). Further evidence suggests that firm-level effects can be of opposite signs in different sectors and seasons (Addoum et al., 2021).

might limit, but not offset weather impacts. Others propose spatial equilibrium models taking into account differential effects on productivity, trade, migration, and policy response across geographic areas (Costinot et al., 2016; Desmet and Rossi-Hansberg, 2015; Balboni, 2019; Conte et al., 2020). At local level, Albert et al. (2021) empirically find that drought events in Brazil had negative long run effects in affected areas through lower credit granted, and spillovers via out-migration flows. With respect to this work, which focuses on geographic redistribution via labor mobility, our analysis is complementary as it studies implications of climate change on firm demography, showing that firm mobility is less relevant than entry-exit choices.

Our paper also connects to the literature on the determinants of firms' entry and exit in the market (Agarwal and Gort, 1996; Audretsch, 1991; Sutaria and Hicks, 2004; Bartelsman et al., 2005; Santarelli and Vivarelli, 2007; Clementi and Palazzo, 2016, among others). With respect to this broad body of literature, we highlight an additional determinant of firm dynamics, showing that heat stress to firm activity might play a non-negligible role. As entry and exit are fundamental drivers of productivity dynamics (Melitz and Polanec, 2015), our findings suggest a potential channel connecting climate change and aggregate productivity, which might deserve further investigation.

3 Data

We combine data on temperatures, weather, firm demography and firm balance sheets from different sources. In the following sections we account for these sources, providing the relevant stylized facts on our sample.

3.1 Temperatures, precipitations and extreme events

We use the JRC MARS Meteorological Database (EU AGRI4CAST project) that contains meteorological observations from weather stations interpolated on a 25x25 km grid, on a daily basis from 1979 to 2019, for the EU and neighbouring countries. In this work we use temper-

ature (maximum and average) and precipitation data for Italy from 1993 to 2019. We linearly interpolate data from 25x25 km² to a 5x5 km² raster to calculate daily data, averaged at the level of local labor market (LLM).³

The measure of extreme temperature we rely on is the number of days with a maximum temperature above 30°C within a year. This is a widely exploited measure in the literature on the economic effects of extreme temperatures (Bauer et al., 2019; Addoum et al., 2020). Its utilization rests on the observation that 30°C is a critical threshold, above which individual productivity starts dropping at increasing rates (Fisk et al., 2006; Somanathan et al., 2021). Hence, it is likely that at this threshold most of the economic consequences of temperatures might start to emerge, for example as a consequence of firms increasing their costs for cooling needs or reorganizing production processes to react to the lower individual efficiency.

Over the 27 years considered in this paper, the number of extreme heat days registered on average in Italian LLMs has considerably increased: at the end of the observation period, there were around 15 days of extreme temperatures more than at the beginning (Figure 1). Despite the large erraticness of the series, a clear upward trend is perceivable especially in the first half of the sample, before a substantial stabilization at the high levels reached around 2007. However, in the latest years the variability in the occurrence of extreme heat days — as captured by the range between the 10th and 90th percentile — has substantially increased.

This broad figure masks a sizable heterogeneity at the geographic level, which clearly emerges from the summary statistics in Table 1. The across-LLM variability in the number of extreme heat days has been increasing over time, but even within single years the realizations of temper-

³A local labor market is a partition of the Italian territory that maximizes the self-containment of home-to-work commuting flows. As such, it identifies relatively homogeneous areas representing the center of interest for most of the residents. From the perspective of the firms, it is the geographic extension of the labor market pool from which they draw their employees. We use the 2011 classification provided by the National Institute of Statistics, which singles out 611 LLMs, with an average size larger than that of a municipality but smaller than that of a province. More information available at <https://www.istat.it/it/informazioni-territoriali-e-cartografiche/sistemi-locali-del-lavoro>. We average at LLM level the data from an interpolated raster at 5x5 km². As for the interpolation we apply nearest neighbour interpolation considering for each interpolated point the 5 nearest neighbours available. We adopt an agnostic approach using inverse distance power equal to 0, namely by making all five neighbors equally weighted, and adopting a linear interpolation scheme on latitude and longitude. Finally we create a 5x5 raster by averaging in each cell the interpolated values.

ature are not evenly spread across geographic units: while in all years there is at least a LLM not experiencing any extreme heat event, there are other LLMs that can suffer as much as 105 days with maximum temperature above 30°C.

Contrary to expectations, the LLMs with a higher frequency of extreme temperature events are not entirely concentrated in the South. Figure 2 panel (a), shows the distribution of extreme heat days at the beginning of the sample.⁴ While certain Southern areas —such as South Sardinia, Eastern Sicily, Campania and Northern Apulia— ranked high in the number of extreme heat days, they shared this destiny with other areas in Central and Northern Italy, especially Tuscany and vast stretches of the Po Valley. Clearly, the mountainous LLMs belonging to the Alpine Arc and to the highest zones of the Apennines display the lowest level of extreme heat incidence. Over the period observed in this paper, the increase in the frequency of extreme temperatures has also been highly heterogeneous across LLMs, as Figure 2 panel (b) shows. The largest increases affected Sardinia, Eastern Sicily, the Po Valley, Southern Apulia and Rome and its surroundings. Mildest increases have also hit the Western Alps, while some LLMs in the South have been spared from this tendency (Campania, Calabria, Northern Apulia).

The measure of precipitation we use is calculated by cumulating for each year the total daily precipitation in millimeters, averaged at the LLM level. In the econometric analyses we use this measure in logarithm.

For certain extensions to our results, we use data on extreme events from the European Severe Weather Database (ESWD), which provides detailed information on localized disruptive weather events. The database includes a variety of events, that can be broadly grouped in the following categories: strong winds, snow, hail, avalanches, lightnings and precipitations. Data are available from 1979, but their reliability has been increasing in time, as the number of reporting entities grew. Preliminary inspection reveals that data prior to 2008 are not sufficiently reliable for our purposes. As a consequence, we only use information from that year onward, which significantly

⁴To avoid highlighting spurious spikes in temperatures, in Figure 2 we consider 5-years averages of the number of extreme heat days.

limits the scope of application of these data. We will include the events reported in ESWD as additional controls in our estimates, with the exclusion of severe precipitations, for which we have more accurate data in millimeters, as discussed above.

3.2 Firm demography data

We draw information on entry year, exit year, geographic location and sector of firms from the Infocamere dataset, which contains administrative registry data for the universe of Italian firms, excluding sole proprietorships. The dataset covers all sectors of activity for the years between 2005 and 2019. Overall, the firms included in our sample are representative of more than three quarters of total employees in Italy.

As many other administrative sources, the Infocamere dataset requires intensive data cleaning. The most relevant step concerns the activity status of the firm. Registered companies can go through different activity statuses during their lives: they can be either active (when production is normally taking place), suspended (when the firm undergoes a temporary interruption of production) or inactive (right after the firm's birth before becoming active, or when all activities cease)⁵. A firm can switch status multiple times and it is not automatically cancelled from the registry, even if it remains inactive for several years. Throughout our data cleaning process, we have tried to single out the dates in which the firms operated the strategic decision to enter the market in a certain location or to exit, disregarding temporary switches across statuses. To do that, this is how we treated the most relevant cases:

- The years in which a firm is suspended are considered as activity years and are not dropped from the sample.
- Firms that never turn active throughout their lives are entirely dropped from the sample. These are entities that were registered for motivations unrelated to production and therefore are not to be included in our analysis.

⁵The activity status is directly reported by each firm.

- The years of inactivity that some firms experience right after their entry are kept in the sample: even if the firm does not immediately start producing, the decision of entering the market is taken when the firm enrolls in the registry.
- Firms might undergo a (potentially long) stretch of inactivity before cancelling from the registry. A closed firm might remain in the registry for various reasons, related for example to the lengthiness of the bankruptcy procedures. Since we are interested in the date in which the firm stops producing, the years of inactivity following an activity period are dropped from the sample and the exit year of the firm is anticipated accordingly.

After data cleaning is carried out and after excluding non-market services, our sample contains on average around 2.1 million active firms per year (Table A.1).⁶ The vast majority of them belongs to the market services sector. Manufacturing and construction are roughly equally represented.

It is important to highlight that we only observe the location of a firm's headquarters, and not the one of its production facilities. This is a limitation of our data that we cannot explicitly address. However, given that our study takes into consideration the universe of Italian firms (including the smallest ones), we expect the phenomenon of multi-location businesses to be limited in relative terms. According to official data from Istat, each Italian firm has on average 1.08 plants, meaning that the practice of multiple localization is very limited in the Italian context.

Since our empirical strategy will rely on extreme temperature variations at the local labor market level, we collapse the relevant firm demography information (active firms, entry and exit) to this geographic aggregation, based on the geographic location of firms' headquarters. Since extreme temperature episodes might push firms to move to less-affected places, we also keep track of relocations to and from other LLMS.

⁶With 'active firms' we refer to the truly active firms, excluding the ones that have temporarily suspended production and the new-born ones that are still inactive.

By definition, when we collapse our data at the local labor market level, the following equality holds for each LLM in all years t :

$$A_t = A_{t-1} + E_t - X_t + R_t^{\text{in}} - R_t^{\text{out}} + Z_t \quad (1)$$

where A is the number of active firms; E and X are firms entering and exiting the market, respectively; R^{in} and R^{out} are firms relocating from and to other LLMs, respectively. The last term Z is a residual—typically negligible—which compounds relocations from/to foreign countries or undefined locations.

Rearranging the terms, we can express the growth rate of active firms as a function of entry, exit and relocation rates, as defined in the following expression:

$$\dot{A}_t \equiv \frac{A_t}{A_{t-1}} - 1 = \frac{E_t}{A_{t-1}} - \frac{X_t}{A_{t-1}} + \frac{R_t^{\text{in}}}{A_{t-1}} - \frac{R_t^{\text{out}}}{A_{t-1}} + \frac{Z_t}{A_{t-1}} = e_t - x_t + r_t^{\text{in}} - r_t^{\text{out}} + z_t \quad (2)$$

where lowercase letters represent rates.

Figure 3 shows the aggregate dynamics of these components in the years covered by our data. Net natality shrunk significantly in the first part of the sample, as a consequence of a sizable drop in entry and a more moderate but relevant increase in exit. From 2012 on, net natality remained stable at a low but positive level. The same trends are displayed with greater detail in Table 2, which reports the average values of demographic components across LLM, highlighting the substantial amount of variability between territorial units. However, no clear geographic pattern emerges in the demographic dynamics of firms. The two maps in Figure 4 illustrate the variation in entry and exit rates between the beginning and the end of our observation period. The changes are fairly dispersed across LLMs, with some of the largest decreases in the entry rates observed in certain parts of the Western coast (Campania, Calabria) and in Piedmont; instead, entry remained roughly stable or increased in some area of Sicily, Sardinia, Apulia, and North-East Alps. The variation in exit rates is equally spread out, with some large increases in

Eastern Sicily, Northern Sardinia, Tuscany and Western Alps. In general, it is difficult to eyeball a clear relationship between temperature variations and firm demographic dynamics: both sets of data are characterized by a substantial amount of variation, that we will try to discipline with our empirical strategy.

3.3 Firm balance-sheet data

As for firm's information we use data provided by Cerved Group, which collects companies' balance sheets and indicators for a very large portion of Italian limited liabilities companies. Our firms' dataset encompasses more than 10 million firm-year observations from 2004 to 2019. We filter the Cerved database according to two rules. First, we select only firms for which we know the location of the head office. In this way we are able associate to each firm a time-varying measure of temperature that it experiences. Then we consider only active firms, i.e. such that their turnover and assets are strictly positive.⁷ Table 3 contains main descriptive statistics for the Cerved sample.

4 The effect of extreme temperatures on firm demography and localization

In this section we analyze the a link between extreme temperature events and firm demography and localization, exploiting variability at the LLM level. Below we describe our empirical strategy, define the temperature variable that we take into account and present the results.

4.1 Empirical strategy

The effects of extreme temperatures on firm demography arguably take some time to build up. The decision process leading to events such as the entry into the market or the relocation of activity to a more favorable place is unlikely to be significantly altered by an isolated temperature

⁷Note that this definition of activity is different from the one used for the firm demography data, where the activity status is explicitly recorded in the registry.

event hitting a LLM in a certain year. The same argument applies to the exit decision of a firm: unless the extreme heat event is particularly disruptive, a company has plenty of potential instruments to absorb a single negative shock (for example using its own liquidity, increasing the use of credit, reorganizing production processes, or adjusting the number of employees). As repeated adverse temperature events accumulate in a certain place, they might start undermining the fundamental growth expectations of incumbent and prospective firms, thus affecting the medium-run considerations on the profitability of locating or remaining in that place. To gauge these effects, we have to both elaborate a specification that takes into account this medium-run decision horizon and define the relevant temperature variation for the firms' choices.

To net from short-run variations and to account for a relatively long time span in a parsimonious way, we first bin our data into 9 three-years periods over the entire observation sample. For each LLM-period cell, we compute the average growth rate of active firms, along with its average components (entry, exit and relocation rates) from equation 2. Notice that the addition property over the components is preserved by the binning procedure. We then estimate by OLS a distributed lag model on the binned data, where the coefficients of interest are the ones on the temperature variable that we will define shortly. Our baseline model is the following:

$$y_{ip} = \sum_{k=1}^3 \beta_k \Delta T_{i,p-k} + \sum_{k=1}^3 \gamma_k \Delta \ln(\text{prec})_{i,p-k} + X_{ip} + \delta_i + \delta_p + \varepsilon_{ip} \quad (3)$$

where i indexes LLMs and p indexes periods. The dependent variable $y_{ip} \in \{\bar{A}, \bar{e}, \bar{x}, \bar{r}^{\text{in}}, \bar{r}^{\text{out}}\}$ is the bin average of either the growth rate of active firms or of one of its components. $\Delta T_{i,p-k}$ is the temperature variation hitting LLM i at lag k from period p . Three lags of the variation in the log millimeters of precipitations are included in the regression in the same fashion. δ_i and δ_p are fixed effects, while X_{ip} contains additional controls that we occasionally add to our regressions. Depending on the specification, these might include area \times year or population quartile \times year dummies, in order to control for trends differentially affecting certain geographic

zones or rural vs urban LLMs.⁸ In an extension we also use the number of extreme events from the ESWD database as an additional control. Since these data are only reliable from 2008 on (see section 3), we can only include them with two lags; even so, using these data entails a substantial loss of observations. Standard errors are clustered at the LLM level.

Notice that, since the decomposition in 2 is exact and is preserved by our binning strategy, the coefficients of the regression using the growth rate of active firms as a dependent variable can be obtained as the sum of the coefficients of all other regressions. This allows us to gauge the relative importance of the various demographic components in determining the evolution of active firms.

As stated above, the coefficients of interest are those attached to the three lags of the temperature variable ΔT . Since heat waves might be correlated with other types of potentially disruptive weather events, we deem important to control for precipitations in order to isolate the pure effect of temperature variations on our variables of interest.⁹ Having a long series of temperature and weather observations (starting in 1993) allows us to deploy a rich lag structure while exploiting the full information on firm demography.

We perform a number of heterogeneity exercises throughout the paper. One of them investigates the stability of the coefficient estimates across different climatic zones. The purpose is to evaluate if the effect of extreme heat differentially affects places that are ex-ante characterized by a higher average temperature. To do that, we interact the temperature and precipitation variables by a categorical variable indicating whether the LLM belongs to the temperate or to the Mediterranean climatic zone.¹⁰ Another exercise aims at assessing what are the sectors that react the most to heat waves. In this case, we slightly modify the structure of our data, collapsing demographic information into LLM \times sector \times period cells and estimating the following

⁸The areas considered here are North West, North East, Center and South (including Islands). Population quartile is assigned to each LLM based on its population in 1999.

⁹Adding the ESWD extreme events data as additional controls responds to the same concern.

¹⁰The two zones are depicted in Figure B.1. They are defined on the basis of the Istat classification at <https://www.istat.it/it/archivio/224780>.

equation:

$$y_{isp} = \sum_{j=1}^S \sum_{k=1}^3 \beta_{jk} \Delta T_{i,p-k} \times \mathbb{1}(j = s) + \sum_{j=1}^S \sum_{k=1}^3 \gamma_{jk} \Delta \ln(\text{prec})_{i,p-k} \times \mathbb{1}(j = s) + X_{isp} + \delta_i + \delta_p + \varepsilon_{isp} \quad (4)$$

where s indexes sectors (defined according to the Nace Rev. 2 classification), $\mathbb{1}()$ is an indicator function identifying sectors, and X_{isp} also contains sector \times period fixed effects. In this case, standard errors are clustered at the LLM-sector level.

Having laid our empirical strategy, the only block that is yet to be defined is the temperature variable ΔT used in our regressions. We have already discussed in section 3 why we choose the number of days with a maximum temperature above 30°C as a measure of the frequency of heat waves. We now want to define what we deem to be the relevant temperature variable affecting firms' decision. We propose the time difference in the number of extreme heat days as a measure of the amount of innovation to the distribution of maximum temperatures known to the firms. In the context of our binned data exercise, for each LLM we define the temperature variable as follows:

$$\Delta T_p = \frac{\overline{M}_p^{>30} - \overline{M}_{p-1}^{>30}}{365} \quad (5)$$

where $\overline{M}_p^{>30}$ is the average number of days with maximum temperature above 30°C in period p . We rescale the difference by 365 to convert it to a share, in order to facilitate the reading of regression results. Figure 5 displays the distribution of ΔT over our 3-years period and across the temperate and Mediterranean climatic zones. Both zones follows roughly the same pattern over time, even though the Mediterranean one displays a little more variability and a slightly higher incidence of outliers.

This specification for the temperature variable allows us to interpret the estimates of our distributed lag model as the parameters of an impulse response function, following a permanent increase in temperatures: suppose that the incidence of extreme heat days increases by 1 percentage point in a certain period; then, the associated change in the dependent variable after p

periods will be equal to the coefficient attached to the p^{th} lag of the explanatory variable.¹¹

From a conceptual point of view, this temperature variable might proxy the update in the information set available to incumbent and prospective firms. When a draw of extreme heat days realizes in p , the firms' initial belief (as captured by the extreme heat realization in $p - 1$) is modified, reverberating on the optimal dynamic choices of the firms.¹²

Overall, the empirical strategy laid out in this section can be interpreted as a halfway compromise between a pure panel structure and the “long difference approach”, proposed by Burke and Emerick (2016) to net from short-run responses to weather events. In our model, the parsimonious distributed lag structure over time-averaged variables performs the same function of muting the erratic short-run effects, while at the same time highlighting the medium-term responses that determine the transition to a new equilibrium. We will show in the section dedicated to robustness exercises that adopting a long differences approach returns qualitatively very similar results.

4.2 Results

The baseline results obtained from the estimation of equation 3 on the growth rate of active firms and its components are displayed in Table 4. We directly report the most demanding specification, which includes LLM, period, area \times period and population quartile \times period fixed effects.

An increase in the number of extreme heat days leads to a decrease in the growth rate of active firms. The effect starts to pick up from the second lag, when it grows in size and becomes significant, and it persists in the following lag. The overall result is the composition of a decrease in the entry rate and a concurrent —though fainter— increase in the exit rate. Relocation does

¹¹Suppose that at $p = 0$ the share of extremely hot days increases by 1 percentage points in location i , so that $\Delta T_{i,0} = 1$. From equation 3 it is easy to show that —everything else equal — the change in y_{ip} after one period is $\Delta y_{i,1} = \beta_1 \Delta T_{i,0} = \beta_1$. Similarly, it can be shown that the change in y after two and three periods is equal to β_2 and β_3 , respectively.

¹²A similar conceptual framework is at the core of the related paper of Pankratz and Schiller (2021), in the context of a different empirical application.

not appear to be equally relevant. Relocation to and from other LLMs provides a positive and significant contribution in the second lag, but its magnitude is negligible with respect to the other components. The effect of precipitations on the growth rate of active firms is negative and mostly mediated by the entry rate component. The exit rate component is negatively affected by precipitations, although to a very limited extent. Since precipitations are not our main focus, we will not always report them in the presented tables, even though they are always included as a control.

As we could expect given the potentially secondary role played by climate variables in firms' strategic decisions, the size of the effects is not massive: a 1% increase in the share of extremely hot days (equivalent to 3.5 days more) reduces the growth rate of active firms by 0.04 percentage points after three periods (the average growth rate is 1.5 percent); it reduces the entry rate by 0.03 percentage points (5 percent on average) and increases the exit rate by 0.02 percentage points (3.5 on average). Nonetheless, the sign and significance of these estimates are robust across different specifications. Moreover, given the highly demanding specification, the variability explained by temperature and precipitation variables is not irrelevant—at least in the case of the entry rate—, as suggested by the within R^2 statistics.

The reduced-form model adopted in our empirical strategy can be thought as capturing the net impact of a host of firm-level and general equilibrium adjustments occurring over the medium run. Isolating each of these channels is out of the scope of this paper, but the overall impact on firm demography that we are able to identify compounds technology adjustments and other forms of medium-run adaptation of firms (e.g., capital reallocation across business units), as well as general equilibrium effects such as climate-induced labor mobility or changes in relative prices.

If the heat waves were correlated with other disruptive extreme weather events, there might be the concern that our results are picking up the effect of these adverse occurrences rather than that of extreme temperatures. To resolve this doubt, we include as additional controls the count

of different extreme events from the ESWD database, as described in the data section above. Given the already discussed limitations of the ESWD data, it is possible to include only two lags of the severe weather events. Results are reported in Table 5. The only significant coefficient estimates are those on hail and avalanches, possibly the most disruptive events in the dataset; as expected, their effect is negative on active firms, and it mostly unravels through a higher exit rate. Our baseline results on extreme temperature remain unaffected in most of its main indications, with an even stronger drop in the growth rate of active firms and in the entry rate. Instead, the coefficient estimates on exit rate reduce in magnitude and become non-significant. This might be due on one side to the fact that the previously singled out effects could have been mediated by other extreme events and were not imputable to extreme temperatures alone; on the other side, it is worth remembering that the limited time span of the ESWD data imply a substantial loss of observations (the estimation sample gets more than halved), potentially giving to rise to less precisely estimated parameters.

With this caveat in mind, it is however useful to compare the relative size of the effects of high temperatures, precipitations and extreme events. To do that, we have computed the impact that two consecutive and equally-sized variations in the explanatory variables would have on firm demography. To favor the comparison between the different phenomena, we have set the size of the variation to the one experienced by the average LLM. Table 6 collects the results. Precipitations are the event that imply a stronger adjustment in the growth rate of active firms, followed by the increase in temperatures. In both cases, the response is essentially driven by the entry rate. The extreme events are comparatively less relevant, also because they less frequently affect the average LLM. Among the two types of events considered, avalanches are the ones that have a slightly more pronounced effect on the demography of firms, leading to both a lower entry and a higher exit. Hail tends to increase firm exit only. Given the vast amount of information that we lose to include extreme events in our regressions, we do not deem these estimates to be the most solid ones we can provide. For this reason, and having shown that including extreme

events does not significantly affect the qualitative implications of our estimates, we will drop the ESWD events from our analysis in what follows.

Going back to the baseline results in Table 4, we have then expanded them to allow for potential heterogeneity in the average effects detected. A first exercise has looked across climatic zones, to investigate if the rise in temperature has different effects in areas characterized by different ex-ante climatic conditions. We only consider two climatic zones: (i) the Mediterranean one—including the two main Islands and all the coasts, except the North Eastern ones—, typically characterized by higher average temperatures; and (ii) the temperate one—including the rest of the country—, characterized by milder summers and colder winters.¹³ Results are displayed in Table 7. They show that the baseline results discussed above are essentially driven by the Mediterranean zone, where an increase in extreme temperatures leads to a clear drop in the growth rate of active firms, as a consequence of both a decrease in entry and an increase in exit. In the temperate zone the effects are less stark, but are if anything reversed: the growth rate of active firms increases as a consequence of the rise in temperatures, essentially through a lower exit rate. These results are broadly consistent with certain arguments brought about by the economic geography literature, claiming that regions might be unequally affected by climate change, with initially colder areas benefiting from a net inflow of population and economic activity at the expenses of initially warmer zones (see Cruz and Rossi-Hansberg (2021), who apply this argument at a global scale).

To provide a further test for this claim and unveil one of the causes at the root of the documented difference between Mediterranean and temperate zones, we have performed a similar heterogeneity exercise, distinguishing between the LLMs above and below the median average temperature in the years 1999–2001. Results displayed in Table A.4 confirms that the initial temperature might be a differentiation margin, showing that the effects are concentrated in the LLMs characterized by a higher average temperature. Their magnitudes are also close

¹³A map of these climatic zones is provided in Figure B.1.

tho the ones presented in Table 7 for the Mediterranean climate zone. A potential concern is that climate zones or average temperatures are essentially discriminating between Northern and Southern regions, which might be characterized by different pre-trends. To address this issue, we first repeat our estimates adding LLM-specific linear trends. Table 8 shows that the effects are even starker under this alternative specification. In Table 9, instead, we repeat the same estimates as in Table 7, but only within Southern regions. The number of observations drops, hence the precision is somewhat diminished. However, the same patterns emerge, with Mediterranean LLMs experiencing a reduction in the growth rate of active firms over the medium term. If anything, the differences between the two areas are even more pronounced, with the temperate zone benefiting from the temperature rise.

Another heterogeneity exercise involves estimating the differential effect of extreme temperatures across sectors. To do that, we have estimated the model in equation 4, with the full set of fixed effects discussed above. Given the large number of parameters to report, we have preferred to provide a graphical representation to summarize the main results.¹⁴ Under the hypothesis that a 1% increase in the share of extreme heat days occurred in three consecutive periods, the effect on entry, exit and relocation rates would be given by the sum of the coefficients on the three lags of ΔT . The histogram in Figure 6 provides these linear combinations of coefficient estimates, together with their standard errors. On one side, entry rate significantly drops for agriculture, manufacturing, construction and retail. All of them are sectors considered as particularly exposed to temperature shocks by the existing literature (Graff Zivin and Neidell, 2014). On the other side, exit rate increases significantly again for manufacturing, construction and retail. Once more, relocation plays no sizable role. The slight increase for the relocation rate from other LLMs among the 'other sectors' category is essentially driven by the electricity, gas, steam and air conditioning supply sector. Overall, the results are in line with expectations, given the nature of the activities carried out by the different sectors.

¹⁴Since the coefficient on the growth rate of active firms can be obtained as the sum of all other coefficients, we will not report it in what follows.

A richer picture emerges if we add another layer of heterogeneity, looking at how coefficients vary across sector and climate zones. Figure 7 displays a heatmap where blue colors indicate decreases and red colors increases; the intensity of the shading is proportional to the magnitude of the coefficient. White cells indicate non-significant values. The reported coefficient is again the linear combination of the three lags, supposing three consecutive 1% increases in heat days. This type of diagram allows a more granular representation of sectors. Again, it is apparent that most of the action takes place in the Mediterranean zone, where the entry rate decreases significantly for agriculture, mining, manufacturing, construction and retail. It also decreases for transportation and professional and support activities, probably indicating potential second-order effects, as these businesses depend on the activity of other firms. The Mediterranean zone also sees an increase in exit rates for manufacturing, construction and retail. Fainter effects can be acknowledged for the temperate zone. It is worth noting, however, that the entry rate in the agriculture sector decreases also in this area, probably signalling that these activities suffer from heat waves, independently of the initial climate conditions. Moreover, the tourism sector in the temperate region experiences a sizable increase in entry (only partly counterbalanced by an increase in exit), probably because higher temperatures allow to reduce the seasonality of trade flows.

4.3 The implications for firm demography of temperature rise in the current decade

The JRC MARS Meteorological Database provides us with a scenario for the evolution of precipitations and temperatures until 2030, according to the ETHZ CLM regional climate model projections run by the Swiss Federal Institute of Technology (see Jaeger et al. (2008) and Duveiller et al. (2017) for a discussion). It is therefore a natural step to provide a rough quantification of the effects that these changes would imply on firm demography, according to our estimates. To do that, we have computed the estimated variation in the growth rate of active

firms and its components between the years 2020 and 2031, as a consequence of the evolution of temperatures and precipitations forecast by the ETHZ scenario.

The results of this back-of-the-envelope calculations are displayed in Table 10. For Italy, the JRC data predict that in 2028 the share of days with maximum temperature above 30°C will be 4.1 percentage points higher than in 2011, while the precipitations will increase by 1.45%.¹⁵ According to our estimates in Table 4, these temperatures and precipitations dynamics would translate into a cumulative variation of -0.22 percentage points in the growth rate of active firms. This figure is the composition of a (cumulative) entry rate drop by -0.15 percentage points and a (cumulative) exit rate increase by 0.09. The relocation terms are quantitatively less relevant. As a term of comparison, over the same time window precipitations are predicted to have a lower impact than temperatures on firm demographics: a -0.07 percentage points decrease in the entry rate is almost entirely counterbalanced by an almost equally-sized decrease in the exit rate.

The lower panel of Table 10 displays how these figures vary across climate zones, once we apply the estimates obtained in Table 7. In the Mediterranean climatic zone, the evolution of temperatures would command a sharper decrease in the growth rate of active firms (-0.36 p.p.), again as a consequence of both a decrease in entry (-0.2) and an increase in exit (0.18). In the temperate climatic zone the effects are reversed in sign, with the exit playing a relatively stronger role. Precipitations also acquire more relevance in the Mediterranean zone, as a consequence of the more pronounced precipitation dynamics which is expected to characterize this area. Overall, this rough quantification exercise points to non-negligible effects of temperatures on the firms' entry and exit decisions over the current decade.

¹⁵The time span 2011–28 is the one that needed to project our estimates forward in the periods 2020–22, 2023–25, 2026–28 and 2029–31.

4.4 Robustness checks

In this section we perform some exercise to show the robustness of our findings. A first concern might be that, even though our battery of fixed effects allows us to capture differences in levels, it fails to control for potentially different trends characterizing the LLMs in our sample. To address this point, we have estimated the model in equation 3 including a linear LLM-specific trend. The results displayed in Table 11 are, if anything, more solid. The coefficients on entry and exit increase both in magnitude and significance.

A second source of worry is that the three-year window adopted to bin our data is of course arbitrary. Existing literature offers no clue on the optimal bin width for this kind of exercise. To support our specification, we show that the obtained results still hold even if we stretch the bin width to the whole sample period. In other words, we adopt a pure long difference approach in the spirit of Burke and Emerick (2016) and estimate our effects on the cross section of the LLMs. The growth rate of (average) active firms between 2005–07 and 2017–19 is regressed against the variation in the (average) share of days above 30°C between 2002–04 and 2014–16. Given that we are now dealing with a cumulative growth rate over a 12-years time window, when we use entry, exit and relocation rates as dependent variables they will also be cumulated over the same period. The accounting identity linking the demographic variables is still satisfied. Results are displayed in Table 12. Again, the effect on the growth rate of active firms is negative and significant; it mainly unfolds through the entry rate, and to a lesser extent through the exit rate. Also precipitations negatively affect the growth rate of active firms, essentially through the entry channel.

Another arbitrary choice —although motivated by extensive literature— is the one related to the 30°C threshold adopted to compute the explanatory variable ΔT . Hence, we have repeated our estimates changing the threshold. The results are graphically displayed in Figure 8. In the same spirit as the heterogeneity exercises presented above, we display —for each temperature choice— the linear combination of the coefficients on the three lags, corresponding to the effect

of three consecutive 1% increases in the temperature variable. For the sake of brevity, we have performed this exercise only for the growth rate of active firms, entry and exit. The results are robust to the choice of the temperature threshold. The effects tend to slightly increase in magnitude in the range between 29 and 32°C, consistently with the indications derived from the existing literature. For temperatures above 32°C the variation in the explanatory variable abruptly reduces, pushing down the precision of our estimates. These patterns emerge even more starkly if we repeat the heterogeneity exercise conducted on the climate zones and focus on the estimated effects in the Mediterranean one (column b).

For temperature thresholds above 32°C the results seem to fade away or even to invert. We argue that this pattern is driven by the sectoral heterogeneity underlying our estimates. In Figure 9 we repeat the same exercise allowing for the coefficients to differ by sector. For sake of compactness, we only perform this exercise for the growth rate of active firms. For temperature thresholds above 32°C, most of the sectoral effects — that are consistently negative for most of the affected sectors throughout the temperature spectrum — start to lose significance; this loss of precision might be due to the lower variability displayed by the variable ΔT as the reference temperature increases. At the same time, a set of very specific sectors appear to benefit disproportionately from high temperatures; these sectors are in the domain of utilities, that might actually benefit from a higher demand for energy and air conditioning as the temperature gets higher. Figure 9 points at two facts: (i) it reiterates the strong sectoral heterogeneity of the estimated effects; (ii) it shows that there is not a single temperature threshold for all sectors. However, threshold values around 30°C appear to capture consistent patterns within each sector.

5 Extreme temperatures and firm performance

The results discussed in the previous section indicate that higher temperatures entail a reduction in the number of active firms in the medium run, driven by a lower entry rate and possibly by a higher exit rate. In order to investigate whether hot temperatures also affect the

activity of the firms that are not involved in entry and exit decisions, we make use of balance sheet data at the firm level for the subset of incorporated firms, recorded in the Company Account Database (CAD) provided by Cerved Group SpA. This dataset contains full balance-sheet information on the universe of incorporated businesses (i.e. limited liability companies) in Italy, which encompass large multinational companies as well as small firms with only one worker. Such a wide variety is crucial to inspect potentially heterogeneous effects of high temperatures on firms' activity.¹⁶ Balance-sheet data allow us to inspect the effects of extreme temperatures on firms that are *in the market*, i.e. that survive to extreme temperature exposure at least during our sample period.

5.1 Empirical strategy

To assess the impact of temperature shocks on firms' fundamentals, we adopt a similar estimation strategy as the one in Section 4.1. As before, we bin our data into three-year periods over the observation sample. Then we use OLS to estimate the following distributed lag model:

$$y_{fp} = \sum_{k=0}^2 \beta_k \Delta T_{f,p-k} + \sum_{k=0}^2 \gamma_k \Delta \ln(\text{prec})_{f,p-k} + \delta_f + \delta_{sp} + \delta_{dp} + \varepsilon_{fp} \quad (6)$$

where f indexes the firm, s and d denote respectively the firm sector and size and p the period. We define firm sector s as the 2-digit NACE rev.2 classification code of each firm. We split our pool of firms into four groups based on firm size (micro, small, medium-sized and large firms) according to the Eurostat classification.¹⁷ $\Delta T_{f,p-k}$ is the temperature variation hitting the LLMs where each firm f is located at lag k from period p . Three lags of the variation in the log millimeters of precipitations are included in the regression as controls. δ_{\star} are fixed effects at the \star -level. With respect to the specification previously adopted, here we also include contemporaneous effects of temperature variations, in order to capture short-run effects that

¹⁶The CAD dataset is richer than other data sources commonly used for non-financial firms balance sheet analysis in economic research, as the latter typically include publicly listed firms only.

¹⁷We adopt the definition coming from the EU recommendation 2003/361 that contains the definition of micro, small and medium-sized enterprises

would have been unrealistic in the previous exercise.

We use the specification in Equation 6 for a range of dependent variables, including three different measures of firm size (total assets, net revenues and the total number of workers), the share of investments over total assets and an indicator of profitability. All these variables are averaged over the three year windows and, with the exception of investments (a flow variable), taken in growth rates.

5.2 Results

Table 13 reports the estimated coefficients of the model in Equation 6. Higher temperatures have contemporaneous effects on balance-sheet variables. These effects are, on average, small in magnitude but significantly positive: a permanent increase in the share of hot days per year, in a three year window, increases net revenues (Column 2) thereby affecting the total value of assets (Column 1). At the same time, the number of employees per firm is estimated to be increasing. This suggests that hotter temperatures might spur firm's growth, possibly because they stimulate the adoption of climate-related adaptation strategies that make them more productive and enhance their value.

Table 14 contains the results of the same regression model for investments and profitability as dependent variables. On one side, the negative effects of hot temperatures on firm investment (Column 1) suggest that firms' adaptation to higher temperatures may not pass through investments. On the other side, in line with previous results, extreme heat events increase profitability (Column (2)).

As the adaptation strategies undertaken to cope with a hotter weather can substantially differ across firms, it is worth to explore whether the impact of extreme temperatures at the firm level is also heterogeneous. For this purpose, we interact our temperature variable with some relevant firms' characteristics. As a first step, we analyze the marginal effect of extreme temperatures on firms of different sizes: as shown in Figure 10, the cumulative effect on firms' balance sheet

is positive across all size classes except for the micro firms, for which revenues, total assets and the number of employees significantly decrease. This result suggests a dichotomous effect of hot temperatures between larger firms and smaller (micro) ones. As a matter of fact, larger firms are better positioned to adapt to climate change, for at least three reasons. First, they can count on larger internal resources and an easier access to financing, which can be levered to undertake climate resilience strategies. Second, they can have a more established position in their product value chain, being able to switch suppliers or customers to cope with supply-chain disruptions due to climate change (Pankratz and Schiller, 2021). Third, larger firms often have more mature and advanced corporate governance systems for managing risk and responding to business disruptions.

Age is another important factor shaping firm's sensitivity to external shocks. For example, younger firms are found to be more reactive to idiosyncratic demand shocks (Berman et al., 2019) or to monetary policy surprises (Durante et al., 2022). We then examine whether firms in our sample are also heterogeneous across age groups by splitting the sample between younger (those less than 10 years old) and older ones. Figure 11 shows that the cumulative effect of extremely high temperatures on growth (in terms of total assets), revenues and employees, is positive for younger firms and negative for older ones. This result may be related to the fact that younger firms have invested less in obsolete, climatic-risky technologies, making it easier for them to pivot towards more sustainable and climate-resilient expenditures.

As both dimensions of age and size look important to disentangle positive and negative effects of temperatures at firm level, we here include a double interaction in our regression specification to jointly account for size effects across different age classes. Results in Figure 12 are twofold. On one side, they confirm that the effects of extreme temperatures on firms' growth is larger for both younger and larger (i.e., non-micro) firms. On the other side, the impact is always negative only for firms that are jointly older and smaller, which account for more than a quarter of our estimation sample. This category encompasses those companies that, for whatever reason, had

failed to pursue any growth path and are stuck to their initially small size. Older and micro firms may struggle to adapt to climate change for similar reasons to those that hampered their growth path, such as, among others, the lack of innovation and capacity to direct resources to new technologies and processes. In the case of older, micro firms, hotter temperatures negatively affect both profitability and capital accumulation (Figure 13).

6 Conclusions

In this paper we investigate medium-run implications of climate change on the business sector, using data on the universe of Italian firms. We find that a permanent increase in hot temperatures ends up reducing the entry rate of new firms and increasing exit rate. Results vary substantially, based on the sector and geographic area to which firms belong to. A balance-sheet level analysis on the subset of incorporated firms also reveals a differential impact of climate change on firms' business depending on their size, as temperatures have negative effects only for older firms that have remained small in size, while it appears to be beneficial, particularly, for younger firms that are already large, probably the ones having a greater propensity to invest in adaptation strategies to the varying climatic conditions.

Our findings might have relevant policy implications. First, as global warming may turn beneficial for the firms in the higher part of the firm size distribution, policy makers might meditate on the opportunity to target policies to smaller firms, in order to assist them in their adaptation process to varying climate conditions. Second, the documented heterogeneity across geographic areas might signal potential effects of temperatures on regional disparities. In Italy, for example, the future evolution of heat waves might exacerbate the existing divide between the North and the South (Mediterranean areas are mostly located in the South). In that case, additional efforts could be placed on the leveling of non-climate related differences in the business environment, that may act as a resilience device to contrast the effects of rising temperatures on the production structure. Finally, our findings call for additional research on the repercussion

of climate-induced entry and exit dynamics on aggregate productivity at the local level.

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Tables

Table 1: Number of extreme heat days, summary statistics

year	mean	median	std. dev.	minimum	maximum
1993	23.10	23	14.77	0	72
1994	38.90	39	20.55	0	90
1995	18.47	17	12.51	0	47
1996	12.98	11	10.14	0	61
1997	17.89	13	15.80	0	73
1998	36.27	39	18.03	0	70
1999	25.63	26	15.64	0	67
2000	29.23	29	16.84	0	65
2001	35.29	36	19.03	0	86
2002	22.27	22	13.51	0	67
2003	63.78	69	23.58	0	96
2004	29.34	29	18.87	0	79
2005	26.19	25	14.66	0	63
2006	36.21	38	15.92	0	75
2007	34.49	36	18.96	0	79
2008	41.76	46	25.25	0	84
2009	42.57	46	22.57	0	81
2010	31.35	32	18.93	0	77
2011	36.96	37	21.89	0	90
2012	53.59	61	26.08	0	105
2013	34.80	36	20.00	0	75
2014	20.11	14	17.63	0	89
2015	45.46	47	18.80	0	80
2016	31.01	31	21.13	0	77
2017	44.97	47	21.34	0	90
2018	33.29	32	20.02	0	95
2019	46.03	49	23.44	0	97
Total	33.78	33	22.18	0	105

Notes: The table displays some summary statistics for the number of extreme heat days across LLMs. Extreme heat days are defined as those in which the maximum temperature exceeds 30°C.

Table 2: Summary statistics for the components of firm demography

year	\dot{A}	e	x	r^{in}	r^{out}
2006	0.0497 (0.0233)	0.0688 (0.0204)	0.0194 (0.0090)	0.0030 (0.0031)	0.0028 (0.0026)
2007	0.0334 (0.0214)	0.0640 (0.0165)	0.0305 (0.0105)	0.0034 (0.0028)	0.0035 (0.0031)
2008	0.0251 (0.0234)	0.0591 (0.0176)	0.0337 (0.0133)	0.0051 (0.0035)	0.0054 (0.0035)
2009	0.0161 (0.0213)	0.0516 (0.0157)	0.0349 (0.0115)	0.0055 (0.0038)	0.0060 (0.0036)
2010	0.0162 (0.0254)	0.0521 (0.0165)	0.0356 (0.0178)	0.0048 (0.0034)	0.0051 (0.0031)
2011	0.0113 (0.0202)	0.0466 (0.0136)	0.0352 (0.0116)	0.0047 (0.0031)	0.0048 (0.0030)
2012	0.0043 (0.0170)	0.0431 (0.0129)	0.0388 (0.0132)	0.0047 (0.0030)	0.0046 (0.0029)
2013	0.0073 (0.0176)	0.0434 (0.0136)	0.0363 (0.0106)	0.0036 (0.0026)	0.0035 (0.0026)
2014	0.0059 (0.0198)	0.0446 (0.0148)	0.0387 (0.0110)	0.0036 (0.0060)	0.0035 (0.0027)
2015	0.0077 (0.0201)	0.0453 (0.0151)	0.0373 (0.0112)	0.0031 (0.0024)	0.0034 (0.0027)
2016	0.0106 (0.0179)	0.0467 (0.0138)	0.0359 (0.0102)	0.0033 (0.0026)	0.0035 (0.0027)
2017	0.0112 (0.0277)	0.0485 (0.0199)	0.0373 (0.0108)	0.0035 (0.0087)	0.0035 (0.0081)
2018	0.0093 (0.0464)	0.0464 (0.0168)	0.0364 (0.0112)	0.0040 (0.0243)	0.0046 (0.0295)
2019	0.0059 (0.0202)	0.0420 (0.0148)	0.0361 (0.0120)	0.0040 (0.0053)	0.0041 (0.0054)
Total	0.0153 (0.0270)	0.0502 (0.0179)	0.0347 (0.0128)	0.0037 (0.0076)	0.0039 (0.0087)

Notes: The table displays the average values across LLMs of the components of firm demography, as defined in equation 2. Standard deviations are displayed in parentheses.

Table 3: Firms' balance sheet data - Descriptive Stats

	mean	sd	p25	p50	p75
Total assets (1)	3.783	46.416	-13.608	3.622	23.779
Net revenues (1)	-11.747	83.150	-27.963	-1.612	18.684
Nr. of employees (1)	-1.937	43.318	-11.848	0.000	12.783
Investments (2)	-0.995	9.697	-1.884	-0.249	0.777
EBITDA (3)	-2.789	19.999	-6.330	-1.150	2.676
Observations	1,525,530				

Notes: Author's elaboration on Cerved Data. All variables are presented in percentage points. (1) Variables are calculated in growth rate. (2) Over total assets. (3) Over total assets and in difference with respect to the previous period.

Table 4: Firm demography regressions, baseline results

	\dot{A}	e	x	r^{in}	r^{out}
ΔT_{p-1}	-0.013 [0.012]	-0.010 [0.009]	0.003 [0.008]	0.004 [0.003]	0.001 [0.003]
ΔT_{p-2}	-0.033** [0.016]	-0.026** [0.012]	0.003 [0.010]	0.005** [0.002]	0.007* [0.004]
ΔT_{p-3}	-0.043** [0.021]	-0.029** [0.012]	0.019* [0.010]	-0.002 [0.006]	-0.008 [0.012]
$\Delta \ln(\text{prec})_{p-1}$	-0.011** [0.005]	-0.015*** [0.002]	-0.005*** [0.002]	0.002 [0.002]	0.003 [0.003]
$\Delta \ln(\text{prec})_{p-2}$	-0.001 [0.004]	-0.006*** [0.002]	-0.006*** [0.002]	0.001 [0.001]	0.002 [0.002]
$\Delta \ln(\text{prec})_{p-3}$	-0.008*** [0.003]	-0.010*** [0.002]	-0.002 [0.001]	0.001 [0.001]	0.002* [0.001]
Obs.	3,055	3,055	3,055	3,055	3,055
R^2	0.609	0.756	0.758	0.334	0.246
Within R^2	0.016	0.055	0.010	0.003	0.004

Notes: Estimation results for the model in equation 3. Column names indicate the dependent variable of each regression. LLM, period, area \times period and population quartile \times period fixed effects included in all specifications. Coefficients on entry, exit and relocation rates regressions might not add up to the coefficients in the first columns, because the residual term in equation 2 is not reported in the table. Standard errors clustered at the LLM level in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5: Firm demography regressions, controlling for extreme events

	\dot{A}	e	x	r^{in}	r^{out}
ΔT_{p-1}	-0.047* [0.025]	-0.062*** [0.020]	-0.000 [0.013]	0.012 [0.008]	-0.003 [0.008]
ΔT_{p-2}	-0.110** [0.047]	-0.107*** [0.028]	-0.007 [0.019]	0.025 [0.015]	0.035 [0.023]
ΔT_{p-3}	-0.125*** [0.044]	-0.120*** [0.030]	0.017 [0.017]	0.002 [0.007]	-0.011 [0.020]
hail $_{p-1}$	-0.012 [0.032]	0.006 [0.021]	0.016 [0.018]	-0.004 [0.006]	-0.002 [0.009]
hail $_{p-2}$	-0.064* [0.034]	-0.017 [0.022]	0.052*** [0.019]	0.014 [0.011]	0.009 [0.007]
avalanches $_{p-1}$	-0.446*** [0.112]	-0.106 [0.085]	0.321*** [0.097]	0.007 [0.023]	0.024 [0.034]
avalanches $_{p-2}$	-0.829*** [0.212]	-0.436*** [0.130]	0.374** [0.174]	-0.001 [0.044]	0.019 [0.079]
Obs.	1,222	1,222	1,222	1,222	1,222
R^2	0.726	0.838	0.808	0.517	0.511
Within R^2	0.079	0.215	0.041	0.012	0.016

Notes: Estimation results for the model in equation 3, augmented with additional controls for extreme events. Column names indicate the dependent variable of each regression. Coefficients on precipitations are not reported. LLM, period, area \times period and population quartile \times period fixed effects included in all specifications. Standard errors clustered at the LLM level in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6: Comparing the size of the effects of temperatures, precipitations and extreme events

	\dot{A}	e	x	r^{in}	r^{out}
ΔT	-0.078**	-0.085***	-0.004	0.018	0.016
$\Delta \ln(\text{prec})$	-0.263**	-0.218***	-0.001	0.038	0.084
hail	-0.034	-0.005	0.031**	0.004	0.003
avalanches	-0.047***	-0.020***	0.026***	0.000	0.002

Notes: For each dependent variable, this table reports the effect of two consecutive temperature, precipitation or extreme event (hail or avalanche) realizations of the size experienced by the average LLM. The comparison is conducted on the restricted sample for which we have information on extreme events. All coefficients are expressed in percentage points.

Table 7: Firm demography regressions, climate zone heterogeneity

	\dot{A}	e	x	r^{in}	r^{out}
$\Delta T_{p-1} \times \text{temperate}$	0.029 [0.021]	0.008 [0.013]	-0.024** [0.010]	0.010 [0.006]	0.014 [0.009]
$\Delta T_{p-2} \times \text{temperate}$	0.052** [0.021]	0.014 [0.014]	-0.034*** [0.013]	0.005 [0.005]	0.008 [0.006]
$\Delta T_{p-3} \times \text{temperate}$	0.037* [0.021]	0.015 [0.014]	-0.023* [0.014]	0.006 [0.004]	0.009* [0.005]
$\Delta T_{p-1} \times \text{Mediterranean}$	-0.026* [0.015]	-0.011 [0.011]	0.016* [0.010]	0.001 [0.003]	-0.004 [0.003]
$\Delta T_{p-2} \times \text{Mediterranean}$	-0.061*** [0.020]	-0.034** [0.015]	0.020 [0.013]	0.005* [0.003]	0.005 [0.004]
$\Delta T_{p-3} \times \text{Mediterranean}$	-0.073*** [0.027]	-0.043*** [0.015]	0.038*** [0.013]	-0.005 [0.008]	-0.016 [0.016]
Obs.	3,055	3,055	3,055	3,055	3,055
R^2	0.613	0.760	0.761	0.336	0.248
Within R^2	0.024	0.069	0.023	0.005	0.006

Notes: Estimation results for the model in equation 3, with parameters being allowed to be heterogeneous across climate zones. Column names indicate the dependent variable of each regression. Coefficients on precipitations are not reported. LLM, period, area \times period and population quartile \times period fixed effects included in all specifications. Coefficients on entry, exit and relocation rates regressions might not add up to the coefficients in the first columns, because the residual term in equation 2 is not reported in the table. Standard errors clustered at the LLM level in parentheses * p<0.10, ** p<0.05, *** p<0.01

Table 8: Firm demography regressions, climate zone heterogeneity and LLM-specific linear trend

	\dot{A}	e	x	r^{in}	r^{out}
$\Delta T_{p-1} \times \text{temperate}$	0.028 [0.035]	0.006 [0.021]	-0.028 [0.017]	0.017* [0.009]	0.023 [0.014]
$\Delta T_{p-2} \times \text{temperate}$	0.039 [0.035]	0.004 [0.023]	-0.038** [0.018]	0.015 [0.009]	0.020* [0.010]
$\Delta T_{p-3} \times \text{temperate}$	0.032 [0.029]	0.009 [0.020]	-0.029* [0.017]	0.016** [0.007]	0.021*** [0.007]
$\Delta T_{p-1} \times \text{Mediterranean}$	-0.018 [0.020]	-0.008 [0.015]	0.009 [0.013]	-0.001 [0.004]	-0.004 [0.004]
$\Delta T_{p-2} \times \text{Mediterranean}$	-0.097*** [0.028]	-0.056*** [0.018]	0.036* [0.019]	0.005 [0.006]	0.007 [0.005]
$\Delta T_{p-3} \times \text{Mediterranean}$	-0.105*** [0.032]	-0.057*** [0.017]	0.056*** [0.015]	-0.007 [0.007]	-0.014 [0.017]
Obs.	3,055	3,055	3,055	3,055	3,055
R^2	0.755	0.839	0.823	0.628	0.614
Within R^2	0.383	0.378	0.274	0.443	0.490

Notes: Estimation results for the model in equation 3, with parameters being allowed to be heterogeneous across climate zones. Column names indicate the dependent variable of each regression. Coefficients on precipitations are not reported. LLM, period, area \times period and population quartile \times period fixed effects included in all specifications. LLM-specific linear trends included in all specifications. Coefficients on entry, exit and relocation rates regressions might not add up to the coefficients in the first columns, because the residual term in equation 2 is not reported in the table. Standard errors clustered at the LLM level in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 9: Firm demography regressions, climate zone heterogeneity in the Southern regions

	\dot{A}	e	x	r^{in}	r^{out}
$\Delta T_{p-1} \times \text{temperate}$	0.214*** [0.075]	0.137** [0.054]	-0.105*** [0.027]	0.012 [0.018]	0.028 [0.029]
$\Delta T_{p-2} \times \text{temperate}$	0.080 [0.102]	0.057 [0.069]	-0.055 [0.044]	-0.010 [0.014]	0.016 [0.019]
$\Delta T_{p-3} \times \text{temperate}$	0.095 [0.094]	-0.001 [0.066]	-0.125*** [0.044]	-0.010 [0.015]	-0.000 [0.023]
$\Delta T_{p-1} \times \text{Mediterranean}$	-0.016 [0.016]	-0.006 [0.012]	0.010 [0.010]	0.001 [0.004]	-0.004 [0.003]
$\Delta T_{p-2} \times \text{Mediterranean}$	-0.044** [0.021]	-0.024 [0.017]	0.013 [0.014]	0.001 [0.003]	0.003 [0.004]
$\Delta T_{p-3} \times \text{Mediterranean}$	-0.068** [0.030]	-0.045*** [0.016]	0.031** [0.013]	-0.008 [0.009]	-0.019 [0.019]
Obs.	1,405	1,405	1,405	1,405	1,405
R^2	0.405	0.633	0.693	0.268	0.229
Within R^2	0.042	0.114	0.034	0.009	0.008

Notes: Estimation results for the model in equation 3, with parameters being allowed to be heterogeneous across climate zones. Column names indicate the dependent variable of each regression. Coefficients on precipitations are not reported. LLM, period, area \times period and population quartile \times period fixed effects included in all specifications. Coefficients on entry, exit and relocation rates regressions might not add up to the coefficients in the first columns, because the residual term in equation 2 is not reported in the table. Standard errors clustered at the LLM level in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 10: Estimated changes in firm demography variables in the 2020 decade, under a potential scenario for temperatures and precipitations

	\dot{A}	e	x	r^{in}	r^{out}
All LLMs					
cumulative ΔT 2011–28 (p.p.)=4.102	-0.223	-0.154	0.085	0.002	-0.025
cumulative $\Delta \ln(\text{prec})$ 2011–28 (%)=1.454	-0.010	-0.074	-0.067	0.011	0.024
Temperate climate zone					
cumulative ΔT 2011–28 (p.p.)=3.978	0.271	0.094	-0.180	0.047	0.073
cumulative $\Delta \ln(\text{prec})$ 2011–28 (%)=-2.459	0.116	0.079	-0.030	-0.000	-0.001
Mediterranean climate zone					
cumulative ΔT 2011–28 (p.p.)=4.273	-0.356	-0.207	0.181	-0.019	-0.067
cumulative $\Delta \ln(\text{prec})$ 2011–28 (%)=7.488	-0.203	-0.325	-0.144	0.031	0.066

Notes: This table reports back of the envelope calculations based on the results displayed in tables 4 and 7. For each dependent variable, the reported coefficients represent the cumulated change in the period 2020–2031, as predicted by our estimates. All coefficients are expressed in percentage points. The future evolution of temperatures and precipitations is defined according the ETHZ CLM regional climate model projections.

Table 11: Firm demography regressions, adding LLM-specific linear trends

	\dot{A}	e	x	r^{in}	r^{out}
ΔT_{p-1}	-0.012 [0.017]	-0.010 [0.013]	-0.001 [0.011]	0.003 [0.005]	0.002 [0.003]
ΔT_{p-2}	-0.063*** [0.024]	-0.044*** [0.015]	0.014 [0.015]	0.007 [0.005]	0.010* [0.005]
ΔT_{p-3}	-0.069*** [0.025]	-0.042*** [0.014]	0.030** [0.012]	-0.001 [0.006]	-0.005 [0.013]
$\Delta \ln(\text{prec})_{p-1}$	-0.010 [0.007]	-0.013*** [0.002]	-0.005** [0.002]	0.002 [0.003]	0.004 [0.005]
$\Delta \ln(\text{prec})_{p-2}$	-0.005 [0.008]	-0.007** [0.003]	-0.003 [0.003]	0.003 [0.003]	0.004 [0.005]
$\Delta \ln(\text{prec})_{p-3}$	-0.011* [0.006]	-0.010*** [0.002]	-0.001 [0.002]	0.001 [0.002]	0.004 [0.004]
Obs.	3,055	3,055	3,055	3,055	3,055
R^2	0.751	0.836	0.819	0.626	0.612
Within R^2	0.374	0.365	0.260	0.439	0.488

Notes: Estimation results for the model in equation 3. Column names indicate the dependent variable of each regression. LLM, period, area \times period and population quartile \times period fixed effects included in all specifications. LLM-specific linear trends included in all specifications. Coefficients on entry, exit and relocation rates regressions might not add up to the coefficients in the first columns, because the residual term in equation 2 is not reported in the table. Standard errors clustered at the LLM level in parentheses * p<0.10, ** p<0.05, *** p<0.01

Table 12: Firm demography regressions, long differences approach

	\dot{A}	e	x	r^{in}	r^{out}
ΔT	-0.160*** [0.061]	-0.128** [0.054]	0.037* [0.022]	-0.006 [0.008]	-0.007 [0.011]
$\Delta \ln(\text{prec})$	-0.075*** [0.010]	-0.078*** [0.010]	-0.000 [0.004]	0.004*** [0.001]	0.004*** [0.001]
Obs.	611	611	611	611	611
R^2	0.111	0.124	0.006	0.015	0.014

Notes: Estimation results using a long differences approach as in Burke and Emrick (2016). Column names indicate the dependent variable of each regression. \dot{A} computed as the variation between the average number of active firms in the periods 2005–07 and 2017–19. Entry, exit and relocation rates are averages over the whole 2005–2019 period. ΔT and $\Delta \ln(\text{prec})$ are variations between average values in the periods 2002–04 and 2014–16. Coefficients on entry, exit and relocation rates regressions might not add up to the coefficients in the first columns, because the residual term in equation 2 is not reported in the table. Robust standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 13: Firms' fundamentals regressions

	(1) Total assets	(2) Net revenues	(3) Number of employees
ΔT_p	0.00054*** [0.00007]	0.00089*** [0.00014]	0.00030*** [0.00008]
ΔT_{p-1}	0.00053*** [0.00009]	0.00130*** [0.00016]	0.00034*** [0.00009]
ΔT_{p-2}	0.00096*** [0.00009]	0.00179*** [0.00018]	0.00099*** [0.00010]
$\Delta \ln(\text{prec})_p$	-2.23135*** [0.49456]	-6.10369*** [0.99164]	-0.79884 [0.51455]
$\Delta \ln(\text{prec})_{p-1}$	-1.22313** [0.49646]	1.82443* [0.93183]	2.51359*** [0.50275]
$\Delta \ln(\text{prec})_{p-2}$	4.27880*** [0.36550]	11.70880*** [0.71434]	7.06853*** [0.37788]
Obs.	1525530	1525530	1474680
R^2	0.477	0.394	0.429
Within R^2	0.00031	0.00053	0.00055

Notes: Column names indicate the dependent variable of each regression. Each variable is calculated in log-difference with respect to the previous period. Coefficients on lagged precipitations are not reported. Firm, sector \times period, size \times period fixed effects included in all specifications. Each dependent variable is winsorized at (0.5, 99.5). Standard errors clustered at the firm level in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

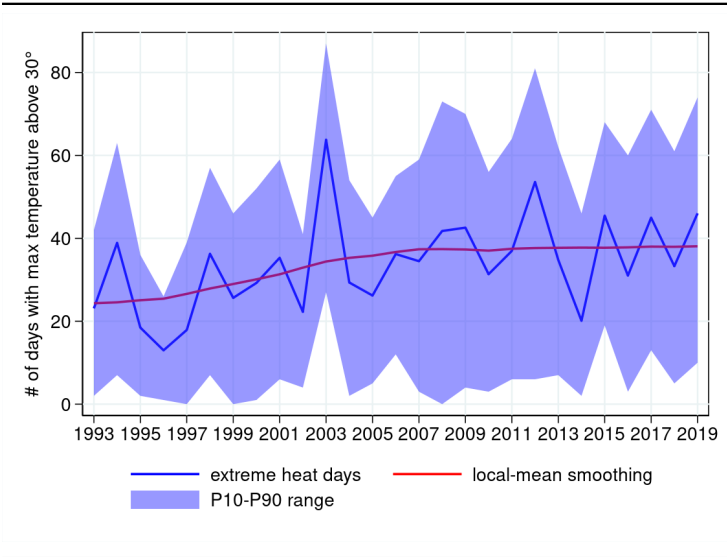
Table 14: Firms' indices regressions

	(1) Investments	(2) EBITDA
ΔT_p	-0.00004** [0.00002]	-0.00004 [0.00003]
ΔT_{p-1}	-0.00001 [0.00002]	0.00011*** [0.00004]
ΔT_{p-2}	0.00002 [0.00002]	0.00002 [0.00005]
$\Delta \ln(\text{prec})_p$	0.21521* [0.11294]	-0.00158 [0.24510]
$\Delta \ln(\text{prec})_{p-1}$	-0.04333 [0.11055]	0.93186*** [0.23823]
$\Delta \ln(\text{prec})_{p-2}$	-0.10135 [0.08386]	1.09117*** [0.17869]
Obs.	1494015	1525530
R^2	0.392	0.304
Within R^2	0.00003	0.00007

Notes: Column names indicate the dependent variable of each regression. Each dependent variable is winsorized at (0.5, 99.5). The variables in the last three columns calculated in difference with respect to the previous period. The variables in the first three columns are calculated as ratio over total assets. Liquidity is computed as the sum of cash and financial assets. Leverage is defined as the ratio of financial debts and the sum of financial debts and capital. Firm, sector \times period, size \times period fixed effects included in all specifications. Standard errors clustered at the firm level in parentheses * p<0.10, ** p<0.05, *** p<0.01

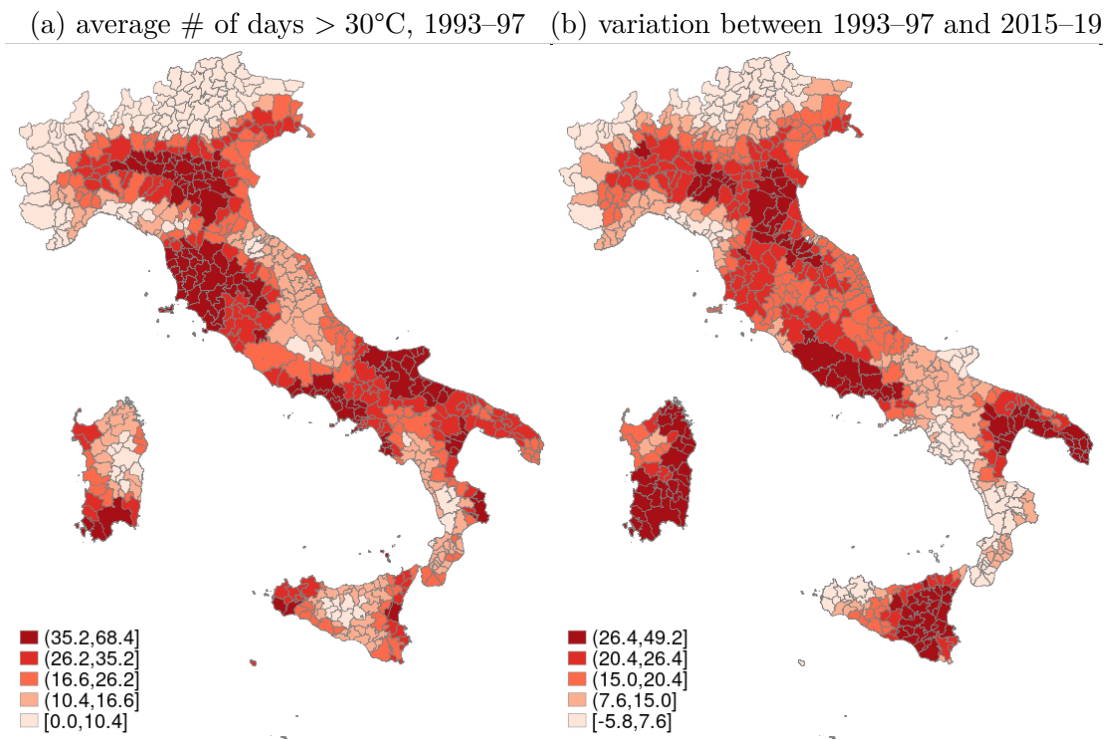
Figures

Figure 1: The evolution of extreme heat days in Italy



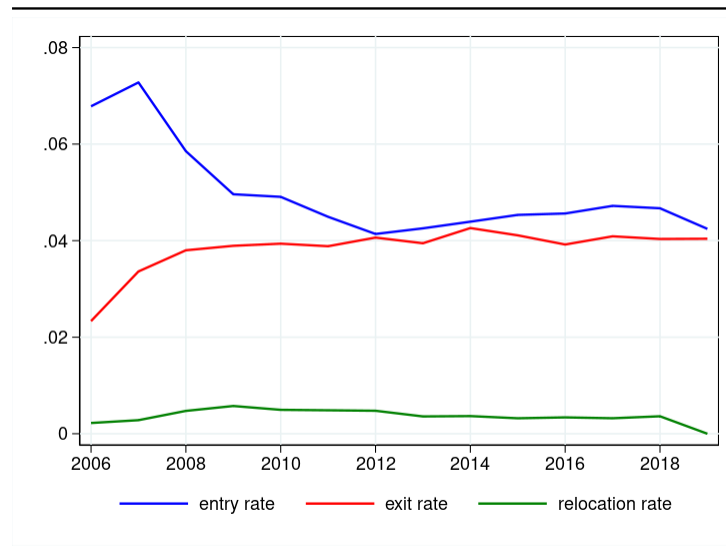
Notes: Average number of extreme heat days across LLMs. The shaded area displays the range between the 10th and 90th percentile of the number of extreme heat days in each year. Extreme heat days are defined as those in which the maximum temperature exceeds 30°C.

Figure 2: The distribution of extreme heat days in Italy



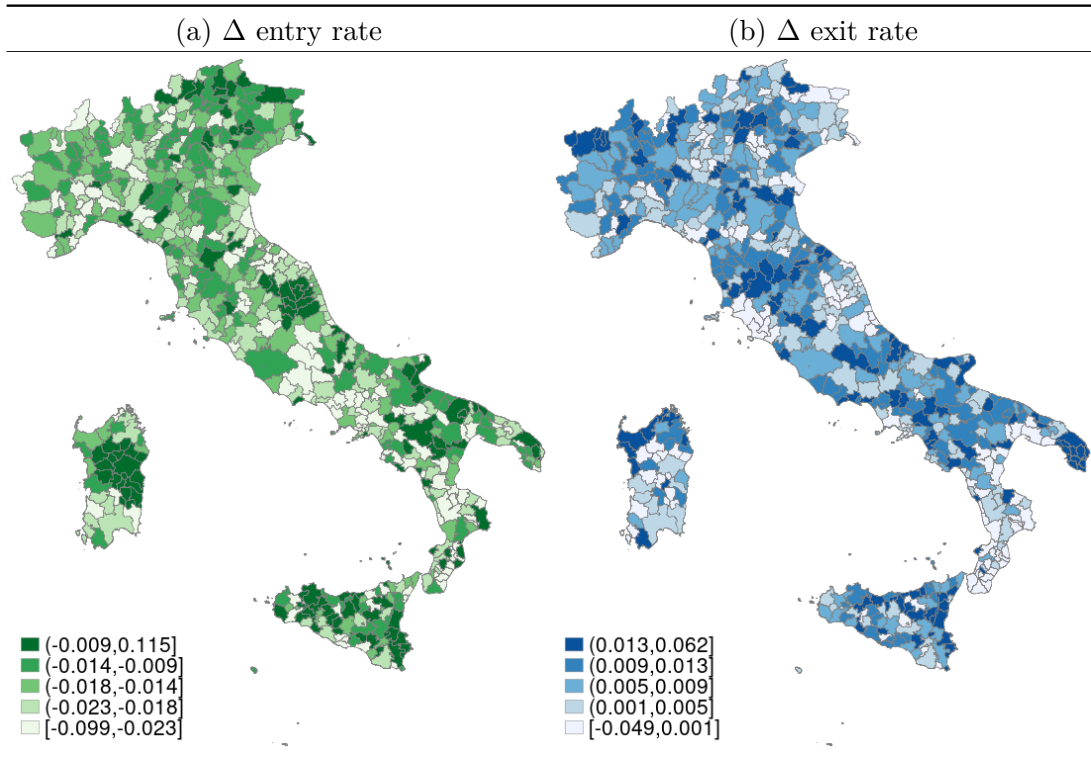
Notes: Extreme heat days are defined as those in which the maximum temperature exceeds 30°C . Data are averaged over 5-years windows to smooth erratic variations in the number of extreme heat days. Panel (a) represents the average number of extreme heat days for each local labor market in the period 1993–97. Panel (b) represents the variation in the average number of extreme heat days between 1993–97 and 2015–19. In both panels, data have been grouped in five equally populated classes.

Figure 3: The evolution of firm demography components in Italy



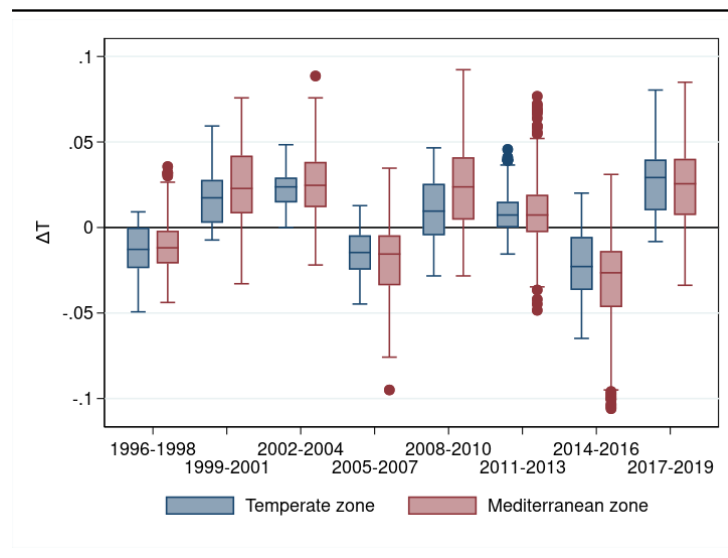
Notes: Aggregate entry, exit and relocation rates, as defined in equation 2. We only draw one relocation component, since in the aggregate the relocation to other LLMs and from other LLMs are equal by definition.

Figure 4: The variation of entry and exit rates, 2005–07 to 2017–2019



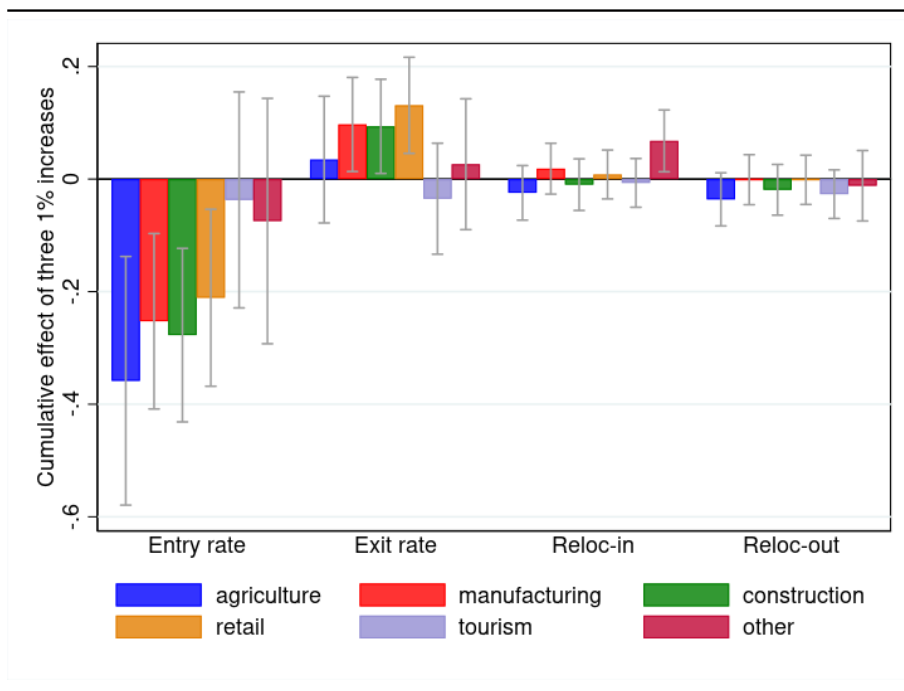
Notes: Entry and exit rates are defined as in equation 2. Data are averaged over 3-years windows to smooth short-run variations in entry and exit rates. Panel (a) represents the variation of the average entry rate between the years 2005–07 and 2017–2019. Panel (b) represents the variation of the average exit rate between the years 2005–07 and 2017–2019. In both panels, data have been grouped in five equally populated classes.

Figure 5: Distribution of ΔT over time and across climate zones



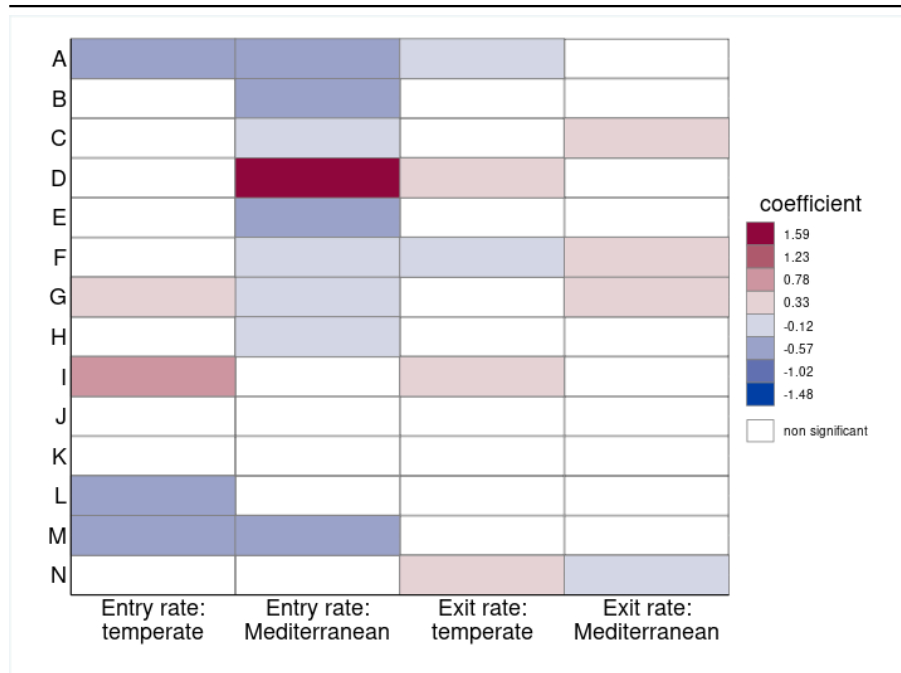
Notes: The figure represents a box and whiskers plot for the variable ΔT , as defined in equation 5. Climate zones are defined according to Istat classification, as in Figure B.1.

Figure 6: The effect of extreme temperature events across sectors



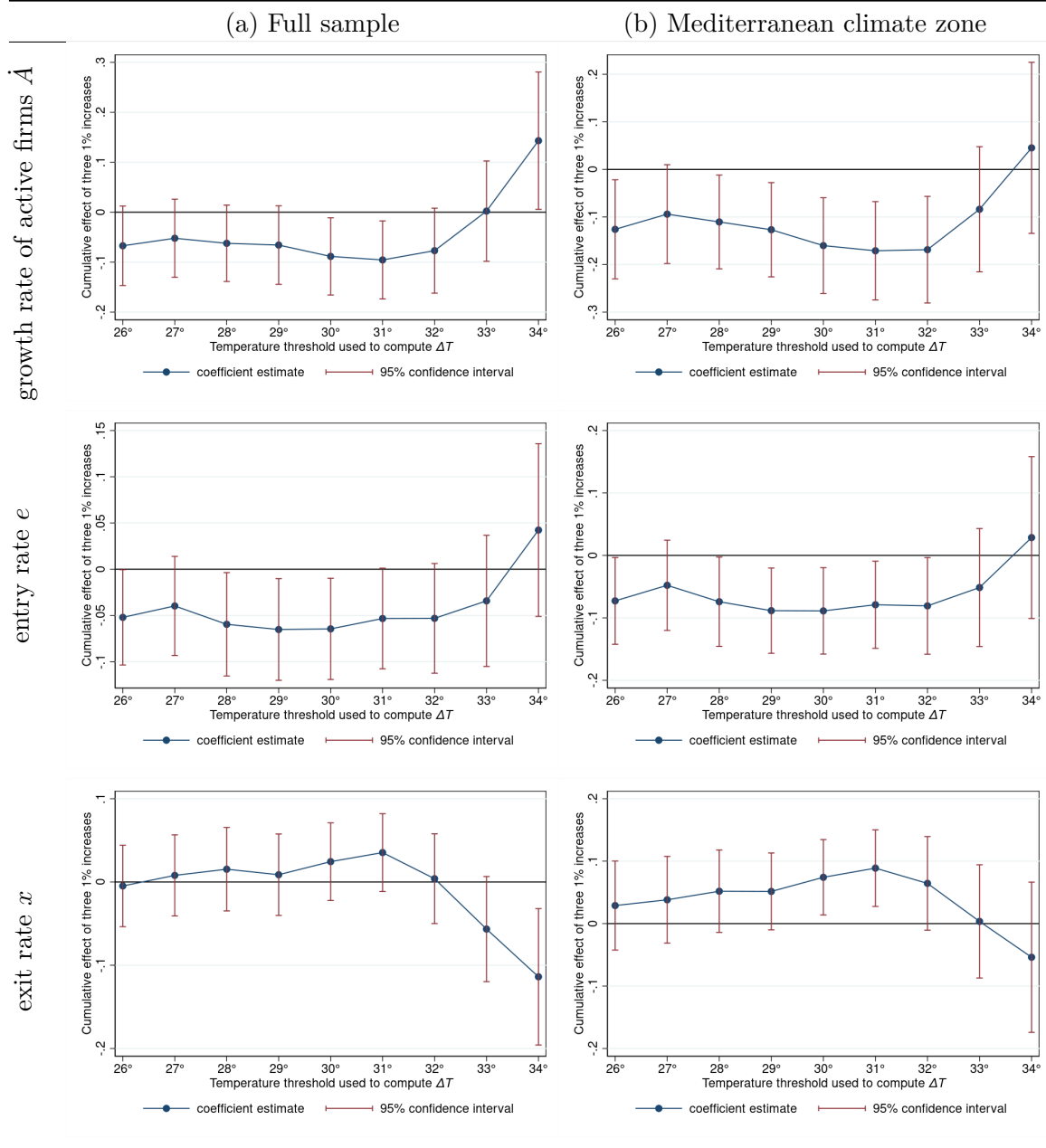
Notes: The graph is a visual representation of the coefficients obtained estimating the model in equation 4. The reported bars depict the linear combination of the three coefficients on lagged ΔT , hypothesizing a 1% increase in the number of extreme heat days in three consecutive periods. The horizontal axis displays the dependent variable used in the regression. The gray lines are confidence intervals at the 95% significance level.

Figure 7: The effect of extreme temperature events across sectors and climate zones



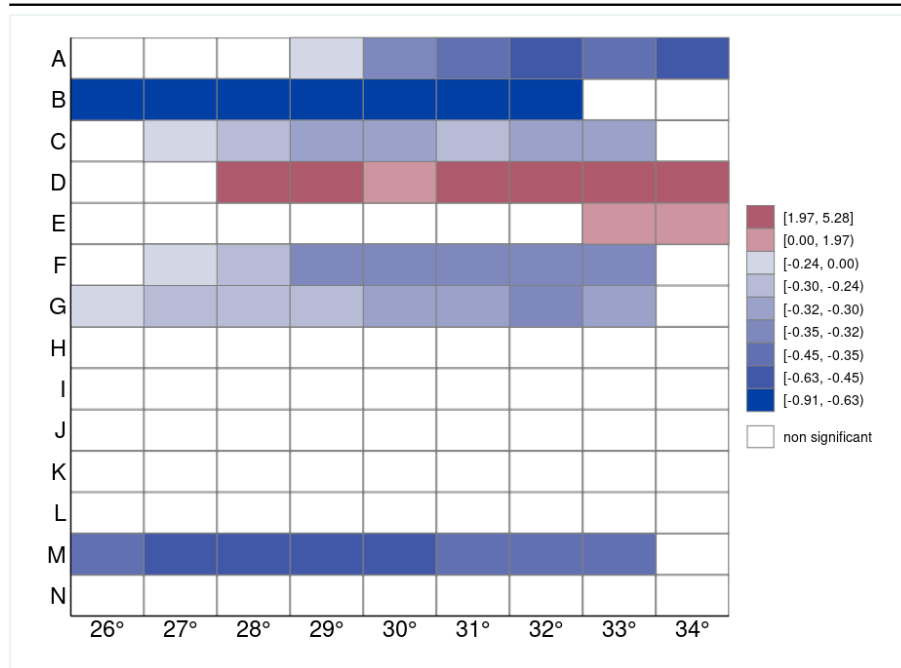
Notes: The graph is a heatmap providing a visual representation of the coefficients obtained estimating the model in equation 4, allowing for the coefficients to be heterogeneous across climate zones. The color of the cells varies according to the values of the linear combination of the three coefficients on lagged ΔT , hypothesizing a 1% increase in the number of extreme heat days in three consecutive periods. Empty cells indicate non-significant estimates at the 95% significance level. The columns of the matrix are labeled by the dependent variable of the regression and the climate zone to which the coefficient estimate is referred. The rows of the matrix indicate the sector according to the Nace Rev. 2 classification: A. Agriculture, Forestry and Fishing; B. Mining and Quarrying; C. Manufacturing; D. Electricity, Gas, Steam and Air Conditioning Supply; E. Water Supply, Sewerage, Waste Management and Remediation Activities; F. Construction; G. Wholesale and Retail Trade, Repair of Motor Vehicles and Motorcycles; H. Transportation and Storage; I. Accommodation and Food Service Activities; J. Information and Communication; K. Financial and Insurance Activities; L. Real Estate Activities; M. Professional, Scientific and Technical Activities; N. Administrative and Support Service Activities.

Figure 8: Coefficient stability for different temperature thresholds for ΔT



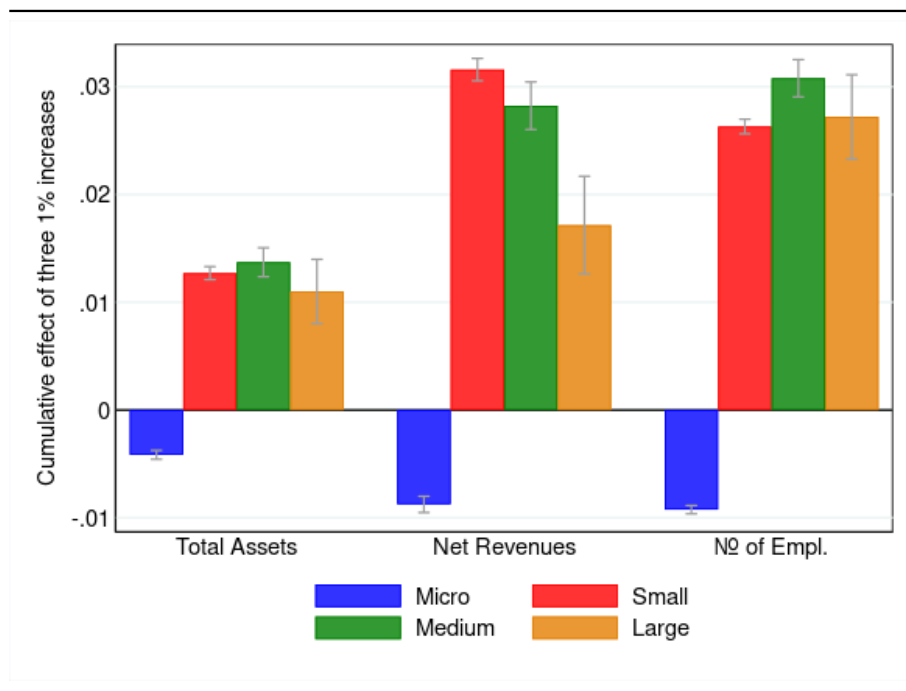
Notes: The graphs display the regression coefficients obtained estimating the model in equation 3 using different thresholds for the temperature variable ΔT . The threshold used is displayed in the horizontal axis of each graph. Each row collects the results obtained from a different dependent variable (growth rate of active firms, entry rate, exit rate). The two columns represent the results obtained for the full sample or the Mediterranean climate zone, under an heterogeneity exercise similar to the one in Table 7.

Figure 9: Coefficient stability for different temperature thresholds for ΔT , by sector



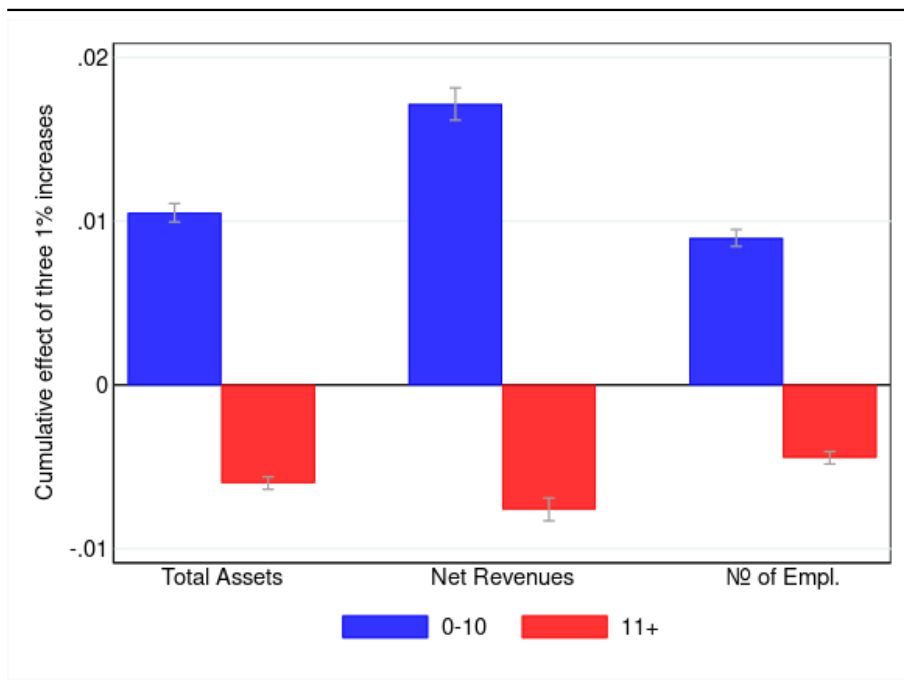
Notes: The graph is a heatmap providing a visual representation of the coefficients obtained estimating the model in equation 4, using different thresholds for the temperature variable ΔT . The color of the cells varies according to the values of the linear combination of the three coefficients on lagged ΔT , hypothesizing a 1% increase in the number of extreme heat days in three consecutive periods. Empty cells indicate non-significant estimates at the 95% significance level. The columns of the matrix indicate the temperature threshold used. The rows of the matrix indicate the sector according to the Nace Rev. 2 classification: A. Agriculture, Forestry and Fishing; B. Mining and Quarrying; C. Manufacturing; D. Electricity, Gas, Steam and Air Conditioning Supply; E. Water Supply, Sewerage, Waste Management and Remediation Activities; F. Construction; G. Wholesale and Retail Trade, Repair of Motor Vehicles and Motorcycles; H. Transportation and Storage; I. Accommodation and Food Service Activities; J. Information and Communication; K. Financial and Insurance Activities; L. Real Estate Activities; M. Professional, Scientific and Technical Activities; N. Administrative and Support Service Activities.

Figure 10: The effect of extreme temperature events on firms' fundamentals by firms' size



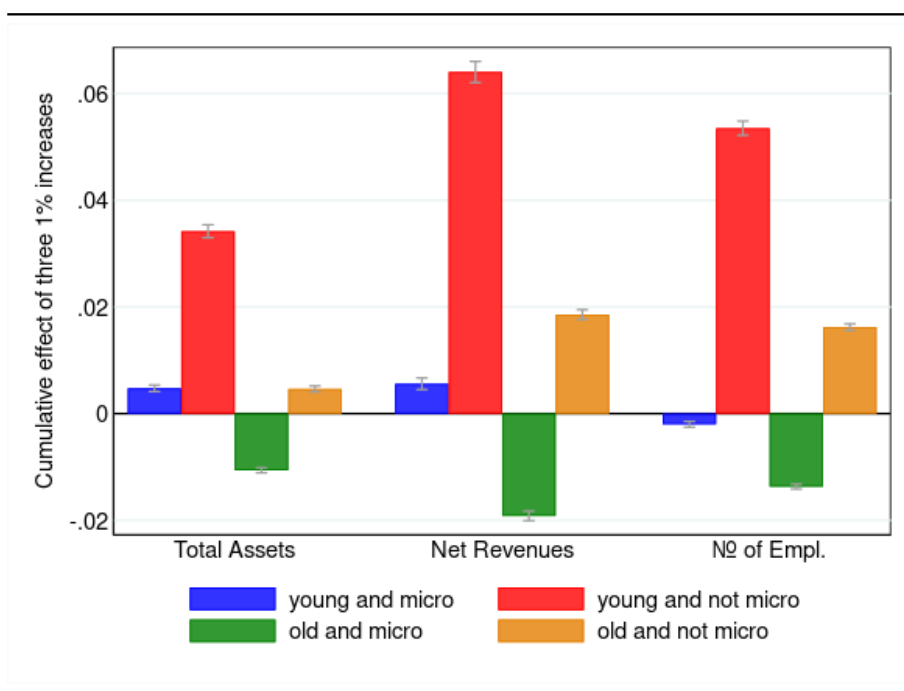
Notes: The graph is a visual representation of the coefficients obtained estimating the model in equation 6. The reported bars depict the linear combination of the three coefficients on lagged ΔT , hypothesizing a 1% increase in the number of extreme heat days in three consecutive periods. The horizontal axis displays the dependent variable used in the regression. Each variable is calculated in log-difference with respect to the previous period. The gray lines are confidence intervals at the 95% significance level. We consider the firm-size classification as in the EU recommendation 2003/361.

Figure 11: The effect of extreme temperature events on firms' fundamentals by firms' age



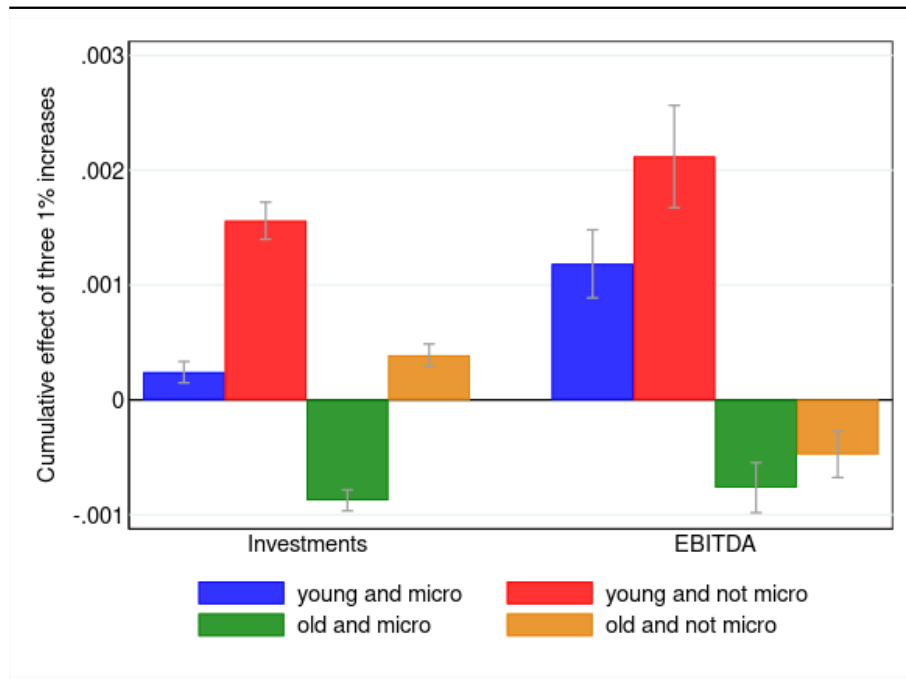
Notes: The graph is a visual representation of the coefficients obtained estimating the model in equation 6. The reported bars depict the linear combination of the three coefficients on lagged ΔT , hypothesizing a 1% increase in the number of extreme heat days in three consecutive periods. The horizontal axis displays the dependent variable used in the regression. Each variable is calculated in log-difference with respect to the previous period. The gray lines are confidence intervals at the 95% significance level.

Figure 12: The effect of extreme temperature events on firms' fundamentals by firms' size and age



Notes: The graph is a visual representation of the coefficients obtained estimating the model in equation 6. The reported bars depict the linear combination of the three coefficients on lagged ΔT , hypothesizing a 1% increase in the number of extreme heat days in three consecutive periods. The horizontal axis displays the dependent variable used in the regression. Each variable is calculated in log-difference with respect to the previous period. The gray lines are confidence intervals at the 95% significance level. Micro firms are those defined according to the firm-size classification as in the EU recommendation 2003/361. Young firms are firms less or equal than 10 years old.

Figure 13: The effect of extreme temperature events on firms' investments and profitability by firms' size and age



Notes: The graph is a visual representation of the coefficients obtained estimating the model in equation 6. The reported bars depict the linear combination of the three coefficients on lagged ΔT , hypothesizing a 1% increase in the number of extreme heat days in three consecutive periods. The horizontal axis displays the dependent variable used in the regression. Each variable is winsorized at (0.5, 99.5). The variables are calculated as ratio over total assets. Profitability (EBITDA) is calculated in difference with respect to the previous period. The gray lines are confidence intervals at the 95% significance level. Micro firms are those defined according to the firm-size classification as in the EU recommendation 2003/361. Young firms are firms less or equal than 10 years old.

A Additional tables

Table A.1: Infocamere sample, by sector and year

year	manufacturing	construction	market services	other	total
2005	316,464	276,865	1,144,147	139,178	1,876,654
2006	323,379	294,319	1,206,746	140,676	1,965,120
2007	334,334	316,180	1,285,638	133,454	2,069,606
2008	351,023	337,867	1,381,245	106,939	2,177,074
2009	351,824	344,858	1,405,702	102,214	2,204,598
2010	343,775	338,175	1,388,130	105,025	2,175,105
2011	339,891	339,655	1,402,923	107,924	2,190,393
2012	335,261	337,566	1,411,222	109,670	2,193,719
2013	331,727	336,928	1,422,642	111,587	2,202,884
2014	327,858	334,428	1,429,038	113,144	2,204,468
2015	325,010	334,110	1,442,765	115,223	2,217,108
2016	322,300	334,337	1,457,504	119,265	2,233,406
2017	319,494	334,876	1,472,881	122,906	2,250,157
2018	316,628	336,206	1,488,019	125,818	2,266,671
2019	311,547	337,851	1,496,395	127,881	2,273,674

Notes: The table displays the number of firms in the Infocamere dataset, after data cleaning. Non-market services are excluded from the sample. The column 'other' groups firms belonging to agriculture, mining and utilities.

Table A.2: Cerved sample, by size and time period

Time period	Nr. of firms					Total
	NA	Micro	Small	Medium	Large	
2008-2010	6,434	206,456	84,043	19,508	4,264	320,705
2011-2013	8,300	278,698	92,266	20,989	4,800	405,053
2014-2016	7,602	303,706	92,465	21,021	5,062	429,856
2017-2019	3,103	252,645	87,126	21,635	5,407	369,916

Notes: Authors' elaboration on Cerved Data. The size classes are those defined by Eurostat, namely (1) micro enterprises as with less than 10 persons employed; (2) small enterprises as with 10 to 49 persons employed; (3) medium-sized enterprises as those with 50 to 249 persons employed; (4) large enterprises as those with 250 or more persons employed.

Table A.3: Cerved sample, by sector and time period

Period	Nr. of firms				Total
	Manufacturing	Construction	Services	Other	
2008-2010	73,049	42,872	192,739	12,045	320,705
2011-2013	86,466	59,603	244,235	14,749	405,053
2014-2016	88,237	64,671	259,762	17,186	429,856
2017-2019	78,127	53,569	222,863	15,357	369,916

Notes: Authors' elaboration on Cerved Data.

Table A.4: Firm demography regressions, heterogeneity by initial average temperature

	\dot{A}	e	x	r^{in}	r^{out}
$\Delta T_{p-1} \times \text{low temperature}$	0.037 [0.043]	-0.010 [0.014]	-0.009 [0.011]	0.007 [0.005]	-0.030 [0.034]
$\Delta T_{p-2} \times \text{low temperature}$	0.031 [0.030]	0.014 [0.020]	-0.018 [0.017]	0.004 [0.005]	0.010 [0.008]
$\Delta T_{p-3} \times \text{low temperature}$	0.033 [0.046]	0.009 [0.020]	0.003 [0.018]	0.005 [0.004]	-0.021 [0.031]
$\Delta T_{p-1} \times \text{high temperature}$	-0.031 [0.023]	-0.006 [0.012]	0.009 [0.010]	0.003 [0.003]	0.014 [0.015]
$\Delta T_{p-2} \times \text{high temperature}$	-0.056*** [0.021]	-0.034** [0.015]	0.012 [0.013]	0.006** [0.003]	0.011 [0.008]
$\Delta T_{p-3} \times \text{high temperature}$	-0.072*** [0.021]	-0.040*** [0.014]	0.026** [0.013]	-0.004 [0.008]	-0.001 [0.004]
Obs.	3,055	3,055	3,055	3,055	3,055
R^2	0.611	0.759	0.759	0.336	0.251
Within R^2	0.021	0.066	0.014	0.006	0.010

Notes: Estimation results for the model in equation 3, with parameters being allowed to be heterogeneous for LLMs below or above the median of average temperatures in the period 1999–2001. Column names indicate the dependent variable of each regression. Coefficients on precipitations are not reported. LLM, period, area \times period and population quartile \times period fixed effects included in all specifications. Coefficients on entry, exit and relocation rates regressions might not add up to the coefficients in the first columns, because the residual term in equation 2 is not reported in the table. Standard errors clustered at the LLM level in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

B Additional figures

Figure B.1: Climate zones in Italy



Notes: Local labor markets have been classified into temperate and mediterranean climate zones according to the Istat classification (<https://www.istat.it/it/archivio/224780>).

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