How Does Climate Change Reshape U.S. Entrepreneurship? A Labor Channel

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Abstract

This paper investigates how climate change affects U.S. entrepreneurship through a labor channel. It finds that unexpected extreme heat reduces new firm and job creation due to increased health risks and reduced worker productivity, which raise labor-related production and financing costs. Some entrepreneurs continue to enter heat-exposed industries, and their firms tend to survive longer and grow more rapidly. Meanwhile, existing firms expand to seize market opportunities but fail to offset the overall decline in business formation. As a result, economic activity contracts, underscoring the economy's limited adaptation to climate-related challenges.

Keywords: Climate Change; Extreme Heat; Climate Adaptation; Entrepreneurship; Job Creation; Labor Costs; Small Business Loans.

JEL Codes: G30, L26, J20, Q54, R11.

1 Introduction

The unprecedented escalation of climate change, particularly extreme heat, has triggered a health crisis and profoundly restructured the U.S. labor market (e.g., Graff Zivin and Neidell, 2014; Park et al., 2021; Lai et al., 2023). Crucially, this health crisis reduces the supply and productivity of affected human capital, leading to lower economic output and worse corporate performance, thereby highlighting a labor channel through which climate change impacts U.S firms (Somanathan et al., 2021; Xiao, 2021; Addoum et al., 2023; Pankratz and Schiller, 2024).[1] A critical yet understudied question is how U.S. businesses adapt to these climate-induced structural changes in the labor market, a concern particularly pivotal for new firms that are inherently vulnerable and heavily reliant on human capital to succeed. This paper aims to shed light on this issue by exploring how climate change impacts the dynamics and vibrancy of U.S. entrepreneurship.

Specifically, this research investigates the impact of extreme heat on U.S. entrepreneurship through a labor channel, emphasizing that climate-driven increases in labor-related production and financing costs discourage business creation. Hypothetically, at least four economic factors contribute to the increased costs for businesses reliant on heat-exposed human capital. First, reduced labor supply and productivity from heat-exposed workers increase labor costs per unit of output and, consequently, decrease operating revenues, leading to lower efficiency of human capital as a production input. Second, employers may need to invest in preventive measures such as cooling facilities to mitigate heat risks, as well as offer enhanced compensation packages and medical care to attract and retain workers. Third, employers face significant reputational damage and litigation risks if workers suffer heat-related injuries. Fourth, employers may incur higher financing costs if creditors factor heat risks into small business loan originations. Collectively, these labor-related production and financing costs impose additional financial burdens on entrepreneurs starting and growing small businesses, with further increases anticipated as climate change worsens. Consequently, extreme heat may discourage individuals from starting businesses that rely on heat-exposed human capital.

Supporting this conjecture, my analysis indicates that unexpected extreme heat reduces entrepreneurial activities, particularly in heat-vulnerable industries. The effects are more pronounced in industries where human capital is critical for business growth, in states adopting heat regulations, and in counties with greater long-run heat risks. Additionally, consistent with the financing channel, small busi-

[1] In Internet Appendix A, I present anecdotal evidence from various sources that highlights the significant heat risks faced by small businesses due to climate change. See also Internet Appendix A in Xiao (2021) for additional anecdotal evidence on heat risks to workers and related workplace safety issues.

ness loans to heat-exposed firms are smaller and carry higher interest rates. However, entrepreneurs who still start businesses in heat-exposed industries tend to be of higher quality, with their businesses more likely to survive and grow in the long run. Furthermore, existing firms fill market gaps left by reduced entrants and expand their networks, but this doesn't offset the overall decline in business formation. This decline further contributes to a macro-level contraction in aggregate economic activity, suggesting insufficient adaptation actions in the economy.

Empirically, I measure entrepreneurship by the birth of new firms at the county by four-digit NAICS (NAICS4) industry level, using establishment-level data from the Your Economy Time Series (YTS). YTS tracks the dynamics of U.S. business establishments and provides comprehensive details, including location, industry classification, founding year, closure year, place type (e.g., headquarters, subsidiary, branch, or independent), employment, and parent company. I identify an establishment as a newly created firm if it is standalone, newly founded, and its name and address have not previously appeared, nor has it relocated or changed its name.

To quantify temperature fluctuations across locations and time, I obtain daily grid-level (4×4 km) temperature data for the U.S. from the PRISM Climate Group, covering 1981 to 2022. I then construct a location- and time-specific measure of *heat shocks* for each county and year building on prior works (Perkins and Alexander, 2013; Addoum et al., 2020; Xiao, 2021). Specifically, I define heat shocks as instances when a county experiences abnormally high temperatures over the past three years, identified by deviations from historical temperature distributions and by absolute temperature levels. The distribution-based requirement captures the abnormal component of temperature fluctuations relative to the historical averages specific to each county and month. The absolute temperature requirement limits the focus to shocks that are extremely hot in an absolute sense. By construction, these heat shocks can be considered random draws from the distribution of temperatures within and across counties, making them plausibly exogenous for any prospective entrepreneur (Auffhammer et al., 2013; Dell et al., 2014).

Each NAICS4 industry's exposure to heat risks through the labor channel is measured by the extent to which its workforce is exposed to high temperatures during production processes, following Xiao (2021). This exposure is quantified using industry- and occupational-level data from the Occupational Employment and Wage Statistics (OEWS) and the Occupational Information Network (O*NET). In particular, OEWS provides information on the occupations required within each NAICS4 industry and the number of employees in each occupation. The O*NET program assigns each occupation a score that reflects the intensity of outdoor activities required to fulfill job duties in all weather

conditions, including extreme heat. The labor exposure measure is then calculated as the weighted average of the outdoor intensity scores across all occupations within a NAICS4 industry, using the percentage of employees in each occupation as weights.

With the data and measures, I first investigate the causal impact of heat shocks on entrepreneurship across counties and NAICS4 industries from 1999 to 2019. The analysis shows a negative and statistically significant impact of heat shocks on entrepreneurial activity. On average, one past heat shock leads to a 0.8% decline in new firm creation. Importantly, the effects are primarily observed in industries with substantial heat exposure through the labor channel. Across the whole economy, about half of the industries at the top end of heat exposure are negatively affected. For instance, industries at the 75^{th} percentile of heat exposure experience a 1.6% decrease in entrepreneurship following heat shocks, while those with the highest exposure see a 2.4% drop. The findings remain robust after controlling for heterogeneities across counties, industries, and county-industry pairs through multiple fixed effects, including county-by-year, county-by-NAICS4 industry, and NAICS4 industry-by-year fixed effects. The findings also remain robust when using state-by-year-by-NAICS4 industry fixed effects to compare how the same NAICS4 industry responds to different county-level heat shocks within a state. Additionally, the results hold after accounting for exposures to cold temperatures, hot temperatures in non-summer months, and other non-heat climate events (e.g., precipitation and natural disasters) and are not driven by consumption demand, declines in crop yields, or population migration. The results also hold under alternative measures of heat shocks and alternative data on measuring entrepreneurship.

The decline in new firm entry in heat-exposed industries also leads to lower job creation. The analysis shows that the number of jobs created by new firms drops by 1.9% in industries with labor exposure at the 75^{th} percentile and by 2.9% in those with the highest exposure. Together, these findings on firm and job creation support my conjecture that heat risks reduce individuals' incentives to start new businesses in exposed industries.

By design, the measure of heat shocks reflects abnormally high temperatures that are beyond expectation and, therefore, are exogenous to individual entrepreneurial decisions. To better understand the timing of heat shocks and alleviate endogeneity concerns, I examine the effects of past, present, and future annual heat shocks on present entrepreneurship. The analysis shows that only past heat shocks negatively affect present entrepreneurship, while future ones do not, indicating that the findings on firm creation are unlikely to be driven by omitted variable bias or reverse causality.

One critical force contributing to the decline in entrepreneurship is that heat risks increase labor

costs and reduce operating revenues. This stems from lower labor supply and productivity under extreme heat, greater investment in preventive measures to mitigate heat risks, additional compensation and medical care to attract workers, and reputational and litigation risks from heat-related worker injuries. In theory, firms could lower wages for inefficient workers or replace them with more productive employees or physical assets. However, market frictions often hinder these adjustments and limit firms' ability to cut labor costs, which drives up labor costs per unit of output.

Recent work by Xiao (2021) shows that heat exposure through the same labor channel reduces firm-level labor productivity, confirming that heat-exposed workers become less efficient for production activities. Furthermore, the paper shows that firms adapt by shifting towards more capital-intensive production functions, which effectively offset labor productivity losses. This suggests that heat risks are more critical for businesses highly dependent on human capital or unable to substitute physical assets for labor. Consequently, in industries where human capital plays a lesser role in operations, heat risks are less of a concern for entrepreneurial decisions. Supporting this prediction, the heat-induced decline in entrepreneurship is significantly weaker in industries with more capital-intensive production functions.

I also follow Ortiz-Molina et al. (2023) to examine the additional labor costs resulting from the implementation of the Heat Illness Prevention Standard (HIPS) in California and Washington. This regulation aims to protect outdoor workers from heat risks by requiring employers to provide cooling methods and preventive measures, such as water, shade, rest breaks, emergency procedures, and employee training. Compliance with HIPS significantly raises labor costs, especially for small businesses, and exposes firms to substantial reputation and litigation risks. I expect these costs and risks to further discourage firm entry. My empirical analysis confirms this prediction, showing that HIPS implementation and related compliance costs create barriers for new firms.

Another economic force contributing to the declined entrepreneurship could be that creditors charge heat-exposed borrowers for liquidity provisions. Consequently, prospective entrepreneurs in heat-exposed industries face higher financing costs, reducing their incentives and abilities to start new businesses. Using small business loan data from the SBA 7(a) loan program, I find that heat shocks reduce loan amounts and raise interest rates for small businesses exposed to heat through the labor channel. This evidence implies that increased financing costs, driven by heat-induced labor risks, partially contribute to the reduced entrepreneurship in heat-exposed industries.

Furthermore, if the decline in entrepreneurship is driven by concerns over heat risks and associated labor-related costs, the effects should be larger in areas expecting significant temperature

increases in the near future. Consistent with this conjecture, the decline in entrepreneurship following heat shocks is concentrated in counties with greater expected heat risks in the long run. This evidence further supports the hypothesis that heat risks in the labor channel deter firm entry.

Additionally, I conduct analyses to explore the broader implications of climate change for U.S. entrepreneurship and employment. I first investigate the long-run performance of new firms established in heat-exposed industries. The analysis reveals that, conditional on entry, these firms tend to survive longer and have larger workforce in the long run. For example, firms in industries at the 75^{th} percentile of heat exposure employ 2% more workers six years after founding. This superior performance could be attributed either to a selection effect, in which only high-quality entrepreneurs enter heat-vulnerable industries, or to reduced competition resulting from lower entry.

I also analyze how existing firms respond to extreme heat, as reduced firm entry may leave certain consumption demands unmet at affordable prices, creating market opportunities for growth. Moreover, existing firms may have greater financial resources and more experience in managing heat-related challenges. My analysis shows that existing firms create more establishments in exposed industries following heat shocks. However, this expansion does not fully offset the county-wide decline in new business formation. This overall business decline, in turn, contributes to a macro-level contraction in aggregate economic activity, suggesting insufficient adaptation actions in the economy.

This paper contributes to several strands of literature. First, it adds to the growing literature on the implications of climate change for the financial market and business operations (e.g., Bernstein et al., 2019; Choi et al., 2020; Hong et al., 2020; Ilhan et al., 2021; Bolton and Kacperczyk, 2021; Giglio et al., 2021). More specifically, this paper joins the discussion on the impact of extreme heat on the performance and adaptation strategies of U.S. businesses (e.g., Addoum et al., 2020; Xiao, 2021; Addoum et al., 2023; Acharya et al., 2023; Pankratz et al., 2023; Ponticelli et al., 2023; Xiao, 2023; Ortiz-Molina et al., 2023; Pankratz and Schiller, 2024). My research differs by examining individuals' entrepreneurial decisions in response to heat risks, thereby extending the discussion to the private sector and small businesses. On this, I find that extreme heat discourages new firm and job creation, especially in industries employing large shares of exposed workers. To the best of my knowledge, this paper is the first to study how climate change reshapes U.S. entrepreneurship across counties and industries via the labor channel. Meanwhile, the findings on entry avoidance echo the call for more research on adaptation to climate change (Fankhauser, 2017).

This paper also broadens our understanding of the determinants of and barriers to entrepreneurship. Existing studies have explored entrepreneurial decisions linked to founder characteristics (e.g.,

Gompers et al., 2010; Ewens and Townsend, 2020; Engelberg et al., 2022), credit constraints (e.g., Black and Strahan, 2002; Schmalz et al., 2017), financial and labor market dynamics (e.g., Babina, 2020; Hacamo and Kleiner, 2022; Jeffers, 2024), among other factors. More relatedly, a few recent studies explore the impact of floods on firm creation, including Cen (2021) and Jia et al. (2022). In contrast to these works, my paper identifies a labor channel of climate exposure and documents that heat risks in the channel discourage entrepreneurship. The findings highlight that expected labor-related business costs can deter entrepreneurial activities, revealing an important yet understudied labor mechanism in the entrepreneurship literature.

Finally, this paper contributes to the literature on labor market frictions and their impact on corporate and individual decision-making (e.g., Chen et al., 2011; Matsa, 2018; Kim, 2020; Nishesh et al., 2024). It extends the analysis to a climate context, focusing on heat-induced workplace safety issues and related production and financing costs. My findings demonstrate that labor costs driven by climate change are crucial for business operations, particularly for small businesses.

The remainder of this paper proceeds as follows. Section 2 outlines the conceptual framework. Section 3 describes the data and measures for empirical analysis. Section 4 presents the effects of heat shocks on entrepreneurship, dynamic tests, and robustness checks. Section 5 investigates the economic mechanisms and Section 6 provides further analyses and discussions. Section 7 concludes.

2 Conceptual Framework

In this section, I discuss the economic mechanisms through which extreme heat may deter entrepreneurial activities, focusing on: (1) increased labor costs; (2) constrained credit access; and (3) expectation of heat risks. Furthermore, I provide examples to more clearly illustrate the key idea.

2.1 Increased Labor Costs

Heat exposure can cause various heat-related illnesses that endanger workers' health and lives (e.g., Luber and McGeehin, 2008; Mora et al., 2017; Park et al., 2021). For instance, a report by the Atlantic Council estimates that extreme heat is responsible for about 120,000 occupational injuries in the U.S. each year, which could rise to nearly 450,000 without adaptation measures taken.[2] These health issues can impair workers' physical and cognitive abilities, leading to lower productivity (e.g., Chen and

[2]See "*Extreme Heat: The Economic and Social Consequences for the United States*." Additionally, the report estimates over 8,500 deaths annually associated with high temperatures, a number projected to increase nearly sevenfold to 59,000 by 2050. Furthermore, Park et al. (2021) estimate that high temperatures caused approximately 360,000 worker injuries in California from 2001 to 2018.

Yang, 2019; Heyes and Saberian, 2019; Xiao, 2021; Lai et al., 2023; LoPalo, 2023). For instance, Xiao (2021) investigate the same labor channel of heat exposure and document that labor productivity of high-exposure firms drops by about 2% following heat shocks. Collectively, these findings suggest that extreme heat can reduce production output and, consequently, business profits.

Moreover, heat risks may deter exposed individuals from participating in the labor market (Graff Zivin and Neidell, 2014; Dillender, 2021). For instance, Graff Zivin and Neidell (2014) show that workers in heat-exposure industries work one hour less when the daily maximum temperature exceeds 85°F (29.4°C), and Somanathan et al. (2021) document increased absenteeism associated with both contemporaneous and past high temperatures. Workers may also voluntarily migrate from hot to cool areas, further contributing to reduced laborforce supply. To attract and retain workers, employers may need to invest in preventive measures such as cooling facilities (where feasible) to mitigate heat risks, as well as offer enhanced compensation packages and medical care, which further increase labor costs.[3] Additionally, employers could face reputational damage and litigation risks if workers suffer heat-related injuries. California, Washington, and Oregon have already implemented heat illness prevention regulations for outdoor workers (Ortiz-Molina et al., 2023). Congress and more states are planning to adopt similar rules.

In a frictionless market, firms could reduce compensation for inefficient workers during hot periods or replace them with more productive employees or automated physical assets. However, in practice, firms face numerous frictions that impede labor adjustments,[4] thereby increasing operating leverage and decreasing firm value (Taylor, 1999; Chen et al., 2011).

Overall, the discussions above indicate that, although heat-induced reductions in labor productivity and supply decrease total output, firms have limited ability to offset these effects by reducing labor-related production costs, thereby leading to *higher labor costs per unit of output*. This production inefficiency imposes substantial financial burdens on firms in heat-exposed industries and reduces their profits, consequently discouraging prospective entrepreneurs from starting new businesses.

[3] A recent report by the Center for American Progress estimates that extreme heat cost the U.S. approximately $1 billion each summer in healthcare expenses between 2016 and 2020. See *"The Health Care Costs of Extreme Heat."*

[4] For instance, labor protection regulations increase workers' bargaining power and limit firms' discretion in wage and firing decisions. Social pressures from local communities and customers compel firms to create a safe and supportive working environment and improve employee welfare (e.g., Edmans, 2011; Xiao et al., 2023). Also, hiring and training new talent, or investing in new production equipment and methods, takes time and requires substantial financial resources.

2.2 Constrained Credit Access

A critical barrier to new business creation and growth is credit access (e.g., Black and Strahan, 2002; Schmalz et al., 2017; Herkenhoff et al., 2021). Meanwhile, another strand of literature documents that natural disasters generate cash flow shocks to business operations and banks incorporate such risks into loan originations and limit credit access for high-risk borrowers (e.g., Bergman et al., 2020; Brown et al., 2021; Collier et al., 2024; Correa et al., 2020). For example, Bergman et al. (2020) show that abnormally high temperatures in the 1980s reduce crop yields in the U.S. farming industry, leading to reduced land prices, higher loan delinquencies, and more bank failures. Collier et al. (2024) find that small and independent businesses have more delinquent loans after Hurricane Harvey, while subsidiaries of larger firms do not. In the aftermath, many affected firms apply for new credit, but more than half are denied. Correa et al. (2020) document that banks charge higher spreads on loans to borrowers at risk of physical climate disasters, even if they are not directly affected by the disasters.

Taken together, these findings indicate that small businesses in heat-sensitive industries are likely to face restricted credit access and increased financing costs if creditors consider heat risks and related labor costs in lending decisions. If this holds true, fewer businesses may be created in heat-exposed industries due to liquidity constraints.

2.3 Expectation of Heat Risks

The above discussion suggests that prospective entrepreneurs anticipate higher labor and related financing costs when creating businesses in heat-exposed industries, driven by expected heat-related risks. Naturally, in areas with greater long-term heat risks, they would expect more frequent temperature anomalies and, consequently, respond more strongly to short-term heat shocks. This implies that the negative impact of heat on entrepreneurship should be more pronounced in areas with higher projected long-term heat risks.

2.4 Industry and Business Examples

The deterrent effects of heat risks on entrepreneurship are widespread in various industries, including construction, manufacturing, repair and maintenance, transportation, waste management, parcel deliveries, recreation, and tourism, among others. For example, extreme heat can reduce service availability from small local businesses such as tour operators, pool cleaning services, building maintenance (e.g., roof repair and installation of outdoor equipment like heat pumps and solar panels),

landscaping, and automotive repair. It can also adversely affect the production of construction materials (e.g., bricks and concrete) and food and beverages, as well as disrupt goods deliveries (e.g., over-the-road drivers). The heightened operational challenges and financial risks can deter many market entrants, reducing new business ventures in heat-sensitive industries.

3 Data, Measures, and Summary Statistics

3.1 Establishments and Entrepreneurship

I obtain data that tracks dynamics of U.S. business establishments from the Your Economy Time Series (YTS), assembled by the Business Dynamics Research Consortium (BDRC). BDRC compiles the YTS data based on verified individual establishments collected by Data Axle (formerly Infogroup), using their unique American Business Identifiers (ABIs). YTS focuses on establishments that are actively conducting commercial activities, excluding businesses created solely for housing financial, real estate, or tax reporting purposes, as well as those suspected of never conducting actual commercial operations. The data is available annually from 1997 to 2022 and has been widely used by academic researchers, policymakers, economic development analysts, and for-profit businesses to evaluate business dynamics across the U.S., including Ghent (2021), Campello et al. (2022), Flynn and Ghent (2022), Coyne and Johnson (2023), Houde et al. (2023), and Arefeva et al. (2024). Although concerns have been raised about the accuracy of YTS data relative to census data—particularly regarding estimated sales and employment figures—these issues are less critical when analyzing the creation and existence of specific establishments, which are the primary focus of my empirical analyses.[5,6]

YTS provides detailed information on each establishment, including its location (e.g., county and ZIP code), industry classification (e.g., NAICS codes), founding year, closure year, place type (e.g., headquarters, subsidiary, or independent), employment, parent company, and more. I measure entrepreneurship by the birth of new firms - establishments that are newly created and standalone. A newly created establishment is identified based on its founding year and verification that its name and address did not previously exist, nor has it relocated or changed its name. A standalone establishment is identified by its place type and the ownership structure of the parent company. I

[5]In a comparison with the BLS's Current Employment Statistics (CES) and Current Population Survey (CPS), Kunkle (2018) shows that CPS and YTS report nearly identical levels of total national employment for 2008 - 2017. Additionally, there has been debate over how to define the "birth" of a firm. YTS typically begins tracking a business—often consisting solely of the founder—within one year of its start date. In contrast, census data generally do not begin tracking the business until it hires at least one full-time employee and starts submitting unemployment compensation filings. See also "https://youreconomy.org/download/recentpubs.pdf" for more recent works using the YTS data.

[6]To further address concerns regarding data quality, Internet Appendix Table B.9 presents robustness checks using alternative measures of entrepreneurship.

aggregate the data at the county-by-NAICS4 industry level and calculate the total number of new firms created, which is the primary measure of entrepreneurship in this study.

In sample construction, I exclude establishments and firms in the following industries: utilities (NAICS2 22), finance and insurance (NAICS2 52), religious, civic and social organizations (NAICS3 813), public administration (NAICS2 92), and unclassified (NAICS2 99). Furthermore, for each county, I keep only the top 20 NAICS4 industries based on total employment, as industries outside the top 20 contribute, on average, only 0.3% to the county's employment.[7] Additionally, I exclude counties in Alaska, Hawaii, and other areas outside the continental U.S.

Figure 1 presents the average annual number of newly established firms for each county in the continental U.S. during the period 1999 – 2019. As can be seen, entrepreneurial activities are primarily concentrated in the east and west coastal areas, with some presence in the central region.

3.2 Temperatures and Heat Shocks

I obtain data on U.S. daily temperatures and precipitation for the 1981 - 2022 period from the PRISM Climate Group maintained by Oregon State University. PRISM compiles climate observations from diverse monitoring networks and applies rigorous quality controls to develop spatial climate datasets that reveal short- and long-term climate patterns. The data covers 481,631 16-square-kilometer (4×4 km) grids across the U.S. and includes daily mean, minimum, and maximum temperatures, as well as precipitation levels. I aggregate the grid-level information to the county level.[8]

Previous studies on temperature effects primarily focus on absolute temperature levels or categorical bins. However, such approaches may not be well-suited for this paper, which investigates how *unexpected high temperatures* in the past influence present entrepreneurial decisions, conditional on business exposure through the labor channel. This is because local temperature levels are often endogenous to individuals' and firms' location and production choices, potentially biasing causal estimates of heat exposure on entrepreneurial activity. To address this concern, I construct a measure of time- and location-specific heat shocks for each county and year based on historical temperature data. This approach provides a more exogenous and locally calibrated measure of heat stress, thereby strengthening the validity of the causal inference (Auffhammer et al., 2013; Dell et al., 2014).

[7] In Internet Appendix Section B.5, I apply alternative sample selection thresholds (e.g., top 10, 15, or 25 industries) and alternative sampling methods (industries with an employment share exceeding 1% or 3% in a given county) to demonstrate the robustness of the results.

[8] I use county as the geographic unit of analysis, considering the potential broad operating reach of small businesses in the local area. For example, a small business specializing in building maintenance may serve customers both within and beyond its own zip codes. The results remain robust when using ZIP codes as the unit of analysis.

Specifically, I define heat shocks as instances in which a county experiences both relative and absolute heat anomalies over the past three years and the current year, which captures heat shocks in both the relative and absolute sense - abnormally hot temperatures in already hot areas.

$$
\begin{aligned}
&\textit{Heat Shocks}_{c,t} = \begin{cases} 1 & \textit{Relative Heat Shocks}_{c,t} \quad \& \quad \textit{Absolute Heat Shocks}_{c,t} \\ 0 & \textit{otherwise} \end{cases} \\
&\textit{Relative Heat Shocks}_{c,t} = \textit{No. Hot Days}[\textit{Rolling } 90^{th} \textit{ Percentile}]_{c,t} \geq N_1 = 45 \\
&\textit{Absolute Heat Shocks}_{c,t} = \textit{No. Hot Days}[30^{\circ}\mathrm{C}]_{c,t} \geq N_2 = 240
\end{aligned}
\tag{1}
$$

where c denotes county and t denotes year. *Rolling* 90^{th} *Percentile* refers to the 90^{th} percentile of past temperature distributions, estimated for each county and month using temperature data from 1981 up to the previous year (*1981 to t-1*), with a maximum of 30 years. *No. Hot Days*$[\textit{Rolling } 90^{th} \textit{ Percentile}]_{c,t}$ denotes the total number of summer days with temperatures exceeding the rolling 90^{th} percentile from $t-3$ to t. The term *No. Hot Days*$[30^{\circ}C]_{c,t}$ reflects the total number of summer days with maximum temperatures exceeding $30^{\circ}C$ from $t-3$ to t.

I choose N_1=*45* to identify a significant upward shift in temperature distributions compared to the expected 40 days,[9] indicating a substantial intensification of heat that adversely affects individuals and small businesses and thereby prompts their response. This choice is broadly consistent with Xiao (2021), which finds that the effects of heat on firm-level labor productivity become significant only when the number of annual relative hot days exceeds 15. The study also shows that public firms respond to temperature fluctuations from year $t-3$ to t by promoting automation as a means of mitigating heat-related threats. In addition, I set N_2=*240* to focus my analysis on already hot areas, which correspond to an average of 60 summer days per year with maximum temperatures exceeding $30^{\circ}C$. In the empirical sample, N_1=*45* and N_2=*240* correspond to approximately the 65^{th} percentile of the distributions of relative and absolute heat shocks, respectively. Eventually, I create a dummy variable as the key variable for empirical analysis, *Heat Shocks*, which indicates the occurrence of abnormally high temperatures in already hot areas. Based on this measure, about 17% of the observations affected by heat shocks in the empirical sample.

The primary focus of this study is to examine how different types of businesses are affected by

[9] Summer months include June, July, and August, following the definition of meteorological seasons. The meteorological summer season comprises a total of 92 days - 30 days in June, 31 days in July, and 31 days in August. Consequently, assuming no changes in temperature distributions, a typical summer would yield around 10 hot days, i.e., 92/10=9.2 (rounded up to 10). Therefore, using N_1=*45* represents an average upward deviation of 12.5% from the historical temperature distribution, relative to the expected 40 days from $t-3$ to t.

heat shocks through the labor channel, rather than by temperature effects alone. Therefore, this dummy measure of heat shocks provides a straightforward yet insightful way to understand the impact of heat across industries, capturing significant operational heterogeneities, as demonstrated in the empirical analyses. To address the concern that the choices of N_1=*45* and N_2=*240* may appear arbitrary and to demonstrate the robustness of the results, in Internet Appendix Section B.1, I presents multiple set of robust results using both alternative thresholds (N_1=*40, 45, 50, or 60* and N_2=*120, 160, 200, or 240*) and continuous measures (*Log(1 + No. Absolute Hot Days) and Log(1 + No. Relative Hot Days)*) to define heat shocks.

This measure of heat shocks is conceptually similar to that in previous studies (e.g., Perkins and Alexander, 2013; Addoum et al., 2020; Xiao, 2021; Pankratz and Schiller, 2024). The requirement for relative heat shocks captures the abnormal component of temperature fluctuations relative to the county- and time-specific historical averages. The requirement for absolute shocks ensures the focus is on heat shocks that are extreme in absolute terms. Figure 2 presents distributions of relative and absolute heat shocks across counties in the continental U.S. As expected, the occurrence of relative heat shocks differs significantly between 2008 and 2014, suggesting that they are not concentrated in specific locations over time. Thus, heat shocks can reasonably be considered exogenous, particularly for individual decision-making. In contrast, absolute heat shocks are primarily concentrated in the southern U.S., specifically in the Sun Belt region.

3.3 Labor Exposure to Climate Risk

I measure each NAICS4 industry's exposure to heat risks through a labor channel following Xiao (2021). This exposure measure quantifies the input of human capital exposed to high temperatures while performing job duties for production and operations. Specifically, I collect industry-specific occupational data from the Occupational Employment and Wage Statistics (OEWS) provided by the U.S. Bureau of Labor Statistics (BLS). It includes occupations needed in each industry, the number of employees working in each occupation, and wage estimates for each occupation. Then, I gather information on the intensity of outdoor activity for each occupation from the Occupational Information Network (O*NET) program of the U.S. Department of Labor. O*NET assigns each occupation a score reflecting the intensity of outdoor activities required to perform job duties in all weather conditions, including extreme heat. The score ranges from "1" (no exposure) to "5" (daily exposure), with

a higher score indicating a greater degree of exposure to changing climates while performing tasks.[10]

Utilizing the OEWS and the O*NET data, I construct an index of labor exposure to climate risk at the NAICS4 industry level using the following equation:

$$Labor\ Exposure_{i,t} = \underset{r=1}{\overset{r=20}{\text{Rank}}} \left\{ \sum_{o=1}^{O_{i,t}} \left(\frac{Emp_{i,o,t}}{Emp_{i,t}} \times Score_{o,t} \right) \right\} \tag{2}$$

where i denotes industry, o denotes occupation, and t denotes year. $O_{i,t}$ is the total number of occupations in industry i and year t. $Score_{o,t}$ is the occupational score of outdoor activity from the O*NET program for occupation o in year t. $Emp_{i,o,t}$ is the number of employees working in occupation o in industry i and year t. $Emp_{i,t}$ is the total number of employees in industry i and year t. This index thus is a weighted average of all occupations' outdoor intensity within a NAICS4 industry. The weight is the percentage of employees working in a given occupation within a NAICS4 industry. With this index, I further create a rank variable $Labor\ Exposure_{i,t}$, ranging from 1 to 20, with 20 indicating the highest exposure. This measure is available for the period 1999 - 2022.

By construction, this measure assumes that occupations and industries employing a greater share of outdoor workers in the production and operating process are more exposed to heat risks during the summer. In Internet Appendix Section B.3 and Table B.4, I examine and control for exposure to other climate disasters to underscore the distinct role of heat stress in shaping labor market dynamics and to demonstrate the robustness of the results.

It is important to highlight three main reasons for focusing on outdoor settings in the context of heat risks. First, as illustrated by anecdotal evidence in Internet Appendix A, outdoor workers are especially vulnerable to heat risks. According to estimates from the Bureau of Labor Statistics (BLS), about 32.9%—or 53 million—of U.S. workers had regular outdoor exposure in 2022.[11] Second, the outdoor setting presents a clean environment where employers have limited options for climate control (e.g., air conditioning). Third, regulatory costs related to heat risks are particularly relevant for outdoor workers, such as the Heat Illness Prevention Standard (HIPS) in California and Washington.

Figure 3 presents the distribution of the labor exposure measure across NAICS2 sectors and NAICS4 industries. The x-axis represents NAICS2 sectors and the y-axis represents the labor exposure measure. The dots denote the minimum, the 25^{th} percentile, the median, the 75^{th} percentile, and the maximum values of labor exposures across NAICS4 industries in each NAICS2 sector. The

[10] A score of "1" indicates that workers in this occupation are *never* exposed to any weather conditions during the working process. "2" indicates "*once a year or more but not every month*." "3" indicates "*once a month or more but not every week*." "4" indicates "*once a week or more but not every day*." "5" indicates "*every day*." The score is derived from the question - "*How often does this job require working outdoors, exposed to all weather conditions?*."

[11] See "*32.9 percent of employees had regular outdoor exposure in 2022*".

key takeaway is that substantial variation in workers' climate exposure exists both within and across sectors, underscoring the broad economic impact of high temperatures across the U.S. economy.[12]

3.4 Additional Data

Temperature Projections. The data on county-level temperature projections is collected from the Centers for Disease Control and Prevention (CDC). This data builds on the Localized Constructed Analogs (LOCA) dataset, derived from 32 Coupled Model Intercomparison Project (CMIP5) models that are widely used in the climate science literature. The CDC processes the raw data on projections of the differences in extreme hot days (90°F/32.2°C) between the reference period (1976 – 2005) and the projected period (2016 - 2045) and aggregates it to the county level.

Small Business Administration(SBA) 7(a) Loans. The data on banks' small business loan originations is sourced from the SBA 7(a) loan program. The data spans from 1991 to 2024 and provides rich details for each loan, including the bank, the SBA office, the borrower, total loan amount, guaranteed loan amount, maturity, interest rate, and more. Crucially for this study, the data includes information on the borrower's location and six-digit NAICS industry code, enabling the matching with measures of heat shocks and labor exposures. The SBA guarantees about 60% of the loan amount on average, so lenders are only partly exposed when lending to heat-exposed firms.

Quarterly Census of Employment and Wages (QCEW). Industry-level employment data for each U.S. county are obtained from the BLS's QCEW program, which reports employment and wage information for all six-digit NAICS industries across more than 3,000 counties from 1990 to 2023.

County-level Characteristics. County-level data on total population and income is from the Bureau of Economic Analysis (BEA), and data on unemployment rate is from the BLS.

3.5 Summary Statistics

Table 1 presents summary statistics for the variables used in the main empirical analyses. The sample is constructed at the county-by-NAICS4 industry level, including 3,056 counties and 268 NAICS4 industries from 1999 to 2019.[13] On average, each NAICS4 industry in a county sees the creation of 5.7 new firms and 32.2 associated jobs annually. Additionally, about 17.4% of the observations in

[12] See Xiao (2021) (Section 4.4 and Internet Appendix Section B) for further discussions of the measure, including the raw datasets, the distribution across labor skill levels, examples of high-exposure industries, and correlations with other climate exposure measures in the literature.

[13] I end the sample in 2019 to avoid potential disruptions caused by the COVID-19 pandemic. For example, industries with high shares of outdoor workers may find it easier to maintain social distancing and are thus less affected.

the sample are affected by heat shocks. Across all industries, the average exposure to heat shocks through the labor channel is 9.9, while the median exposure level stands at 9.

4 Heat Shocks and Entrepreneurship

4.1 Empirical Methodology

I estimate the causal impact of unexpected extreme heat on U.S. entrepreneurial activities across counties and NAICS4 industries, which I expect to be negative and statistically significant.

$$Y_{s,c,i,t} = \mu_{s,t} + \pi_{i,t} + \theta_{c,i} + \beta_1 \, Heat\ Shocks_{s,c,t} + \delta \boldsymbol{X}_{s,c,t} + \varepsilon_{s,c,i,t} \tag{3}$$

$$\begin{aligned} Y_{s,c,i,t} = &\mu_{s,t} + \pi_{i,t} + \theta_{c,i} + \beta_1 \, Heat\ Shocks_{s,c,t} + \beta_2 \, Heat\ Shocks_{s,c,t} \times Labor\ Exposure_{i,t} \\ &+ \beta_3 \, Labor\ Exposure_{i,t} + \delta \boldsymbol{X}_{s,c,t} + \varepsilon_{s,c,i,t} \end{aligned} \tag{4}$$

where s denotes state, c denotes county, i denotes NAICS4 industry, and t denotes year. $Y_{s,c,i,t}$ is the dependent variable for entrepreneurial activities in county c, NAICS4 industry i, and year t, measured as the natural logarithm of one plus the number of new firms created.[14] $Heat\ Shocks_{s,c,t}$ is an indicator that equals one if heat shocks defined in Equation (1) occur in county c and year t, and zero otherwise. $Labor\ Exposure_{i,t}$ measures a NAICS4 industry's exposure to climate risks through the labor channel (Equation (2)). $X_{s,c,t}$ is a vector of controls at the county level, including the natural logarithm of the county's total population (*Log(Population)*), the natural logarithm of the county's income per capita (*Log(Income per Capita)*), and the county's unemployment rate (*Unemployment Rate*).

Model (3) estimates the average effect of heat shocks on entrepreneurship, captured by the coefficient of *Heat Shocks*, β_1. I expect β_1 to be negative and statistically significant, which suggests an overall negative impact of heat shocks on entrepreneurship. Model (4) estimates heat effect conditional on each NAICS4 industry's exposure through the labor channel by adding *Heat Shocks* $\times$ *Labor Exposure* and *Labor Exposure*. I expect β_2 to be negative and statistically significant, indicating that the heat impact is larger in industries with larger shares of exposed workers.

Both models include various fixed effects to control for unobserved heterogeneities across states, counties, and industries. Specifically, $\mu_{s,t}$ represents state-by-year fixed effects that control for time-varying economic conditions and policy changes in a state. $\pi_{i,t}$ denotes NAICS2 (or NAICS3, or NAICS4) industry-by-year fixed effects, and $\theta_{c,i}$ denotes county-by-NAICS4 fixed effects. In the

[14] This log transformation is applied to account for the skewness of the variable. To further address concerns about the spurious negative relation documented by Cohn et al. (2022), I use either the fixed effects Poisson model or other forms of the dependent variable (e.g., a dummy indicating firm creation, the number of new firms created, or the number of new firms created scaled by the number of existing establishments) to demonstrate the robustness of the finding.

strictest version of Model (4), I include county-by-year fixed effects to compare how different industries respond to the same local heat shock, account for industry-level heterogeneities with NAICS4 industry-by-year fixed effects, and control for the importance of an industry within a county using county-by-NAICS4 fixed effects. In this specification, the entrepreneurial gap between high- and low-exposure industries in non-heat-shocked counties serves as a benchmark for estimating the impact of heat on high- and low-exposure industries in heat-shocked counties. As additional analysis, in Internet Appendix Table B.5, I include state-by-year-by-NAICS4 industry fixed effects to compare how the same NAICS4 industry responds to different county-level heat shocks within a state.

4.2 New Firm Creation

Table 2 presents estimates of the causal impact of heat shocks on entrepreneurial activities. The dependent variable *Firm Creation* is measured at the county-by-NAICS4 industry level. Columns (1) - (3) present the population average effect of heat shocks using Model (3). Across all three columns, the coefficient estimate for *Heat Shocks* is negative and statistically significant, suggesting that heat shocks discourage economy-wide entrepreneurial activities. This finding is unlikely to be driven by state- or industry-level time-varying dynamics, or any hidden links between counties and industries, as the model in column (3) includes state-by-year, NAICS4-by-year, and county-by-NAICS4 fixed effects. On average, one past heat shock leads to a 0.8% decline in new firm creation.

In column (4), I investigate the labor channel of heat exposure using Model (4). The coefficient estimate of *Heat Shocks* becomes positive and statistically significant, suggesting that industries with *hypothetically zero heat exposure* even experience an increase in new firm creation following heat shocks. Importantly, the coefficient estimate of the interaction term *Heat Shocks* $\times$ *Labor Exposure* is negative and statistically significant. This indicates that high-exposure industries experience reduced entrepreneurial activities and a lower rate of new firm creation following heat shocks, compared to their low-exposure counterparts. The economic magnitude is large: a one-unit increase in labor exposure leads to a 0.2% decline in entrepreneurship.

Based on the estimation, I report the net treatment effects of heat shocks on entrepreneurship for industries in each exposure category (*Labor Exposure = 1 to 20*) in Figure 4 (A) and for high-exposure industries at the bottom of the table. The results indicate that heat shocks begin to negatively impact entrepreneurship in industries with the median exposure of 10. For industries at the 75^{th} percentile of exposure (*Labor Exposure = 15*), new firm creation declines by 1.6% following heat shocks. Industries with the highest exposure (*Labor Exposure = 20*) experience a 2.4% drop. The findings show that heat

shocks negatively impact entrepreneurship in about half of the industries in the economy.

A few industries with the minimum heat exposure index of 1 exhibit a marginally significant positive response in firm creation. There are at least two plausible explanations for this finding. First, individuals working in industries with minimal heat exposure may adjust their work schedules, increasing productivity and firm creation during abnormally hot periods and relaxing more when temperatures cool down (e.g., outdoor leisure) (Xiao (2021)). Second, individuals with transferable skills may shift from high-exposure to low-exposure industries, contributing to increased business creation in the latter. The net effects of heat shocks are also positive for a few industries with *Labor Exposure* = 2, 3, 4, or 5 but are not statistically significant.

In column (5), I replace state-by-year with county-by-year fixed effects to control for time-varying county-level characteristics. The coefficient of *Heat Shocks* $\times$ *Labor Exposure* remains negative and statistically significant, and the economic magnitude is unchanged, implying that county-level heterogeneities cannot explain the findings. Additionally, I replace NAICS2-by-year fixed effects with NAICS3-by-year fixed effects in column (6) and with NAICS4-by-year fixed effects in column (7). The results still hold, suggesting that the findings are not driven by industry-level heterogeneities.

4.3 New Firm Creation: Alternative Empirical Specifications

I also employ alternative empirical specifications to address concerns over the log form of the dependent variable (Cohn et al., 2022). The results are reported in Table 3. Columns (1) - (2) use a linear regression model and the dependent variable is the number of new firms created at the county-by-NAICS4 industry level. Columns (3) - (4) use a linear regression model and the dependent variable is a dummy indicating that at least one new firm is created. Columns (5) - (6) use a linear regression model and the dependent variable is the number of new firms created scaled by the number of existing establishments in the same NAICS4 industry and county from the previous year. Columns (7) - (8) use the fixed effects Poisson model and the dependent variable is the number of new firms created at the county-by-NAICS4 industry level. The results hold across all columns and the economic magnitude in column (8) is even larger than that in column (4) of Table 2 (*-0.004 vs. -0.002*). In summary, the results consistently support my conjecture that extreme heat discourages new firm entry, particularly in industries that are highly exposed through the labor channel.

4.4 Jobs Created by New Firms

As additional analysis, I examine the number of jobs created by new firms in Table 4. The dependent variable is the natural logarithm of one plus the number of jobs created by new firms. The analysis in columns (1) - (3) shows that the population average effect of heat shocks on job creation is negative, although statistically insignificant. Importantly, consistent with Table 2, the coefficient estimate of the interaction term *Heat Shocks* $\times$ *Labor Exposure* is negative and significant. This result indicates that heat shocks negatively affect job creation, but only in highly exposed industries. In column (4), a one-unit increase in labor exposure leads to a 0.2% decrease in job creation, equivalent to a 2% drop when moving from the 25^{th} percentile to the 75^{th} percentile.

Same as before, I report the net treatment effects of heat shocks on job creation for industries in each exposure category (*Labor Exposure = 1 to 20*) in Figure 4 (B). As expected, the negative and significant effects of heat shocks on job creation are only observed among high-exposure industries. For instance, for industries with labor exposure at the 75^{th} percentile (*Labor Exposure=15*), the number of jobs created by new firms drops by 1.9% after heat shocks. Industries with the highest exposure (*Labor Exposure = 20*) experience a 2.9% reduction in job creation.

Overall, these findings align with those on firm creation and further support my hypothesis that heat risks discourage entrepreneurial activities and, consequently, job creation in exposed industries.

4.5 Robustness Checks and Excluding Alternative Channels

In Internet Appendix Section B, I conduct additional analyses to demonstrate the robustness of the results in Table 2 and exclude alternative channels. I briefly discuss these analyses below.

Alternative Definitions of Heat Shocks. First, to address the concern that the choices of N_1*=45* and N_2*=240* may appear arbitrary, in Internet Appendix Section B.1 and Table B.1, I use alternative thresholds (N_1*=40, 45, 50, or 60* and N_2*=120, 160, 200, or 240*) to define heat shocks. The results hold. The economic magnitude generally increases to 1.6% as the absolute threshold rises for industries with labor exposure at the 75^{th} percentile. As additional analysis, I also use two continuous measures of absolute and relative heat shocks (*Log(1 + No. Absolute Hot Days) and Log(1 + No. Relative Hot Days)*), and the results remain robust.

Sector Breakdowns and Excluding Alternative Channels. Second, in Table B.2 and B.3, I repeat the analysis using sector-based subsamples and excluding alternative channels related to lower agricultural outputs and consumer demand. For example, in Table B.2, I show that the results hold after

excluding the agriculture, mining, oil, and gas industries (*NAICS2 11 & 21*), and consumer-oriented industries (*NAICS2 44, 45, 61, 62, 71, & 72*). In Table B.3, I show that the results hold after excluding non-tradable industries. The economic magnitudes remain the same. Additionally, the drop in consumption demand could be driven by households moving from hot to cool areas. In untabulated results, I show that the results hold in counties with limited population changes.

Controlling for Other Climate Events. Third, in Table B.4, I show that the results are robust to controlling for other climate events, e.g., hot temperatures in non-summer months, extreme cold, precipitation, and non-heat disasters reported in the SHELDUS database.[15]

Alternative Set of Fixed Effects. Fourth, Table B.5 includes state-by-year-by-NAICS4 industry fixed effects to compare how the same NAICS4 industry responds to different county-level heat shocks within a state. The results hold after further adding county-by-year fixed effects.

Alternative Sample Constructions. Fifth, I test the robustness of the results by reconstructing the sample. Instead of focusing on the top 20 industries in a county, in columns (1) - (4) of Table B.6, I repeat the analysis by including the top 10, 15, 25, and 30 industries in a county, respectively. Furthermore, I include industries that account for more than 1% of total employment in a county in column (5), and those contributing more than 3% in column (6). The coefficient estimate for *Heat Shocks* $\times$ *Labor Exposure* remains negative and statistically significant across all columns.

County-level Population Change. Sixth, I discuss the varying impact of population migration (either workers or prospective entrepreneurs) on business formation in heat-vulnerable industries within hot regions in Internat Appendix B.6. I also test the robustness of the baseline results to population migration in Table B.7 and find that the findings are unlikely to be driven by migration.

A Continuous Measure of Labor Exposure. Seventh, in Table B.8, I conduct robustness checks using a continuous measure of labor exposure instead of a rank variable, and the results remain consistent.

Alternative Data on County-level Entrepreneurship. Eighth, in addition to YTS, I also measure entrepreneurial activities at the county level using the business registration data provided by Fazio et al. (2019).[16] The results are consistent and are reported in Table B.9.

[15] Through the same labor channel, Xiao (2021) find no effects of non-heat climate events on firm-level labor productivity losses (Internet Appendix Section D.2.4).

[16] See, for example, Guzman and Stern (2020), Engelberg et al. (2022), Bryan and Guzman (2023), and Denes et al. (2023) for works using this data. I do not use this data for the main analysis because it only quantifies entrepreneurship at the county level, which does not allow me to match with the labor exposure measure at the NAICS4 industry level.

4.6 Dynamic Treatment Effects of Heat Shocks on Firm Creation

Additionally, I investigate the timing of heat shocks and their dynamic treatment effects on entrepreneurship. To this end, I break down heat shocks defined from Equation (2), which include temperature fluctuations from $t-3$ to t, into annual short-term heat shocks. In particular, for any given county and year, I define annual heat shocks as instances where a county experiences at least 12 summer days (45/4=11.25, rounded up to 12) with temperatures above the rolling 90^{th} percentile, and at least 60 summer days (240/4=60) with temperatures above 30°C.

Table 5 presents the results. The dependent variable is the natural logarithm of one plus the number of new firms created in year t. The key independent variables are the interaction terms between *Labor Exposure* and indicators of heat shocks for the respective years from $t-3$ to $t+3$. *Heat Shocks (T-3)*, *Heat Shocks (T-2)*, *Heat Shocks (T-1)*, *Heat Shocks (T)*, *Heat Shocks (T+1)*, *Heat Shocks (T+2)*, and *Heat Shocks (T+3)* denote heat shocks occurring in the years $t-3$, $t-2$, $t-1$, t, $t+1$, $t+2$, and $t+3$, respectively. In column (1), I examine the influence of heat shocks occurring in year $t-3$. The coefficient estimate for *Heat Shocks* $\times$ *Labor Exposure* is negative and statistically significant, suggesting that past heat shocks can have a long-lasting impact on entrepreneurship decisions for up to three years. Columns (2), (3), and (4) examine heat shocks occurring in years $t-2$, $t-1$, and t, respectively. All the coefficient estimates for *Heat Shocks* $\times$ *Labor Exposure* are negative and statistically significant. In column (5), I include all annual heat shocks from $t-3$ to t. Among the four coefficient estimates, the one for $t-2$ is the largest, indicating that heat shocks from two years prior have the most significant impact on present entrepreneurial activities. In column (6), I further include future heat shocks occurring in years $t+1$, $t+2$, and $t+3$. The significance of contemporaneous heat shocks disappears while the significance of past heat shocks at year $t-2$ and $t-1$ remains. Most importantly, the coefficient estimates for *Heat Shocks* $\times$ *Labor Exposure* at $t+1$, $t+2$, and $t+3$ are not statistically significant, indicating that future heat shocks have no impact on present entrepreneurial activities. The dynamic effects are also presented in Figure 5.

Taken together, these results demonstrate that only past heat shocks negatively affect present entrepreneurial decisions in heat-exposed industries, while future ones do not, thereby alleviating endogeneity concerns.

5 Economic Mechanisms

Analysis so far has provided consistent and robust evidence demonstrating that extreme heat negatively affects entrepreneurship, particularly in high-exposure industries. The economic rationale is that extreme heat raises labor-related production and financing costs for business operations with substantial heat exposure, thereby reducing individuals' incentives to start new businesses. In this section, I provide evidence to identify heat risks embedded within this labor channel and the underlying economic mechanisms.

5.1 Labor Costs

As discussed in Section 2 "Conceptual Framework", one key mechanism behind the decline in entrepreneurship is that extreme heat raises labor costs per unit of output in the production process and consequently reduces operating profits, imposing substantial financial burdens on businesses in heat-exposed industries. This, in turn, discourages individuals from starting new businesses. The rise in labor costs per unit of output may be attributed to at least four factors: (1) lower productivity while at work, (2) reduced labor supply, (3) higher non-wage labor costs, and (4) increased reputation and litigation risks. Below I present some tests based on existing evidence in the literature on these factors to pin down the labor mechanism.[17]

5.1.1 Labor Utilization in Production

Recent research by Xiao (2021) demonstrates that heat exposure through the same labor channel reduces firm-level labor productivity,[18] confirming that heat-exposed workers indeed become less efficient for production activities. Furthermore, the paper shows that firms adapt by shifting towards more capital-intensive production functions, which effectively offset labor productivity losses.[19] This evidence suggests that heat risks are more critical for businesses that rely heavily on human capital relative to physical assets as production inputs or for businesses unable to use physical assets to

[17] Ideally, we would have precise data on firms' expenditures related to human capital as a production input, allowing us to examine the impact of heat on these costs. However, in practice, data limitations arise, as many labor costs are non-pecuniary, including employee hiring costs, contractual protections, training, paid sick leave, medical care support, and reputation and litigation costs, etc.

[18] I include Figure C.1 from Xiao (2021) in Internet Appendix Section C, which illustrates the treatment effects of heat shocks on firm-level labor productivity losses.

[19] More specifically, Xiao (2021) find that (1) exposed firms significantly increase capital-labor ratios after heat shocks, and (2) heat shocks negatively affect labor productivity only in firms with low capital-labor ratios, while firms with high capital-labor ratios remain unaffected.

substitute for human capital. Motivated by the evidence, I conjecture that the labor channel leading to reduced entrepreneurship is more pronounced in industries that depend more on human capital.

I test this conjecture in Table 6. In particular, I interact *Heat Shocks* $\times$ *Labor Exposure* with *High K/L*, an indicator that equals one if a NAICS4 industry's capital-labor ratio (*K/L*) is above the sample median, and zero otherwise. The industry-level *K/L* is measured as the median firm's property, plant, and equipment (PPENT) per employee within each NAICS4 industry, using Compustat data. The sample size is reduced to about half of the original after merging with the industry-level capital intensity measure. In columns (1) and (2), I verify that the main results in Table 2 hold in this smaller sample. In columns (3) and (4), the coefficient of the triple interaction term *Heat Shocks* $\times$ *Labor Exposure* $\times$ *High K/L* is positive and statistically significant, indicating that the heat-induced decline in entrepreneurship is weaker in industries with above-median capital-labor ratios. This finding implies that in industries where human capital plays a lesser role in business operations, heat risks are less of a concern for entrepreneurial decisions.[20]

5.1.2 Labor Costs of HIPS Compliance

In recognition of heat risks, states including California, Washington, and Oregon have adopted HIPS to enhance protections for outdoor workers. This regulation requires employers to provide preventive measures under specific heat conditions, such as provision of water, access to shade, cool-down rest, emergency and response procedures, and employee training. Importantly, compliance with HIPS substantially increases labor costs, especially for small businesses (Ortiz-Molina et al., 2023).[21] Meanwhile, HIPS exposes firms to significant reputation and litigation risks if workers suffer heat-related injuries. I expect that these labor-related regulation costs, along with reputation and litigation costs, will further discourage new firm creation in heat-exposed industries.

I test this prediction in Table 7 using a refined sample that focuses on states adopting HIPS — California in 2005 and Washington in 2006 — and their neighboring states in the West and South regions, over the period 2001 to 2007. Analysis in column (1) confirms that the baseline finding holds in this sample. In column (2), I interact *Heat Shocks* $\times$ *Labor Exposure* with *HIPS*, an indicator variable set to

[20] The finding aligns with Internet Appendix Table C.2, which shows that the decline in entrepreneurship through the labor channel is more pronounced in industries requiring more skilled workers. The evidence is consistent with the notion that physical capital assets are less effective at replacing skilled workers, thereby making it harder to mitigate heat-induced productivity losses. As a result, prospective entrepreneurs are more concerned with entering industries requiring skilled workers because they cannot rely on automation to lower heat-induced labor costs.

[21] For instance, a report by the Small Business Advocacy Review Panel on OSHA's proposed heat regulations in 2023 highlights that many small businesses express concerns about the challenging costs of implementing the preventive measures. See "RE: Report of the Small Business Advocacy Review Panel on OSHA's Potential Standard for Heat Injury and Illness Prevention in Outdoor and Indoor Work Settings."

one for California starting in 2005 and for Washington starting in 2006 and to zero otherwise. Supporting my prediction, the coefficient for the interaction term is negative and statistically significant, indicating that HIPS-associated compliance costs further deter firm entry in heat-exposed industries.

5.2 Credit Access

Entrepreneurs may face higher financing costs when starting new businesses if creditors consider heat risks in loan decisions, potentially discouraging market entry. I test this financing mechanism using small business loan originations from the SBA 7(a) loan program and present the results in Table 8.[22] In Panel A, the dependent variable is *Log(Loan Amount)*, the natural logarithm of the loan amount. Columns (1) - (4) report the average impact of extreme heat on loan originations, showing that heat shocks significantly reduce the average loan amount small businesses receive from banks. This result remains robust after controlling for state-by-year, county, business type, industry-by-year, SBA office, and bank fixed effects. Economically, one past heat shock reduces the total loan amount by 0.4%. Columns (5) - (10) report the heterogeneous effects of heat shocks across varying levels of heat exposure. As expected, the coefficient for interaction term *Heat Shocks* $\times$ *Labor Exposure* is negative and statistically significant, indicating that the decline in credit access is primarily concentrated in high-exposure industries. Specifically, in column (5), the loan amount is 0.8% smaller for small businesses with heat exposure at the 75^{th} percentile, and 1.2% smaller for small businesses with the highest exposure.[23] The findings remain robust after incorporating an extensive set of fixed effects to account for heterogeneities across banks, SBA offices, locations, and industries. Detailed net treatment effects of heat shocks on loan amounts for each labor exposure category (*Labor Exposure = 1 to 20*) are presented in Internet Appendix Section C.3 Figure C.2 (A).

In Panel B of Table 8, I examine the effects of heat shocks on interest rates. Analysis in columns (1) - (4) reveals that the average small business experiences a 0.4% increase in interest rates following heat shocks. Columns (5) - (10) further show that this increase is primarily driven by loans to small businesses in heat-exposed industries. For example, loans to small businesses at the 75^{th} percentile of heat exposure experience a 0.7% increase in interest rates, while those with the highest exposure see an increase of 1.1%. Detailed net treatment effects of heat shocks on loan interest rates for each labor exposure category (*Labor Exposure = 1 to 20*) are presented in Internet Appendix Figure C.2 (B).

In summary, these findings suggest that increased financing costs, driven by heat-related labor

[22] Summary statistics for the sample and variables are reported in Internet Appendix Table C.1.

[23] Note that on average about 60% of the 7(a) loan amounts are guaranteed by the SBA. The economic magnitudes could be significantly larger if lenders are fully exposed to heat risks through the lending process.

risks, partially contribute to the decline in entrepreneurship observed in heat-exposed industries.

5.3 Expected Heat Risks

As climate change intensifies, extreme heat events are expected to occur more severely and frequently. If the decline in entrepreneurship is driven by concerns about heat risks and associated labor-related production and financing costs, the effects should be more pronounced in areas where significant temperature increases are anticipated in the near future. Conversely, if a past heat shock is an isolated event with no expectation of recurrence, businesses would not anticipate increased labor-related costs, and entrepreneurial decisions would not be affected. I test this conjecture by examining the impact of heat on entrepreneurship conditional on projected temperature increases in each county.

Table 9 presents the results. In column (1), a county is classified as "*High Projection*" if its projected increase in extreme heat days compared to the historical period is above the sample median. The coefficient estimate for *Heat Shocks* $\times$ *Labor Exposure* is not statistically significant. However, the coefficient estimate for the triple interaction term *High Projection* $\times$ *Heat Shocks* $\times$ *Labor Exposure* is negative and statistically significant, indicating that the heat-induced decline in entrepreneurship is most pronounced in areas with substantial projected heat risks. Column (2) repeats the analysis using a continuous variable for temperature projections, and the results remain consistent. Overall, this evidence supports my conjecture that the decline in entrepreneurship results from concerns about heat risks that are expected to significantly raise business costs as climate change worsens.

6 Further Analyses and Discussions

In this section, I provide additional analysis to further explore the broader implications of climate change for U.S. entrepreneurship, employment, and economic dynamics.

6.1 Long-term Survival of New Entrant Firms in Heat-Exposed Industries

Despite rising heat risks and associated labor-related costs, some entrepreneurs continue to start businesses in heat-exposed industries, particularly if they possess specialized knowledge of heat risks or strategies to mitigate the costs. Ex ante, it is unclear whether new firms in heat-exposed industries are more or less likely to survive than those in less exposed ones. On the one hand, heat-induced business costs reduce the cash flow of exposed firms, limiting their operational flexibility, investment capacity, and growth potential, thereby reducing their likelihood of survival. On the other hand,

entrepreneurs who start businesses in these challenging conditions are likely to be of higher quality, potentially increasing their chances of success. Furthermore, the reduced entry of new firms may lead to lower competition and greater growth opportunities.

I explore this question in Table 10. The dependent variable in columns (1) - (3) is *Log(Survival Years)*, the natural logarithm of the average number of years that newly created firms survive until 2022, measured at the county-by-NAICS4 industry level. The analysis shows that, conditional on entry, new firms in heat-exposed industries have significantly longer survival times. For instance, firms founded in industries at the 75^{th} percentile of heat exposure have a 1.2% longer survival time, while those in the most exposed industries survive 1.8% longer. Furthermore, columns (4) - (6) analyze the average number of jobs maintained by new firms six years after their founding. The results show that firms in high-exposure industries tend to maintain higher employment levels compared to those in low-exposure industries after six years. In particular, firms established in industries at the 75^{th} percentile of heat exposure have 2% more employees, while those in the most exposed industries have 2.7% more employees. This superior performance could be attributed either to a selection effect, in which only high-quality entrepreneurs enter heat-vulnerable industries, or to reduced competition resulting from lower entry.

6.2 New Establishments Created by Existing Firms

The reduced entry of new firms in heat-exposed industries may leave certain consumption demands unmet at affordable prices. Existing firms, with greater financial resources and practical experience, may be better positioned to scale up operations to meet these consumption demands. This suggests that existing firms could leverage heat-related challenges as growth opportunities, potentially expanding their operations and establishing more plants. However, like new entrants, existing firms also face higher labor-related costs for business operations, which may deter them from expanding their production networks in heat-exposed industries. I investigate this question in Table 11.

In columns (1) - (3), the dependent variable is *Establishment Creation, Existing*, the natural logarithm of one plus the number of new establishments created by existing firms at the county-by-NAICS4 industry level. In columns (4) - (6), the dependent variable is *Establishment Creation, All*, the natural logarithm of one plus the number of new establishments created by both new and existing firms. The analysis shows that existing firms establish more new plants in heat-exposed industries following heat shocks. However, the expansion by existing firms does not sufficiently offset the county-wide decline in new entrants. Specifically, the county-wide total establishment creation in

industries at the 75^{th} percentile of heat exposure declines by 1.4% following heat shocks. One implication of this finding is that industry concentration may increase as high temperatures discourage new entrants while prompting existing firms to expand their networks.

6.3 Macroeconomic Effects: Total County Income

Considering the importance of new firms for job creation and economic activities (Adelino et al., 2017), the county-wide decline in business formation could lead to a macro-level contraction in aggregate economic output. I test this conjecture using the county-level total personal income data provided by the BEA, which captures the total returns from capital and labor as production inputs.[24] Table 12 represent the results. The variable *Labor Exposure* denotes a county's exposure to climate risks through the labor channel, calculated as the employment-weighted average of the industry-level measure of labor exposure defined in Equation (2). The weight is the number of employees working in a NAICS4 industry in a county from QCEW. Supporting my conjecture, past heat shocks result in significant declines in county-level total income, and the decline is primarily concentrated in counties with significant shares of heat-exposed workers. For instance, total income drops by 1.4% for counties at the 75^{th} percentile of heat exposure and by 2.3% for counties with the highest exposure. Internet Appendix Figure C.3 provides additional details of the effects of heat shocks on county-level total income by labor exposure category (1 to 20), based on the estimation in column (4) of Table 12. This evidence indicates that rising heat risks could significantly slow macroeconomic growth in the foreseeable future, and the society is not taking sufficient adaptation actions.

7 Conclusions

The escalating extreme heat, a direct consequence of climate change, presents significant challenges to business operations. This paper explores how these challenges impact individuals' incentives to start new businesses through a labor channel.

Specifically, this paper focuses on health risks associated with high temperatures, which reduce the supply and productivity of exposed workers, leading to higher production and operating costs for affected businesses. In recognition of the risks, states including California, Washington, and Oregon

[24] By the BEA definition, personal income consists of the income that persons receive in return for their provision of labor, land, and capital used in current production as well as other income. This broad definition accounts for adaptation actions that economic agents can take to mitigate the negative impact of heat risks on firm and job formation, such as changing jobs or reallocating time to other income sources, thereby capturing the overall effect of heat risks on aggregate economic activity.

have adopted HIPS to protect outdoor workers, requiring employers to provide cooling methods and preventive measures. However, compliance with HIPS further increases labor costs and exposes firms to reputation and litigation risks. Meanwhile, creditors may restrict credit access to heat-exposed small businesses, which further discourages firm entry. With global temperatures projected to rise further, these climate-induced business costs are likely to increase substantially, potentially reshaping the landscape of entrepreneurial activities.

I conjecture that prospective entrepreneurs would consider these heat-induced labor-related production and financing costs when deciding to start a business. Supporting this conjecture, I find that extreme heat discourages new firm creation, particularly in industries with substantial heat exposure. The deterrent effect is more pronounced in industries where human capital is critical for business growth, in states adopting HIPS, and in counties with greater long-run heat risks. However, entrepreneurs who continue to start businesses in heat-vulnerable industries are likely to be of higher quality, and their businesses are more likely to survive and grow faster in the long run. In addition, existing firms fill market gaps left by reduced entrants and expand their networks, but this expansion fails to offset the county-wide decline in new business formation. This overall business decline, in turn, contributes to a macro-level contraction in aggregate economic activity, suggesting that the society is not taking sufficient adaptation actions.

In summary, this research underscores the profound impact of climate change on entrepreneurial activities across counties and industries in the U.S., highlighting the need for targeted policies and interventions to foster business growth while building more resilient and sustainable communities.

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Appendix A: Variable Definitions

Variables	Description
Dependent Variables	
Firm Creation	The natural logarithm of one plus the number of new firms created at the county-by-NAICS4 industry level.
Job Creation	The natural logarithm of one plus the number of jobs created by new firms at the county-by-NAICS4 industry level.
Establishment Creation, Existing	The natural logarithm of one plus the number of new establishments created by existing firms at the county-by-NAICS4 industry level.
Establishment Creation, All	The natural logarithm of one plus the number of new establishments created by both new and existing firms at the county-by-NAICS4 industry level.
Log(Survival Years)	The natural logarithm of the average number of years that newly created firms survive until 2022 at the county-by-NAICS4 industry level.
Log(6-Year Jobs)	The natural logarithm of the average number of employment that newly created firms have six years after establishment at the county-by-NAICS4 industry level.
Log(Loan Amount)	The natural logarithm of the loan amount at the loan level.
Log(Loan Interest Rate)	The natural logarithm of the loan interest rate at the loan level.
Log(Total County Income)	The natural logarithm of the county-level total personal income from the BEA, in thousands of dollars.
Key Independent Variables	
Heat Shocks	An indicator that equals one if heat shocks occur in the county, and zero otherwise, defined in Equation (1).
Labor Exposure	The NAICS4 industry's exposure to climate risks through the labor channel, defined in Equation (2).
Other Independent Variables	
Log(Population)	The natural logarithm of the county's total population.
Log(Income per Capita)	The natural logarithm of the county's income per capita.
Unemployment Rate	The county's unemployment rate.
Log(SBA Loan Amount)	The natural logarithm of the loan amount guaranteed by the SBA.
Maturity	The natural logarithm of loan maturity in months.
Log(1+Jobs Supported)	The natural logarithm of one plus the number of jobs supported by the loan.
Credit Line	An indicator that equals one if the loan is a revolving line of credit, and zero it it's a term loan.

Figures

Figure 1. Distribution of Newly Established Firms Across U.S. Counties

This figure presents the average annual number of newly established firms for each county in the continental U.S. during the period 1999 – 2019.

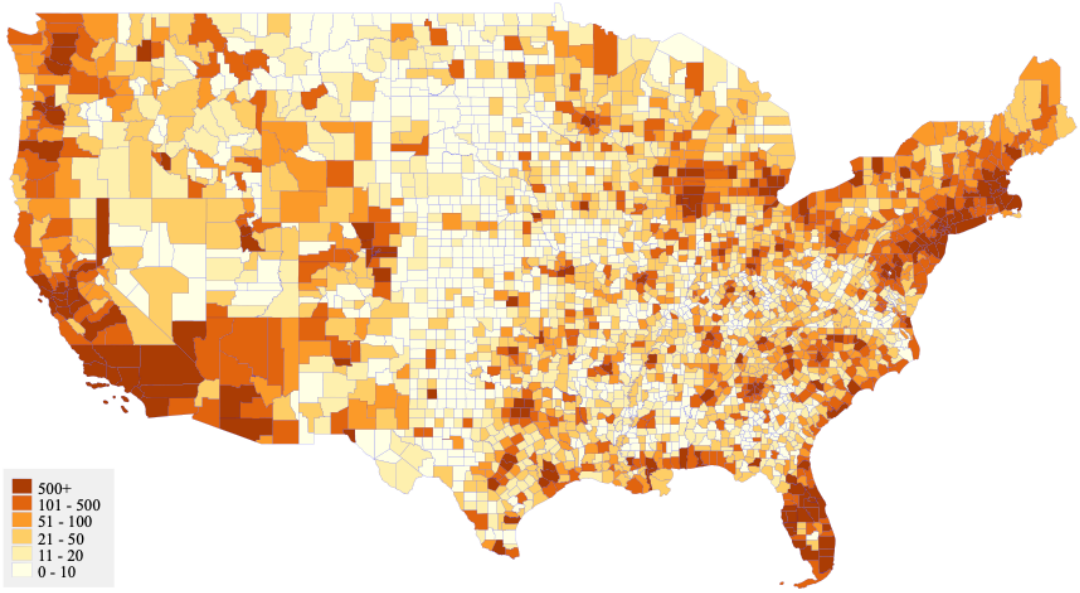
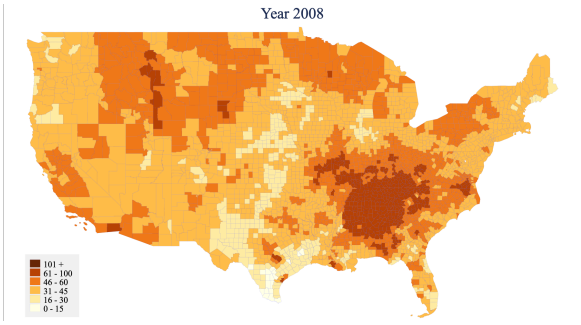


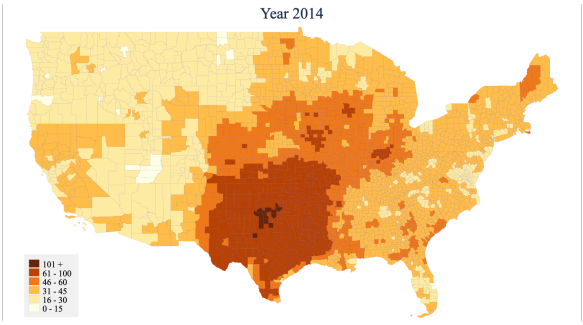
Figure 2. Distributions of Relative and Absolute Heat Shocks Across U.S. Counties

These figures present distributions of relative and absolute heat shocks across counties in the continental U.S. Specifically, Figure (A) presents the number of summer days from 2005 to 2008 with temperatures above the rolling estimated 90^{th} percentile. Figure (B) presents the number of summer days from 2011 to 2014 with temperatures above the rolling estimated 90^{th} percentile. Figure (C) presents the number of summer days from 2005 to 2008 with temperatures above 30°C. Figure (D) presents the number of summer days from 2011 to 2014 with temperatures above 30°C. Refer to Equation (1) for detailed definitions of relative and absolute heat shocks.

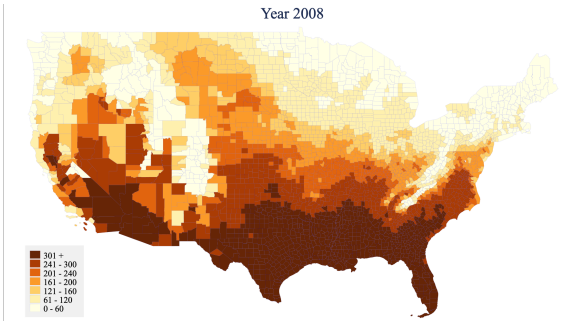
(A) No. Days Above the 90^{th} Percentile, 2008



(B) No. Days Above the 90^{th} Percentile, 2014



(C) No. Days Above 30°C, 2008



(D) No. Days Above 30°C, 2014

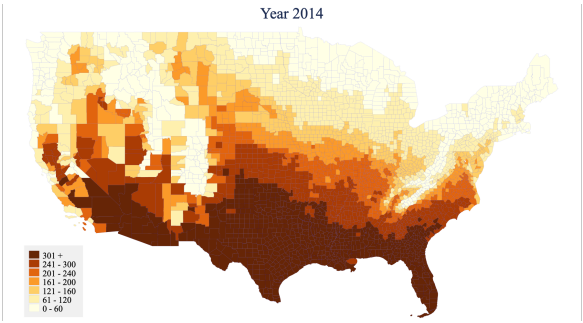


Figure 3. Distributions of the Labor Exposure Measure Across and Within Sectors

This figure presents the distributions of the NAICS4 industry-level measure of labor exposure to climate risk (Equation (2) across and within NAICS2 sectors.

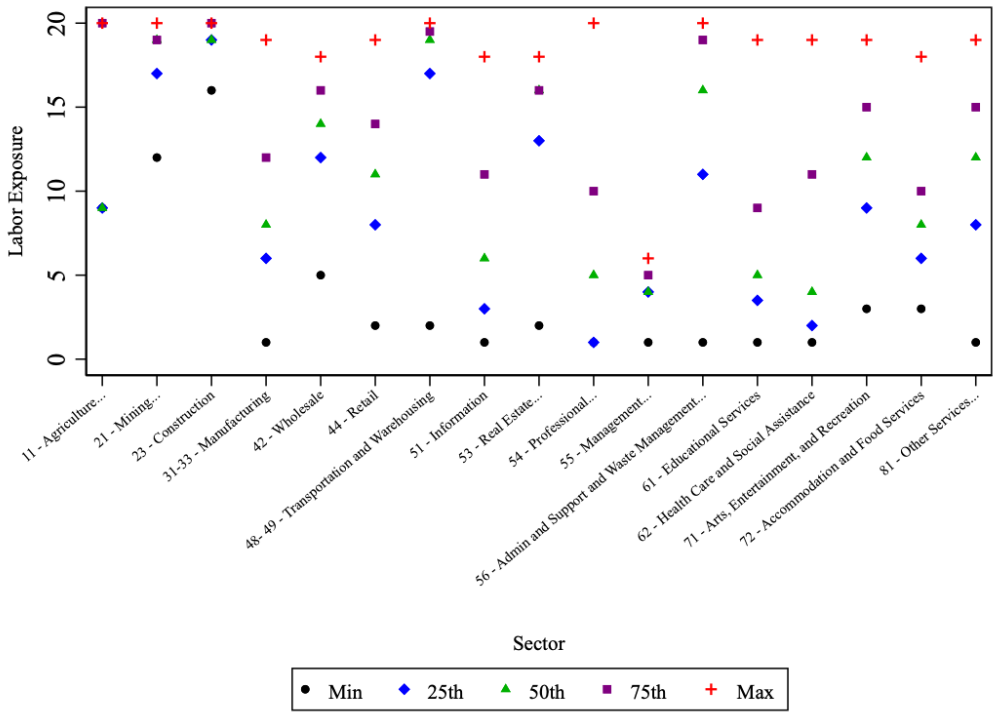
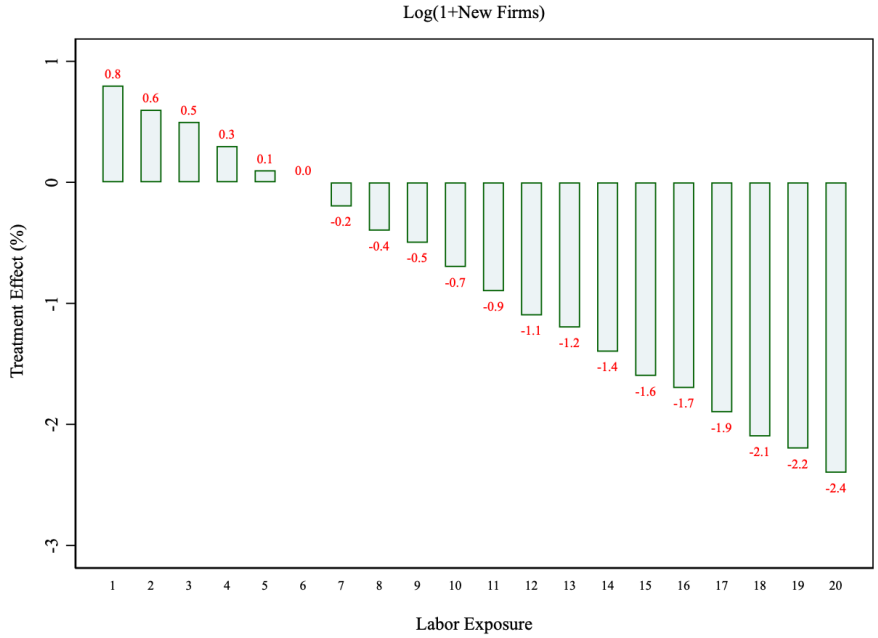


Figure 4. Heat Shocks and Entrepreneurship: Firm and Job Creation

These figures present the treatment effects of heat shocks on entrepreneurship by labor exposure category (1 to 20). Figure (A) presents the creation of new firms at the county-by-NAICS4 industry level, based on the estimation in Table 2 column (4). Figure (B) presents the number of jobs created by new firms at the county-by-NAICS4 industry level, based on the estimation in Table 4 column (4).

(A) Firm Creation



(B) Job Creation

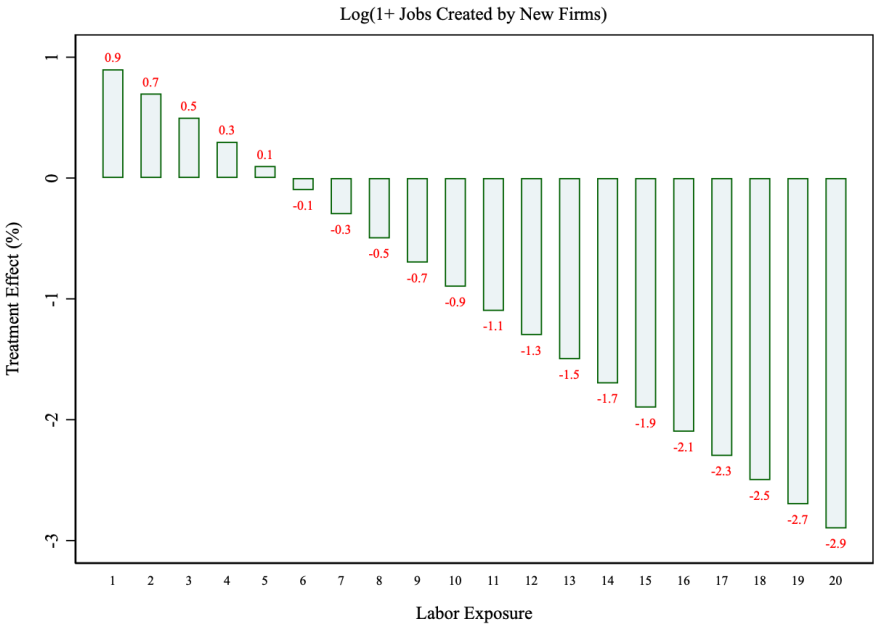
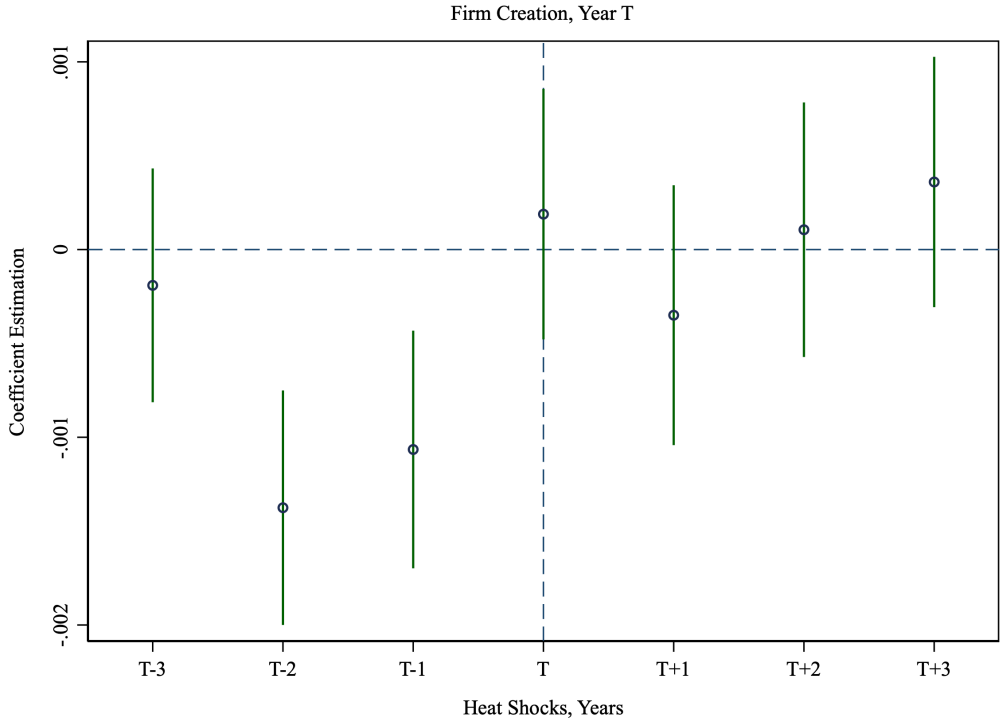


Figure 5. Heat Shocks and Entrepreneurship: Dynamic Effects

This figure presents the dynamic treatment effects of past, present, and future heat shocks on present entrepreneurship at the county-by-NAICS4 industry level. *T-3*, *T-2*, *T-1*, *T*, *T+1*, *T+2*, and *T+3* represent heat shocks occurring in years T-3, T-2, T-1, T, T+1, T+2, and T+3, respectively. Each dot represents the coefficient estimation of the interaction term between heat shocks and the labor exposure measure for the respective years in column (6) of Table 5.



Tables

Table 1. Summary Statistics

This table presents summary statistics of variables used in empirical analyses. *No. New Firms* is the number of new firms created at the county-by-NAICS4 industry level. *Firm Creation* is the natural logarithm of one plus the number of new firms created at the county-by-NAICS4 industry level. *No. Jobs Created by New Firms* is the number of jobs created by new firms at the county-by-NAICS4 industry level. *Job Creation* is the natural logarithm of one plus the number of jobs created by new firms at the county-by-NAICS4 industry level. *No. New Establishments, Existing* is the number of new establishments created by existing firms at the county-by-NAICS4 industry level. *Log(1+ New Establishments), Existing* is the natural logarithm of one plus the number of new establishments created by existing firms at the county-by-NAICS4 industry level. *No. New Establishments, All* is the number of new establishments created by both new and existing firms at the county-by-NAICS4 industry level. *Log(1+ New Establishments), All* is the natural logarithm of one plus the number of new establishments created by both new and existing firms at the county-by-NAICS4 industry level. *Log(Survival Years)* is the natural logarithm of the average number of years that newly created firms survive until 2022, measured at the county-by-NAICS4 industry level. *Log(6-Year Jobs)* is the natural logarithm of the average number of employment that newly created firms have six years after establishment, measured at the county-by-NAICS4 industry level. *Heat Shocks* is an indicator that equals one if heat shocks defined in Equation (1) occur in the county, and zero otherwise. *Labor Exposure* denotes the NAICS4 industry's exposure to climate risks through the labor channel, defined in Equation (2). *Log(Population)* is the natural logarithm of the county's total population. *Log(Income per Capita)* is the natural logarithm of the county's income per capita. *Unemployment Rate* is the county's unemployment rate. The sample period is from 1999 to 2019.

	N	Mean	P25	Median	P75	SD
No. New Firms	1,263,051	5.655	0	0	2	20.762
Firm Creation	1,263,051	0.791	0	0	1.099	1.128
No. Jobs Created by New Firms	1,263,051	32.213	0	0	13	109.283
Job Creation	1,263,051	1.436	0	0	2.639	1.812
No. New Establishments, Existing	1,263,051	0.381	0	0	0	1.737
Establishment Creation, Existing	1,263,051	0.148	0	0	0	0.437
No. New Establishments, All	1,263,051	6.035	0	0	3	21.64
Establishment Creation, All	1,263,051	0.832	0	0	1.386	1.148
Log(Survival Years)	601,758	1.771	1.386	1.842	2.197	0.643
Log(6-Year Jobs)	601,758	0.936	0	0.811	1.427	0.988
Heat Shocks	1,263,051	0.174	0	0	0	0.379
Labor Exposure	1,263,051	9.858	4	9	15	6.17
Log(Population)	1,263,051	10.287	9.347	10.168	11.115	1.445
Log(Income per Capita)	1,263,051	10.378	10.163	10.37	10.576	0.307
Unemployment Rate	1,263,051	5.946	4	5.4	7.3	2.683

Table 2. Heat Shocks and Entrepreneurship: Firm Creation

This table presents the treatment effects of heat shocks on the creation of new firms. The dependent variable is *Firm Creation*, the natural logarithm of one plus the number of new firms created at the county-by-NAICS4 industry level. The key independent variables are *Heat Shocks*, *Labor Exposure*, and the interaction term of the two (*Heat Shocks* × *Labor Exposure*). *Heat Shocks* is an indicator that equals one if heat shocks defined in Equation (1) occur in the county, and zero otherwise. *Labor Exposure* denotes the NAICS4 industry's exposure to climate risks through the labor channel, defined in Equation (2). Controls include the natural logarithm of the county's total population (*Log(Population)*), the natural logarithm of the county's income per capita (*Log(Income per Capita)*), and the county's unemployment rate (*Unemployment Rate*). The sample period is from 1999 to 2019. Numbers in parentheses are standard errors. Standard errors are clustered at the county level. ***, **, and * indicate p-values of 1%, 5%, and 10%, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Firm Creation						
Heat Shocks	-0.007*	-0.008**	-0.008**	0.010**			
	(0.004)	(0.004)	(0.004)	(0.004)			
Heat Shocks × Labor Exposure				-0.002***	-0.002***	-0.001***	-0.001***
				(0.000)	(0.000)	(0.000)	(0.000)
Labor Exposure				-0.002***	-0.002***	-0.005***	
				(0.000)	(0.000)	(0.000)	
Log(Population)	0.678***	0.669***	0.645***	0.680***			
	(0.027)	(0.027)	(0.026)	(0.027)			
Log(Income per Capita)	0.050***	0.052***	0.057***	0.050***			
	(0.013)	(0.012)	(0.012)	(0.012)			
Unemployment Rate	0.000	0.000	0.000	0.000			
	(0.001)	(0.001)	(0.001)	(0.001)			
Observations	1,243,296	1,243,274	1,243,177	1,243,296	1,243,296	1,243,274	1,243,177
State x Year FE	Yes	Yes	Yes	Yes	No	No	No
County x NAICS4 FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
NAICS2 x Year FE	Yes	No	No	Yes	Yes	No	No
NAICS3 x Year FE	No	Yes	No	No	No	Yes	No
NAICS4 x Year FE	No	No	Yes	No	No	No	Yes
County x Year FE	No	No	No	No	Yes	Yes	Yes
Adjusted R^2	0.848	0.853	0.860	0.848	0.864	0.869	0.877
Treatment Effects							
Labor Exposure=15				-1.6***			
				(0.004)			
Labor Exposure=16				-1.7***			
				(0.004)			
Labor Exposure=17				-1.9***			
				(0.004)			
Labor Exposure=18				-2.1***			
				(0.004)			
Labor Exposure=19				-2.2***			
				(0.005)			
Labor Exposure=20				-2.4***			
				(0.005)			

Table 3. Heat Shocks and Entrepreneurship: Firm Creation, Alternative Empirical Specifications

This table presents robustness checks of the treatment effects of heat shocks on the creation of new firms by using alternative empirical specifications. Columns (1) - (2) use a linear regression model and the dependent variable is the number of new firms created at the county-by-NAICS4 industry level. Column (3) - (4) use a linear regression model and the dependent variable is a dummy indicating that at least one new firm is created at the county-by-NAICS4 industry level. Column (5) - (6) use a linear regression model and the dependent variable is the number of new firms created scaled by the number of existing establishments in the same NAICS4 industry and county from the previous year. Column (7) - (8) use the fixed effects Poisson model and the dependent variable is the number of new firms created at the county-by-NAICS4 industry level. The key independent variables is the interaction term *Heat Shocks* $\times$ *Labor Exposure*. *Heat Shocks* is an indicator that equals one if heat shocks defined in Equation (1) occur in the county, and zero otherwise. *Labor Exposure* denotes the NAICS4 industry's exposure to climate risks through the labor channel, defined in Equation (2). Controls include *Labor Exposure*, *Heat Shocks*, the natural logarithm of the county's total population (*Log(Population)*), the natural logarithm of the county's income per capita (*Log(Income per Capita)*), and the county's unemployment rate (*Unemployment Rate*). The sample period is from 1999 to 2019. Numbers in parentheses are standard errors. Standard errors are clustered at the county level. ***, **, and * indicate p-values of 1%, 5%, and 10%, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Linear Regression						Possion	
	No. New Firms		No. New Firms>0		New Firm Creation Rate		No. New Firms	
Heat Shocks	0.213		0.004		0.414***		0.035***	
	(0.206)		(0.003)		(0.093)		(0.010)	
Heat Shocks $\times$ Labor Exposure	-0.021***	-0.031***	-0.001***	-0.001***	-0.046***	-0.044***	-0.004***	-0.004***
	(0.008)	(0.006)	(0.000)	(0.000)	(0.007)	(0.007)	(0.001)	(0.001)
Observations	1,243,296	1,243,296	1,243,296	1,243,296	1,167,011	1,167,011	1,074,282	1,057,350
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State x Year FE	Yes	No	Yes	No	Yes	No	Yes	No
County x NAICS4 FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
NAICS2 x Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County x Year FE	No	Yes	No	Yes	No	Yes	No	Yes
Adjusted R^2	0.773	0.839	0.511	0.524	0.197	0.217	0.868	0.880

Table 4. Heat Shocks and Entrepreneurship: Jobs Created by New Firms

This table presents the treatment effects of heat shocks on the creation of jobs by new firms. The dependent variable is *Job Creation*, the natural logarithm of one plus the number of jobs created by new firms at the county-by-NAICS4 industry level. The key independent variables are *Heat Shocks*, *Labor Exposure*, and the interaction term of the two (*Heat Shocks* $\times$ *Labor Exposure*). *Heat Shocks* is an indicator that equals one if heat shocks defined in Equation (1) occur in the county, and zero otherwise. *Labor Exposure* denotes the NAICS4 industry's exposure to climate risks through the labor channel, defined in Equation (2). Controls include the natural logarithm of the county's total population (*Log(Population)*), the natural logarithm of the county's income per capita (*Log(Income per Capita)*), and the county's unemployment rate (*Unemployment Rate*). The sample period is from 1999 to 2019. Numbers in parentheses are standard errors. Standard errors are clustered at the county level. ***, **, and * indicate p-values of 1%, 5%, and 10%, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Job Creation						
Heat Shocks	-0.009	-0.010	-0.009	0.011			
	(0.007)	(0.007)	(0.007)	(0.009)			
Heat Shocks $\times$ Labor Exposure				-0.002***	-0.002***	-0.002***	-0.002***
				(0.001)	(0.001)	(0.001)	(0.001)
Labor Exposure				-0.004***	-0.004***	-0.011***	
				(0.001)	(0.001)	(0.001)	
Log(Population)	0.890***	0.880***	0.860***	0.893***			
	(0.037)	(0.037)	(0.036)	(0.037)			
Log(Income per Capita)	0.140***	0.143***	0.150***	0.139***			
	(0.022)	(0.021)	(0.021)	(0.022)			
Unemployment Rate	0.003	0.003*	0.003*	0.003			
	(0.002)	(0.002)	(0.002)	(0.002)			
Observations	1,243,296	1,243,274	1,243,177	1,243,296	1,243,296	1,243,274	1,243,177
State x Year FE	Yes	Yes	Yes	Yes	No	No	No
County x NAICS4 FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
NAICS2 x Year FE	Yes	No	No	Yes	Yes	No	No
NAICS3 x Year FE	No	Yes	No	No	No	Yes	No
NAICS4 x Year FE	No	No	Yes	No	No	No	Yes
County x Year FE	No	No	No	No	Yes	Yes	Yes
Adjusted R^2	0.697	0.701	0.705	0.697	0.714	0.718	0.722

Table 5. Heat Shocks and Entrepreneurship: Dynamic Effects

This table presents the dynamic treatment effects of past, present, and future heat shocks on present entrepreneurship at the county-by-NAICS4 industry level. The dependent variable is *Firm Creation*, the natural logarithm of one plus the number of new firms created at the county-by-NAICS4 industry level in year t. The key independent variables are the interaction terms between *Labor Exposure* and indicators of heat shocks for the respective years from $t-3$ to $t+3$. *Heat Shocks (T-3)*, *Heat Shocks (T-2)*, *Heat Shocks (T-1)*, *Heat Shocks (T)*, *Heat Shocks (T+1)*, *Heat Shocks (T+2)*, *Heat Shocks (T+3)* represent heat shocks occurring in years *t-3*, *t-2*, *t-1*, *t*, *t+1*, *t+2*, and *t+3*, respectively. *Labor Exposure* denotes the NAICS4 industry's exposure to climate risks through the labor channel, defined in Equation (2). Controls include heat shocks in each year, *Labor Exposure*, the natural logarithm of the county's total population (*Log(Population)*), the natural logarithm of the county's income per capita (*Log(Income per Capita)*), and the county's unemployment rate (*Unemployment Rate*). The sample period is from 1999 to 2019. Numbers in parentheses are standard errors. Standard errors are clustered at the county level. ***, **, and * indicate p-values of 1%, 5%, and 10%, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
	Firm Creation					
Heat Shocks (T-3) × Labor Exposure	-0.001***				-0.001***	-0.000
	(0.000)				(0.000)	(0.000)
Heat Shocks (T-2) × Labor Exposure		-0.001***			-0.001***	-0.001***
		(0.000)			(0.000)	(0.000)
Heat Shocks (T-1) × Labor Exposure			-0.001***		-0.002***	-0.001***
			(0.000)		(0.000)	(0.000)
Heat Shocks (T) × Labor Exposure				-0.001***	-0.001**	0.000
				(0.000)	(0.000)	(0.000)
Heat Shocks (T+1) × Labor Exposure						-0.000
						(0.000)
Heat Shocks (T+2) × Labor Exposure						0.000
						(0.000)
Heat Shocks (T+3) × Labor Exposure						0.000
						(0.000)
Observations	770,865	882,942	1,026,625	1,243,296	770,865	537,187
Controls	Yes	Yes	Yes	Yes	Yes	Yes
County x NAICS4 FE	Yes	Yes	Yes	Yes	Yes	Yes
NAICS2 x Year FE	Yes	Yes	Yes	Yes	Yes	Yes
County x Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.882	0.881	0.874	0.864	0.882	0.883

Table 6. Heat Shocks and Entrepreneurship: Labor Utilization in Production

This table presents the treatment effects of heat shocks on entrepreneurship conditional on labor utilization in production. The dependent variable is *Firm Creation*, the natural logarithm of one plus the number of new firms created at the county-by-NAICS4 industry level. The key independent variables are *Heat Shocks*, *Heat Shocks* $\times$ *Labor Exposure*, and *Heat Shocks* $\times$ *Labor Exposure* $\times$ *High K/L*. *Heat Shocks* is an indicator that equals one if heat shocks defined in Equation (1) occur in the county, and zero otherwise. *Labor Exposure* denotes the NAICS4 industry's exposure to climate risks through the labor channel, defined in Equation (2). *High K/L* is an indicator that equals one if the NAICS4 industry's capital-labor ratio (*K/L*) is above the sample median, and zero otherwise. The industry-level *K/L* is calculated as the median firm's property, plant, and equipment (PPENT) per employee within each NAICS4 industry. The data on firm-level PPENT and employment is from Compustat. Controls include *Labor Exposure*, *High K/L*, other two-way interactions, the natural logarithm of the county's total population (*Log(Population)*), the natural logarithm of the county's income per capita (*Log(Income per Capita)*), and the county's unemployment rate (*Unemployment Rate*). The sample period is from 1999 to 2019. Numbers in parentheses are standard errors. Standard errors are clustered at the county level. ***, **, and * indicate p-values of 1%, 5%, and 10%, respectively.

	(1)	(2)	(3)	(4)
	Firm Creation			
Heat Shocks	0.010**		0.016***	
	(0.005)		(0.005)	
Heat Shocks $\times$ Labor Exposure	-0.002***	-0.001***	-0.002***	-0.002***
	(0.000)	(0.000)	(0.000)	(0.000)
Heat Shocks $\times$ Labor Exposure $\times$ High K/L			0.002***	0.001**
			(0.001)	(0.001)
Observations	700,141	700,124	700,141	700,124
Controls	Yes	Yes	Yes	Yes
State x Year FE	Yes	No	Yes	No
County x NAICS4 FE	Yes	Yes	Yes	Yes
NAICS2 x Year FE	Yes	Yes	Yes	Yes
County x Year FE	No	Yes	No	Yes
Adjusted R^2	0.846	0.862	0.846	0.862

Table 7. Heat Shocks and Entrepreneurship: Labor Costs of HIPS Compliance

This table presents the treatment effects of heat shocks on entrepreneurship conditional on additional labor costs imposed by HIPS. The dependent variable is *Firm Creation*, the natural logarithm of one plus the number of new firms created at the county-by-NAICS4 industry level. The key independent variables are *Heat Shocks*, *Heat Shocks* $\times$ *Labor Exposure*, and *Heat Shocks* $\times$ *Labor Exposure* $\times$ *HIPS*. *Heat Shocks* is an indicator that equals one if heat shocks defined in Equation (1) occur in the county, and zero otherwise. *Labor Exposure* denotes the NAICS4 industry's exposure to climate risks through the labor channel, defined in Equation (2). *HIPS* is an indicator variable set to one for California starting in 2005 and for Washington starting in 2006, the years the regulation was implemented in each state, and to zero otherwise. Controls include *Labor Exposure*, *HIPS*, other two-way interactions, the natural logarithm of the county's total population (*Log(Population)*), the natural logarithm of the county's income per capita (*Log(Income per Capita)*), and the county's unemployment rate (*Unemployment Rate*). The sample period is from 2001 to 2007 and includes states in the West (Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Wyoming, California, Oregon, Washington) and South regions (Alabama, Arkansas, Delaware, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, West Virginia). Numbers in parentheses are standard errors. Standard errors are clustered at the county level. ***, **, and * indicate p-values of 1%, 5%, and 10%, respectively.

	(1)	(2)
	Firm Creation	
Heat Shocks	0.001	-0.001
	(0.008)	(0.008)
Heat Shocks x Labor Exposure	-0.002***	-0.002***
	(0.001)	(0.001)
Heat Shocks x Labor Exposure x HIPS		-0.006*
		(0.003)
Observations	233,172	233,172
Controls	Yes	Yes
County x NAICS4 FE	Yes	Yes
NAICS2 x Year FE	Yes	Yes
Adjusted R^2	0.848	0.848

Table 8. Heat Shocks and Entrepreneurship: Credit Access

This table presents the treatment effects of heat shocks on credit access using the origination of small business loans in the SBA 7(a) loan program. The dependent variable in Panel A is *Log(Loan Amount)*, the natural logarithm of the loan amount. The dependent variable in Panel B is *Log(Loan Interest Rate)*, the natural logarithm of the loan interest rate. The key independent variables are *Heat Shocks* and the interaction term (*Heat Shocks* × *Labor Exposure*). *Heat Shocks* is an indicator that equals one if heat shocks defined in Equation (1) occur in the county, and zero otherwise. *Labor Exposure* denotes the NAICS4 industry's exposure to climate risks through the labor channel, defined in Equation (2). Controls include *Labor Exposure*, the natural logarithm of the loan amount guaranteed by the SBA (*Log(SBA Loan Amount)*), the natural logarithm of loan maturity in months (*Log(Maturity)*), the natural logarithm of one plus the number of jobs supported by the loan (*Log(1+Jobs Supported)*), an indicator that equals one if the loan is a revolving line of credit and zero if it's a term loan (*Credit Line*), the natural logarithm of the county's total population (*Log(Population)*), the natural logarithm of the county's income per capita (*Log(Income per Capita)*), and the county's unemployment rate (*Unemployment Rate*). Panel B further controls for the natural logarithm of the loan amount (*Log(Loan Amount)*). The sample period is from 1999 to 2019 in Panel A, and from 2008 to 2019 in Panel B. Numbers in parentheses are standard errors. Standard errors are clustered at the county level. ***, **, and * indicate p-values of 1%, 5%, and 10%, respectively.

Panel A. Loan Amount

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Log(Loan Amount)									
Heat Shocks	-0.0038**	-0.0041**	-0.0041**	-0.0031**	0.0047*	0.0014	0.0013	0.0015		
	(0.0020)	(0.0019)	(0.0019)	(0.0015)	(0.0026)	(0.0024)	(0.0024)	(0.0018)		
Heat Shocks × Labor Exposure					-0.0008***	-0.0005***	-0.0005***	-0.0004***	-0.0004***	-0.0003***
					(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Observations	1,138,122	1,138,122	1,138,120	1,137,644	1,138,122	1,138,122	1,138,120	1,137,644	1,127,738	1,127,575
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State x Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Business Type FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
NAICS2 x Year FE	No	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No
SBA Office FE	No	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes
Bank FE	No	No	No	Yes	No	No	No	Yes	Yes	Yes
County x Year FE	No	No	No	No	No	No	No	No	Yes	Yes
NAICS4 x Year FE	No	No	No	No	No	No	No	No	No	Yes
Adjusted R^2	0.988	0.988	0.988	0.990	0.988	0.988	0.988	0.990	0.991	0.991
Treatment Effects										
Labor Exposure=15					-0.008***	-0.006***	-0.006***	-0.005***		
					(0.002)	(0.002)	(0.002)	(0.002)		
Labor Exposure=20					-0.012***	-0.009***	-0.009***	-0.007***		
					(0.002)	(0.002)	(0.002)	(0.002)		

Panel B. Loan Interest Rate

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Log(Loan Interest Rate)									
Heat Shocks	0.0038	0.0039*	0.0039*	0.0036*	-0.0039	-0.0044	-0.0045	-0.0025		
	(0.0023)	(0.0023)	(0.0023)	(0.0022)	(0.0031)	(0.0030)	(0.0030)	(0.0030)		
Heat Shocks × Labor Exposure					0.0007***	0.0008***	0.0008***	0.0006***	0.0006***	0.0005***
					(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Observations	557,370	557,370	557,370	556,958	557,370	557,370	557,370	556,958	551,603	551,482
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State x Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Business Type FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
NAICS2 x Year FE	No	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No
SBA Office FE	No	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes
Bank FE	No	No	No	Yes	No	No	No	Yes	Yes	Yes
County x Year FE	No	No	No	No	No	No	No	No	Yes	Yes
NAICS4 x Year FE	No	No	No	No	No	No	No	No	No	Yes
Adjusted R^2	0.436	0.439	0.439	0.507	0.436	0.439	0.439	0.507	0.513	0.516
Treatment Effects										
Labor Exposure=15					0.007***	0.008***	0.008***	0.006***		
					(0.002)	(0.002)	(0.002)	(0.002)		
Labor Exposure=20					0.011***	0.012***	0.012***	0.009***		
					(0.003)	(0.003)	(0.003)	(0.002)		

Table 9. Heat Shocks and Entrepreneurship: Expected Heat Risks

This table presents the treatment effects of heat shocks on entrepreneurship conditional on expected heat risks. The dependent variable is *Firm Creation*, the natural logarithm of one plus the number of new firms created at the county-by-NAICS4 industry level. The key independent variables are *Heat Shocks* × *Labor Exposure*, *Heat Shocks* × *Labor Exposure* × *High Projection*, and *Heat Shocks* × *Labor Exposure* × *Projection*. *Heat Shocks* is an indicator that equals one if heat shocks defined in Equation (1) occur in the county, and zero otherwise. *Labor Exposure* denotes the NAICS4 industry's exposure to climate risks through the labor channel, defined in Equation (2). *Projection* is the projected differences in extreme heat days as compared to the historical period, scaled to one-tenth. *High Projection* is an indicator that equals one if a county's projected temperature increase is above the sample median, and zero otherwise. Controls include *Labor Exposure*, *High Projection* (column (1)), *Projection* (column (2)), and other two-way interactions. The sample period is from 1999 to 2019. Numbers in parentheses are standard errors. Standard errors are clustered at the county level. ***, **, and * indicate p-values of 1%, 5%, and 10%, respectively.

	(1)	(2)
	Firm Creation	
Heat Shocks × Labor Exposure	-0.001	0.000
	(0.001)	(0.001)
Heat Shocks × Labor Exposure x High Projection	-0.002**	
	(0.001)	
Heat Shocks × Labor Exposure x Projection		-0.001*
		(0.001)
Observations	1,242,894	1,242,894
Controls	Yes	Yes
County x NAICS4 FE	Yes	Yes
NAICS2 x Year FE	Yes	Yes
County x Year FE	Yes	Yes
Adjusted R^2	0.864	0.864

Table 10. Long-term Survival of New Entrant Firms in Heat-Exposed Industries

This table presents the analysis of the long-term survival of new entrant firms following heat shocks. The dependent variable is *Log(Survival Years)* in columns (1) - (3), the natural logarithm of the average number of years that newly created firms survive until 2022, measured at the county-by-NAICS4 industry level. The dependent variable is *Log(6-Year Jobs)* in columns (4) - (6), the natural logarithm of the average number of employment that newly created firms have six years after founding, measured at the county-by-NAICS4 industry level. The key independent variables are *Heat Shocks* and the interaction term (*Heat Shocks* × *Labor Exposure*). *Heat Shocks* is an indicator that equals one if heat shocks defined in Equation (1) occur in the county, and zero otherwise. *Labor Exposure* denotes the NAICS4 industry's exposure to climate risks through the labor channel, defined in Equation (2). Controls include *Labor Exposure*, the natural logarithm of the county's total population (*Log(Population)*), the natural logarithm of the county's income per capita (*Log(Income per Capita)*), and the county's unemployment rate (*Unemployment Rate*). The sample period is from 1999 to 2019. Numbers in parentheses are standard errors. Standard errors are clustered at the county level. ***, **, and * indicate p-values of 1%, 5%, and 10%, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
	Log(Survival Years)			Log(6-Year Jobs)		
Heat Shocks	0.007*	-0.004		0.014**	0.001	
	(0.004)	(0.005)		(0.007)	(0.009)	
Heat Shocks × Labor Exposure		0.001***	0.001***		0.001**	0.002***
		(0.000)	(0.000)		(0.001)	(0.001)
Observations	573,074	573,074	570,136	573,074	573,074	570,136
Controls	Yes	Yes	Yes	Yes	Yes	Yes
State x Year FE	Yes	Yes	No	Yes	Yes	No
County x NAICS4 FE	Yes	Yes	Yes	Yes	Yes	Yes
NAICS2 x Year FE	Yes	Yes	Yes	Yes	Yes	Yes
County x Year FE	No	No	Yes	No	No	Yes
Adjusted R^2	0.376	0.377	0.402	0.360	0.360	0.371
Treatment Effects						
Labor Exposure=15		0.012***			0.020***	
		(0.004)			(0.007)	
Labor Exposure=20		0.018***			0.027***	
		(0.006)			(0.009)	

Table 11. New Establishments Created by Existing Firms

This table presents the treatment effects of heat shocks on the creation of new establishments by existing firms and overall establishment creation. The dependent variable is *Log(1+ New Establishments), Existing* in columns (1) - (3), the natural logarithm of one plus the number of new establishments created by existing firms at the county-by-NAICS4 industry level. The dependent variable is *Log(1+ New Establishments), All* in columns (4) - (6), the natural logarithm of one plus the number of new establishments created by both new and existing firms at the county-by-NAICS4 industry level. The key independent variables are *Heat Shocks* and the interaction term (*Heat Shocks* $\times$ *Labor Exposure*). *Heat Shocks* is an indicator that equals one if heat shocks defined in Equation (1) occur in the county, and zero otherwise. *Labor Exposure* denotes the NAICS4 industry's exposure to climate risks through the labor channel, defined in Equation (2). Controls include *Labor Exposure*, the natural logarithm of the county's total population (*Log(Population)*), the natural logarithm of the county's income per capita (*Log(Income per Capita)*), and the county's unemployment rate (*Unemployment Rate*). The sample period is from 1999 to 2019. Numbers in parentheses are standard errors. Standard errors are clustered at the county level. ***, **, and * indicate p-values of 1%, 5%, and 10%, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
	Establishment Creation, Existing			Establishment Creation, All		
Heat Shocks	-0.001	-0.007***		-0.007*	0.006	
	(0.002)	(0.002)		(0.004)	(0.004)	
Heat Shocks $\times$ Labor Exposure		0.001***	0.001***		-0.001***	-0.002***
		(0.000)	(0.000)		(0.000)	(0.000)
Observations	1,243,296	1,243,296	1,243,296	1,243,296	1,243,296	1,243,296
Controls	Yes	Yes	Yes	Yes	Yes	Yes
State x Year FE	Yes	Yes	No	Yes	Yes	No
County x NAICS4 FE	Yes	Yes	Yes	Yes	Yes	Yes
NAICS2 x Year FE	Yes	Yes	Yes	Yes	Yes	Yes
County x Year FE	No	No	Yes	No	No	Yes
Adjusted R^2	0.663	0.663	0.679	0.849	0.849	0.865
Treatment Effects						
Labor Exposure=15		0.002			-0.014***	
		(0.002)			(0.004)	
Labor Exposure=20		0.005**			-0.021***	
		(0.002)			(0.005)	

Table 12. Macroeconomic Effects of Heat Shocks on Total County Income

This table presents the macroeconomic effects of heat shocks on county-level total personal income. The dependent variable is *Log(Total County Income)*, the natural logarithm of the county-level total personal income from the BEA. The key independent variables are *Heat Shocks* and the interaction term *Heat Shocks* $\times$ *Labor Exposure*. *Heat Shocks* is an indicator that equals one if heat shocks defined in Equation (1) occur in the county, and zero otherwise. *Labor Exposure* denotes a county's exposure to climate risks through the labor channel. The county-level exposure variable is calculated as the employment-weighted average of the industry-level measure of labor exposure defined in Equation (2). The weight is the number of employees working in a NAICS4 industry and a county from QCEW. Controls include *Labor Exposure* and the natural logarithm of the county's total population (*Log(Population)*). NAICS2 and NAICS4 industry codes denote the leading industries at the two-digit and four-digit NAICS code levels in a county, respectively. The sample period is from 1999 to 2019. Numbers in parentheses are standard errors. Standard errors are clustered at the county level. ***, **, and * indicate p-values of 1%, 5%, and 10%, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
	Log(Total County Income)					
Heat Shocks	-0.005***	-0.006***	-0.003*	0.012	0.018**	0.017*
	(0.001)	(0.001)	(0.002)	(0.009)	(0.009)	(0.009)
Heat Shocks $\times$ Labor Exposure				-0.002**	-0.002**	-0.002**
				(0.001)	(0.001)	(0.001)
Observations	62,827	62,814	62,814	62,814	62,814	62,094
Controls	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	No	No	No	No	No
NAICS2 x Year FE	No	Yes	Yes	Yes	Yes	No
NAICS4 x Year FE	No	No	No	No	No	Yes
Region x Year FE	No	No	Yes	No	Yes	Yes
Adjusted R^2	0.998	0.998	0.998	0.998	0.998	0.998
Treatment Effects						
Labor Exposure=15				-0.014***	-0.012***	-0.010**
				(0.004)	(0.004)	(0.004)
Labor Exposure=20				-0.023***	-0.021***	-0.019**
				(0.008)	(0.008)	(0.009)

Internet Appendix to

"How Does Climate Change Reshape U.S. Entrepreneurship? A Labor Channel"

Apr 2025

A Anecdotal Evidence on the Impact of Extreme Heat on Small Businesses

In this section, I present several pieces of anecdotal evidence from various sources that highlight the significant heat-related risks and costs faced by small businesses due to climate change.

[1] Heat Wave 2012 Taking Toll On Small Businesses, Physically And Financially

Janean Chun, *The Huffington Post*, 2012

[2] Record-Breaking Heat Waves Impact Small Businesses and Employees

Editorial, *SmallBizTechnology*, 2023

[3] The Impact of Extreme Heat on Small Businesses and the Economy

Becca Williams, *SmallBizTechnology*, 2023

[4] Weeks of Extreme Heat Strain Small Businesses and Economy

Scott Patterson, Jennifer Hiller, and Alyssa Lukpat, *The Wall Street Journal*, 2023

[5] Working Hours Drop as Temperatures Rise Nationwide

Luke Pardue, *Gusto*, 2023

[6] 'You Feel Death at Your Doorstep but Have No Choice': Extreme Heat Takes Toll on Outdoor Workers

Alicia Wallace, *CNN*, 2024

[7] First There Was the Derecho, Now Heat Is Hurting Texas Small Businesses

Erica Grieder, *Houston Chronicle*, 2024

B Robustness of Results in Table 2 and Excluding Alternative Channels

In this section, I present additional analyses to demonstrate the robustness of the results in Table 2 on heat shocks and firm creation and exclude alternative channels.

B.1 Alternative Definitions of Heat Shocks

In the main analysis, heat shocks are defined as cases where a county has at least 45 summer days with temperatures exceeding the rolling 90^{th} percentile and at least 240 summer days with temperatures above 30°C from $t-3$ to t. In Table B.1, I use alternative thresholds to define heat shocks. In particular, Panel A tests different thresholds for defining relative heat shocks. In columns (1) - (2), heat shocks are redefined as instances where the county has at least 40 summer days with temperatures exceeding the rolling 90^{th} percentile (expected without upward shift in temperature distributions) and at least 240 summer days with temperatures above 30°C from $t-3$ to t. Columns (3) - (4) increase the threshold from 40 to 45 days, while maintaining the requirement of 240 absolute hot days. Columns (5) - (6) increase the threshold to 50 days, and columns (7) - (8) increase the threshold to 60 days. As shown, the coefficient estimate for the interaction term *Heat Shocks* $\times$ *Labor Exposure* remains negative and statistically significant. The economic magnitude increases from -1.7% in column (1) to -2.4% in column (3) as the threshold rises from 40 to 45 days, then stabilizes at around -2%.

Meanwhile, Panel B tests different thresholds for defining absolute heat shocks. In columns (1) - (2), heat shocks are redefined as instances where the county has at least 45 summer days with temperatures exceeding the rolling 90^{th} percentile and at least 120 summer days with temperatures above 30°C from $t-3$ to t. Columns (3) - (4) increase the threshold from 120 to 160 days, while maintaining the requirement of 45 relative hot days. Columns (5) - (6) increase the threshold to 200 days, and columns (7) - (8) increase the threshold to 240 days. The analysis shows that the results hold, with the economic magnitude increasing from -1.3% in column (1) to -2.4% in column (7) as the threshold rises from 120 to 240 days.

In Panel C, I use two continuous measures of absolute and relative heat shocks. *Log(1 + No. Absolute Hot Days)* is the natural logarithm of one plus the number of summer days with temperatures above 30°C from $t-3$ to t. *Log(1 + No. Relative Hot Days)* is the natural logarithm of one plus the number of summer days with temperatures exceeding the rolling 90^{th} percentile from $t-3$ to t. The results remain consistent. For industries with heat exposure at the 75^{th} percentile, there is

approximately a 2.4% gap in new firm creation when moving from median to the 75^{th} percentile in the number of summer days above 30°C from $t-3$ to t.

B.2 Sector Breakdowns and Excluding Alternative Channels

In addition to the labor channel, heat risks could discourage entrepreneurship through a consumer demand channel. That is, extreme heat may push consumers toward indoor activities, reducing visits to stores and restaurants and resulting in lower sales (Addoum et al., 2023). Moreover, heat risks could harm crop yields, thereby deterring the formation of new firms in the agricultural sector. I exclude these alternative channels in Table B.2 and B.3.

Specifically, in Table B.2 column (1), I repeat the analysis in Table 2 by excluding the agriculture, mining, oil, and gas sectors (*NAICS2 11 & 21*). Column (2) further excludes consumer-oriented industries (*NAICS2 44, 45, 61, 62, 71, & 72*). The results hold in both columns and the economic magnitudes are the same as in column (4) of Table 2. This evidences suggests that my findings are not likely driven by lower agricultural outputs or consumer demand. Furthermore, I split the remaining industries into two categories in columns (3) and (4): those engaged in real activities (*NAICS2 23, 31-33, 42, & 48 - 49*) and those in non-consumer-oriented service sectors (*NAICS2 51, 53, 54, 56, & 81*). I find that the negative effect of heat shocks on entrepreneurship exists in both categories. Interestingly, the economic effect is larger in service sectors compared to real activity sectors (*-0.003 in column (4) vs. -0.002 in column (3)*). This finding is consistent with Xiao (2021), which documents that service sectors suffer larger heat-related losses in labor productivity relative to real activity sectors.

To provide further evidence excluding the consumer demand channel, I repeat the analysis by excluding non-tradable industries in columns (1) - (2) of Table B.3, following the classification method in Mian and Sufi (2014). The results hold and the economic magnitudes are the same as in column (4) of Table 2. The results also hold in columns (3) - (6) after further excluding construction industries. These results confirm that reduced consumer demand can not explain the baseline findings.

B.3 Controlling for Other Climate Events

By construction, the labor exposure measure defined in Equation (2) also captures a NAICS4 industry's exposure to climate events other than extreme heat, such as extreme cold and precipitation. To avoid biases introduced by other climate events, I control for each NAICS4 industry's exposure to hot days in non-summer months, cold shocks, and total precipitation in Table B.4 columns (1) - (3). I also control for each NAICS4 industry's exposure to all non-heat-related climate events covered

by SHELDUS in column (4). The significance of the interaction term *Heat Shocks* $\times$ *Labor Exposure* remains and the economic magnitude is the same as that in column (4) of Table 2.

B.4 Alternative Set of Fixed Effects

Table B.5 presents analyses utilizing an alternative set of fixed effects to further address concerns about heterogeneities across industries. In column (1), I include state-by-year-by-NAICS4 industry fixed effects, which allows for comparisons of how the same NAICS4 industry responds to different county-level heat shocks within a state. Columns (2) and (3) further add county and county-by-year fixed effects to account for county-level heterogeneities. The results remain consistent.

B.5 Alternative Sample Constructions

In the main analysis, I focus on the top 20 industries in a county based on total employment, as industries outside the top 20 contribute, on average, only 0.3% to the county's employment. In Table B.6, I reconstruct the sample using alternative methods to demonstrate the robustness of the results. In column (1), I repeat the analysis by including only the top 10 industries in a county. Columns (2), (3), and (4) differ by including the top 15, 25, and 30 industries, respectively. Furthermore, beyond constructing samples based on industry employment ranks, I include industries that account for more than 1% of total employment in a county in column (5), and those contributing more than 3% in column (6). The coefficient estimate for the interaction term *Heat Shocks* $\times$ *Labor Exposure* remains negative and statistically significant across all six columns.

B.6 County-level Population Change

Individuals may relocate from hotter to cooler areas due to concerns about heat-related risks. This migration may have varying impacts on entrepreneurial activity in heat-vulnerable industries within hotter regions.

First, the migration of individuals who have no intention of starting a business reduces the labor supply, thereby reinforcing the labor mechanism documented in this paper. In this case, prospective entrepreneurs face greater difficulty in finding suitable talent for their businesses and may be compelled to offer higher wages, which could further discourage entry decisions. Additionally, the outmigration of these workers may reduce local consumption demand, thereby limiting business opportunities. However, this consumption channel is excluded in Section B.2, which shows that reduced consumer demand can not explain the paper's main findings.

Second, individuals intending to start businesses in heat-vulnerable industries may voluntarily relocate to cooler areas in search of better opportunities. Such relocation may contribute to reduced business formation in heat-vulnerable industries within hotter regions. This argument does not contradict the paper's findings but rather provides a complementary explanation, as the migration of these entrepreneurs is motivated by concerns over heat-related risks and associated costs.

To further assess the sensitivity of the results to population migration, I re-estimate the models using subsamples based on county-level population changes, as shown in Table B.7. Columns (1) and (2) restrict the sample to counties experiencing non-significant population changes (within 1% or 3%). The estimates indicate that the baseline findings hold in these counties. Column (3) focuses on counties with negative population growth rates, a proxy for net out-migration, and the results remain statistically significant. Overall, these findings suggest that the main results of the paper are unlikely to be driven by population migration.

B.7 A Continuous Measure of Labor Exposure

In Table B.8, I conduct robustness checks using a continuous measure of labor exposure instead of a rank-transformed variable, and the results remain consistent.

B.8 Alternative Data on County-level Entrepreneurship

In addition to YTS, I also measure entrepreneurship using business registration data provided by Fazio et al. (2019).[1] A limitation of this data, compared to YTS, is that it is only available at the county level and lacks detailed breakdowns by NAICS4 industries, which does not allow me to match with the labor exposure measure at the NAICS4 industry level. Consequently, my analysis using the data is conducted at the county level.

Table B.9 presents the results. The dependent variable is *Log(1+New Business Registrants)*, the natural logarithm of one plus the quantity of new business registrants within a given population at the county level. The variable *Labor Exposure* denotes a county's exposure to climate risks through the labor channel. The county-level exposure variable is calculated as the employment-weighted average of the industry-level measure of labor exposure defined in Equation (2). The weight is the number of employees working in a NAICS4 industry and a county from QCEW. The NAICS2 and NAICS4 industry codes used in fixed effects denote the leading industries based on total employment at the

[1]The data can be accessed from "THE STARTUP CARTOGRAPHY PROJECT." Refer to Fazio et al. (2019) for more detailed information.

two-digit and four-digit code levels in a county, respectively.

As shown, the analysis yields consistent findings with those in Table 2. In columns (1) - (3), heat shocks negatively affect on county-wide new firm creation. In column (3), the average county's entrepreneurship drops by 1.5% following heat shocks. Importantly, the coefficient estimate of the interaction term *Heat Shocks* $\times$ *Labor Exposure* is also negative and statistically significant, suggesting that the decline in new firm creation is primarily concentrated in counties highly exposed to heat through the labor channel. The economic impacts are even more substantial than those reported in Table 2. For counties at the 75^{th} percentile of heat exposure, entrepreneurial activities drop by 3.7% following heat shocks. Overall, this evidence further supports the findings in the main analysis.

Table B.1. Heat Shocks and Entrepreneurship: Alternative Definitions of Heat Shocks

This table presents robustness checks of the treatment effects of heat shocks on the creation of new firms by using alternative definitions of heat shocks. In Panel A columns (1) - (2), heat shocks are defined as instances where the county has at least 40 summer days with temperatures exceeding the rolling 90^{th} percentile and at least 240 summer days with temperatures above 30°C from $t-3$ to t. Columns (3) - (4) increase the threshold from 40 to 45 days, while maintaining the requirement of 240 absolute hot days. Columns (5) - (6) increase the threshold to 50 days, and columns (7) - (8) increase the threshold to 60 days. In Panel B columns (1) - (2), heat shocks are redefined as instances where the county has at least 45 summer days with temperatures exceeding the rolling 90^{th} percentile and at least 120 summer days with temperatures above 30°C from $t-3$ to t. Columns (3) - (4) increase the threshold from 120 to 160 days, while maintaining the requirement of 45 relative hot days. Columns (5) - (6) increase the threshold to 200 days, and columns (7) - (8) increase the threshold to 240 days. Panel C uses two continuous measures of absolute and relative heat shocks. *Log(1 + No. Absolute Hot Days)* is the natural logarithm of one plus the number of summer days with temperatures above 30°C from $t-3$ to t. *Log(1 + No. Relative Hot Days)* is the natural logarithm of one plus the number of summer days with temperatures exceeding the rolling 90^{th} percentile from $t-3$ to t. In all panels, the dependent variable is *Firm Creation*, the natural logarithm of one plus the number of new firms created at the county-by-NAICS4 industry level. *Labor Exposure* denotes the NAICS4 industry's exposure to climate risks through the labor channel, defined in Equation (2). Controls include *Labor Exposure*, other two-way interaction terms, the natural logarithm of the county's total population (*Log(Population)*), the natural logarithm of the county's income per capita (*Log(Income per Capita)*), and the county's unemployment rate (*Unemployment Rate*). The sample period is from 1999 to 2019. Numbers in parentheses are standard errors. Standard errors are clustered at the county level. ***, **, and * indicate p-values of 1%, 5%, and 10%, respectively.

Panel A. Adjustments in Defining Relative Heat Shocks

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Firm Creation							
	40		45		50		60	
Heat Shocks	0.011**		0.010**		0.009**		0.011**	
	(0.004)		(0.004)		(0.004)		(0.005)	
Heat Shocks × Labor Exposure	-0.001***	-0.002***	-0.002***	-0.002***	-0.001***	-0.002***	-0.002***	-0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	1,243,296	1,243,296	1,243,296	1,243,296	1,243,296	1,243,296	1,243,296	1,243,296
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State x Year FE	Yes	No	Yes	No	Yes	No	Yes	No
County x NAICS4 FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
NAICS2 x Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County x Year FE	No	Yes	No	Yes	No	Yes	No	Yes
Adjusted R^2	0.848	0.864	0.848	0.864	0.848	0.864	0.848	0.864
Treatment Effects								
Labor Exposure=15	-1.0**		-1.6***		-1.4***		-1.2***	
	(0.004)		(0.004)		(0.004)		(0.004)	
Labor Exposure=20	-1.7***		-2.4***		-2.1***		-2.0***	
	(0.005)		(0.005)		(0.005)		(0.005)	

Panel B. Adjustments in Defining Absolute Heat Shocks

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Firm Creation							
	120		160		200		240	
Heat Shocks	0.002		0.002		0.006		0.010**	
	(0.003)		(0.004)		(0.004)		(0.004)	
Heat Shocks × Labor Exposure	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***	-0.002***	-0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	1,243,296	1,243,296	1,243,296	1,243,296	1,243,296	1,243,296	1,243,296	1,243,296
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State x Year FE	Yes	No	Yes	No	Yes	No	Yes	No
County x NAICS4 FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
NAICS2 x Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County x Year FE	No	Yes	No	Yes	No	Yes	No	Yes
Adjusted R^2	0.848	0.864	0.848	0.864	0.848	0.864	0.848	0.864
Treatment Effects								
Labor Exposure=15	-0.9***		-1.0***		-1.0***		-1.6***	
	(0.003)		(0.003)		(0.004)		(0.004)	
Labor Exposure=20	-1.3***		-1.5***		-1.5***		-2.4***	
	(0.003)		(0.004)		(0.004)		(0.005)	

Panel C. Continuous Measures of Absolute and Relative Heat Shocks

	(1)	(2)
	Firm Creation	
Log(1 + No. Absolute Hot Days)	-0.0198*	
	(0.0114)	
Log(1 + No. Relative Hot Days)	-0.0729***	
	(0.0206)	
Log(1 + No. Absolute Hot Days) x Labor Exposure	0.0046***	0.0059***
	(0.0008)	(0.0008)
Log(1 + No. Relative Hot Days) x Labor Exposure	0.0082***	0.0085***
	(0.0013)	(0.0012)
Log(1 + No. Absolute Hot Days) x Log(1 + No. Relative Hot Days) x Labor Exposure	-0.0016***	-0.0017***
	(0.0002)	(0.0002)
Observations	1,243,296	1,243,296
Controls	Yes	No
State x Year FE	Yes	No
County x NAICS4 FE	Yes	Yes
NAICS2 x Year FE	Yes	Yes
County x Year FE	No	Yes
Adjusted R^2	0.848	0.864

Table B.2. Heat Shocks and Entrepreneurship: Sector Breakdowns

This table presents robustness checks of the treatment effects of heat shocks on the creation of new firms by using sector-based subsamples. Columns (1) excludes the agriculture, mining, oil, and gas sectors (*NAICS2 11 & 21*). Column (2) further excludes consumer-oriented industries (*NAICS2 44, 45, 61, 62, 71, & 72*). Columns (3) and (4) further split the remaining industries into two categories: those conducting real activities (*NAICS2 23, 31-33, 42, & 48 - 49*) and those in non-consumer-oriented service sectors (*NAICS2 51, 53, 54, 56, & 81*). The dependent variable is *Firm Creation*, the natural logarithm of one plus the number of new firms created at the county-by-NAICS4 industry level. The key independent variables is the interaction term *Heat Shocks* $\times$ *Labor Exposure*. *Heat Shocks* is an indicator that equals one if heat shocks defined in Equation (1) occur in the county, and zero otherwise. *Labor Exposure* denotes the NAICS4 industry's exposure to climate risks through the labor channel, defined in Equation (2). Controls include *Labor Exposure*, *Heat Shocks*, the natural logarithm of the county's total population (*Log(Population)*), the natural logarithm of the county's income per capita (*Log(Income per Capita)*), and the county's unemployment rate (*Unemployment Rate*). The sample period is from 1999 to 2019. Numbers in parentheses are standard errors. Standard errors are clustered at the county level. ***, **, and * indicate p-values of 1%, 5%, and 10%, respectively.

	(1)	(2)	(3)	(4)
	Firm Creation			
	Industries Excluded		Industries Included	
	Agriculture/Mining/Oil/Gas	Consumer-oriented	Real Activities	Services
Heat Shocks $\times$ Labor Exposure	-0.002***	-0.002***	-0.002***	-0.003***
	(0.000)	(0.000)	(0.001)	(0.001)
Observations	1,216,466	510,132	343,262	147,887
Controls	Yes	Yes	Yes	Yes
County x NAICS4 FE	Yes	Yes	Yes	Yes
NAICS2 x Year FE	Yes	Yes	Yes	Yes
County x Year FE	Yes	Yes	Yes	Yes
Adjusted R^2	0.867	0.896	0.852	0.913

Table B.3. Heat Shocks and Entrepreneurship: Excluding Non-Tradable and Construction Industries

This table presents robustness checks of the treatment effects of heat shocks on the creation of new firms by excluding non-tradable and construction industries. Columns (1) and (2) exclude non-tradable industries. Columns (3) and (4) exclude construction industries. Columns (5) and (6) exclude both non-tradable and construction industries. The classification method of tradable and non-tradable industries is from Mian and Sufi (2014). The dependent variable is *Firm Creation*, the natural logarithm of one plus the number of new firms created at the county-by-NAICS4 industry level. The key independent variables is the interaction term *Heat Shocks* × *Labor Exposure*. *Heat Shocks* is an indicator that equals one if heat shocks defined in Equation (1) occur in the county, and zero otherwise. *Labor Exposure* denotes the NAICS4 industry's exposure to climate risks through the labor channel, defined in Equation (2). Controls include *Labor Exposure*, *Heat Shocks*, the natural logarithm of the county's total population (*Log(Population)*), the natural logarithm of the county's income per capita (*Log(Income per Capita)*), and the county's unemployment rate (*Unemployment Rate*). The sample period is from 1999 to 2019. Numbers in parentheses are standard errors. Standard errors are clustered at the county level. ***, **, and * indicate p-values of 1%, 5%, and 10%, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
	Firm Creation					
	Non-tradable Industries		Construction Industries		Non-tradable and Construction Industries	
Heat Shocks × Labor Exposure	-0.002***	-0.002***	-0.002***	-0.002***	-0.002***	-0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	950,620	950,611	860,402	860,386	756,204	756,186
Controls	Yes	Yes	Yes	Yes	Yes	Yes
State x Year FE	Yes	No	Yes	No	Yes	No
County x NAICS4 FE	Yes	Yes	Yes	Yes	Yes	Yes
NAICS2 x Year FE	Yes	Yes	Yes	Yes	Yes	Yes
County x Year FE	No	Yes	No	Yes	No	Yes
Adjusted R^2	0.853	0.869	0.843	0.858	0.851	0.865

Table B.4. Heat Shocks and Entrepreneurship: Controlling for Other Climate Events

This table presents robustness checks of the treatment effects of heat shocks on the creation of new firms by controlling for exposures to other climate events. Columns (1) controls for the number of hot days in non-summer months. Column (2) further controls for cold shocks. Column (3) further controls for total precipitation. Column (5) controls for all non-heat-related climate events covered by SHELDUS. The dependent variable is *Firm Creation*, the natural logarithm of one plus the number of new firms created at the county-by-NAICS4 industry level. The key independent variables are the interaction terms. *Heat Shocks* is an indicator that equals one if heat shocks defined in Equation (1) occur in the county, and zero otherwise. *Labor Exposure* denotes the NAICS4 industry's exposure to climate risks through the labor channel, defined in Equation (2). Controls include *Labor Exposure*, *Heat Shocks*, *Log(1+Non-Summer Hot Days)*, *Cold Shocks*, *Log(Precipitation)*, *Non-Heat Climate Events*, the natural logarithm of the county's total population (*Log(Population)*), the natural logarithm of the county's income per capita (*Log(Income per Capita)*), and the county's unemployment rate (*Unemployment Rate*). The sample period is from 1999 to 2019. Numbers in parentheses are standard errors. Standard errors are clustered at the county level. ***, **, and * indicate p-values of 1%, 5%, and 10%, respectively.

	(1)	(2)	(3)	(4)
	Firm Creation			
Heat Shocks x Labor Exposure	-0.002***	-0.002***	-0.002***	-0.002***
	(0.000)	(0.000)	(0.000)	(0.000)
Log(1+Non-Summer Hot Days) x Labor Exposure	-0.000	-0.000	-0.000	
	(0.000)	(0.000)	(0.000)	
Cold Shocks x Labor Exposure		-0.001***	-0.001***	
		(0.000)	(0.000)	
Log(Precipitation) x Labor Exposure			-0.001*	
			(0.000)	
Non-Heat Climate Events x Labor Exposure				0.001
				(0.096)
Observations	1,243,296	1,243,296	1,243,296	1,243,296
County x NAICS4 FE	Yes	Yes	Yes	Yes
NAICS2 x Year FE	Yes	Yes	Yes	Yes
County x Year FE	Yes	Yes	Yes	Yes
Adjusted R^2	0.864	0.864	0.864	0.864

Table B.5. Heat Shocks and Entrepreneurship: Alternative Set of Fixed Effects

This table presents robustness checks of the treatment effects of heat shocks on the creation of new firms by using alternative set of fixed effects. The dependent variable is *Firm Creation*, the natural logarithm of one plus the number of new firms created at the county-by-NAICS4 industry level. The key independent variables are the interaction terms. *Heat Shocks* is an indicator that equals one if heat shocks defined in Equation (1) occur in the county, and zero otherwise. *Labor Exposure* denotes the NAICS4 industry's exposure to climate risks through the labor channel, defined in Equation (2). Controls include *Labor Exposure*, *Heat Shocks*, the natural logarithm of the county's total population (*Log(Population)*), the natural logarithm of the county's income per capita (*Log(Income per Capita)*), and the county's unemployment rate (*Unemployment Rate*). The sample period is from 1999 to 2019. Numbers in parentheses are standard errors. Standard errors are clustered at the county level. ***, **, and * indicate p-values of 1%, 5%, and 10%, respectively.

	(1)	(2)	(3)
	Firm Creation		
Heat Shocks x Labor Exposure	-0.002***	-0.002***	-0.001***
	(0.001)	(0.001)	(0.001)
Observations	1,223,246	1,223,246	1,223,246
Controls	Yes	Yes	Yes
State x Year x NAICS4 FE	Yes	Yes	Yes
County FE	No	Yes	No
County x Year FE	No	No	Yes
Adjusted R^2	0.552	0.789	0.804

Table B.6. Heat Shocks and Entrepreneurship: Alternative Sample Constructions

This table presents robustness checks of the treatment effects of heat shocks on the creation of new firms by using alternative methods of sample construction. Columns (1), (2), (3), and (4) reconstruct the sample by including the top 10, 15, 25, and 30 industries in a county, respectively. The sample in column (5) includes industries that account for more than 1% of total employment in a county, while in column (6) includes those contributing more than 3% of total employment. The dependent variable is *Firm Creation*, the natural logarithm of one plus the number of new firms created at the county-by-NAICS4 industry level. The key independent variables is the interaction term *Heat Shocks* $\times$ *Labor Exposure*. *Heat Shocks* is an indicator that equals one if heat shocks defined in Equation (1) occur in the county, and zero otherwise. *Labor Exposure* denotes the NAICS4 industry's exposure to climate risks through the labor channel, defined in Equation (2). Controls include *Labor Exposure*, *Heat Shocks*, the natural logarithm of the county's total population (*Log(Population)*), the natural logarithm of the county's income per capita (*Log(Income per Capita)*), and the county's unemployment rate (*Unemployment Rate*). The sample period is from 1999 to 2019. Numbers in parentheses are standard errors. Standard errors are clustered at the county level. ***, **, and * indicate p-values of 1%, 5%, and 10%, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
	Firm Creation					
	Top Industries				Employment Share	
	Top 10	Top 15	Top 25	Top 30	1%	3%
Heat Shocks x Labor Exposure	-0.002***	-0.002***	-0.001***	-0.001***	-0.002***	-0.001*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	618,330	929,978	1,557,442	1,870,875	1,413,161	397,799
Controls	Yes	Yes	Yes	Yes	Yes	Yes
County x NAICS4 FE	Yes	Yes	Yes	Yes	Yes	Yes
NAICS2 x Year FE	Yes	Yes	Yes	Yes	Yes	Yes
County x Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.877	0.870	0.858	0.852	0.865	0.869

Table B.7. Heat Shocks and Entrepreneurship: County-level Population Change

This table presents robustness checks of the treatment effects of heat shocks on the creation of new firms conditional county-level population changes. Column (1) restricts the sample to counties with population growth rates between -3% and 3%. Column (2) restricts the sample to counties with population growth rates between -1% and 1%. Column (3) restricts the sample to counties with negative population growth rates. The dependent variable is *Firm Creation*, the natural logarithm of one plus the number of new firms created at the county-by-NAICS4 industry level. The key independent variables is the interaction term *Heat Shocks* $\times$ *Labor Exposure*. *Heat Shocks* is an indicator that equals one if heat shocks defined in Equation (1) occur in the county, and zero otherwise. *Labor Exposure* denotes the NAICS4 industry's exposure to climate risks through the labor channel, defined in Equation (2). Controls include *Labor Exposure*, *Heat Shocks*, the natural logarithm of the county's total population (*Log(Population)*), the natural logarithm of the county's income per capita (*Log(Income per Capita)*), and the county's unemployment rate (*Unemployment Rate*). The sample period is from 1999 to 2019. Numbers in parentheses are standard errors. Standard errors are clustered at the county level. ***, **, and * indicate p-values of 1%, 5%, and 10%, respectively.

	(1)	(2)	(3)
	Firm Creation		
	-0.03 $\leq$ Population Growth $\leq$ 0.03	-0.01 $\leq$ Population Growth $\leq$ 0.01	Population Growth $<$ 0
Heat Shocks x Labor Exposure	-0.002***	-0.002***	-0.001***
	(0.000)	(0.000)	(0.000)
Observations	1,180,431	768,291	511,677
Controls	Yes	Yes	Yes
County x NAICS4 FE	Yes	Yes	Yes
NAICS2 x Year FE	Yes	Yes	Yes
County x Year FE	Yes	Yes	Yes
Adjusted R^2	0.863	0.853	0.777

Table B.8. Heat Shocks and Entrepreneurship: A Continuous Measure of Labor Exposure

This table presents robustness checks of the treatment effects of heat shocks on the creation of new firms by using a continuous measure of labor exposure. The dependent variable is *Firm Creation*, the natural logarithm of one plus the number of new firms created at the county-by-NAICS4 industry level. The key independent variable is the interaction term *Heat Shocks* $\times$ *Labor Exposure*. *Heat Shocks* is an indicator that equals one if heat shocks defined in Equation (1) occur in the county, and zero otherwise. *Labor Exposure* denotes the NAICS4 industry's exposure to climate risks through the labor channel, defined in Equation (2), but without the rank transformation. Controls include *Labor Exposure*, *Heat Shocks*, the natural logarithm of the county's total population (*Log(Population)*), the natural logarithm of the county's income per capita (*Log(Income per Capita)*), and the county's unemployment rate (*Unemployment Rate*). The sample period is from 1999 to 2019. Numbers in parentheses are standard errors. Standard errors are clustered at the county level. ***, **, and * indicate p-values of 1%, 5%, and 10%, respectively.

	(1)	(2)	(3)	(4)
	Firm Creation			
Heat Shocks x Labor Exposure	-0.015***	-0.018***	-0.013***	-0.012***
	(0.002)	(0.002)	(0.002)	(0.002)
Observations	1,243,296	1,243,296	1,243,274	1,243,177
Controls	Yes	Yes	Yes	Yes
State x Year FE	Yes	No	No	No
County x NAICS4 FE	Yes	Yes	Yes	Yes
NAICS2 x Year FE	Yes	Yes	No	No
NAICS3 x Year FE	No	No	Yes	No
NAICS4 x Year FE	No	No	No	Yes
County x Year FE	No	Yes	Yes	Yes
Adjusted R^2	0.848	0.864	0.869	0.877

Table B.9. Heat Shocks and Entrepreneurship: New Business Registrants

This table presents robustness checks of the treatment effects of heat shocks on the creation of new firms by using alternative data on entrepreneurship, provided by Fazio et al. (2019). The dependent variable is *Log(1+New Business Formation Rate)*, the natural logarithm of one plus the quantity of new business registrants within a given population at the county level. The key independent variables are *Heat Shocks*, *Labor Exposure*, and the interaction term of the two (*Heat Shocks* $\times$ *Labor Exposure*). *Heat Shocks* is an indicator that equals one if heat shocks defined in Equation (1) occur in the county, and zero otherwise. *Labor Exposure* denotes a county's exposure to climate risks through the labor channel. The county-level exposure variable is calculated as the employment-weighted average of the industry-level measure of labor exposure defined in Equation (2). The weight is the number of employees working in a NAICS4 industry and a county from QCEW. NAICS2 and NAICS4 industry codes denote the leading industries at the two-digit and four-digit NAICS code levels in a county, respectively. The sample period is from 1999 to 2016. Numbers in parentheses are standard errors. Standard errors are clustered at the county level. ***, **, and * indicate p-values of 1%, 5%, and 10%, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
	Log(1+New Business Formation Rate)					
Heat Shocks	-0.083***	-0.012**	-0.015**	0.153*	0.032	0.037
	(0.031)	(0.006)	(0.006)	(0.083)	(0.026)	(0.028)
Heat Shocks $\times$ Labor Exposure				-0.023***	-0.004*	-0.005*
				(0.007)	(0.002)	(0.003)
Labor Exposure				0.021***	0.006***	0.008***
				(0.006)	(0.002)	(0.002)
Observations	53,612	52,575	51,933	52,594	52,575	51,933
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Region x Year FE	Yes	Yes	Yes	Yes	Yes	Yes
County FE	No	Yes	Yes	No	Yes	Yes
NAICS2 x Year FE	No	Yes	No	No	Yes	No
NAICS4 x Year FE	No	No	Yes	No	No	Yes
Adjusted R^2	0.754	0.970	0.970	0.748	0.970	0.970
Treatment Effects						
Labor Exposure=15				-0.195***	-0.032**	-0.037***
				(0.043)	(0.013)	(0.014)
Labor Exposure=20				-0.310***	-0.053**	-0.062**
				(0.072)	(0.025)	(0.026)

C Supplementary Figures, Tables, and Analyses

In this section, I provide additional figures, tables, and analyses to complement and extend the findings presented in the main part of this paper.

C.1 Treatment Effects of Heat Shocks on Labor Productivity: Xiao (2021)

Figure C.1, drawn from Xiao (2021), presents the treatment effects of heat shocks[2] on firm-level labor productivity (sales per employee) across labor exposure categories (*Labor Exposure = 1 to 20*). The figure demonstrates that extreme heat significantly reduces firm-level labor productivity, but only among firms employing a large number of heat-exposed workers in production. Specifically, labor productivity for firms at the 75^{th} percentile of heat exposure drops by 1.9% following heat shocks, while firms with the highest exposure experience a decline of 3%. Given that labor costs are sticky, this figure supports the conjecture that extreme heat increases labor costs per unit of output, thereby discouraging entrepreneurship when heat risks materialize.

C.2 Summary Statistics: Table 8

Table C.1 presents summary statistics for variables used in empirical analysis in Table 8. The loan data is from the SBA 7(a) loan program.

C.3 Heat Shocks and Credit Access

Figure C.2 (A) and (B) the treatment effects of heat shocks on small business loan amount and interest rate by labor exposure category (1 to 20).

C.4 Heat Shocks and Entrepreneurship: Labor Skill

Table C.2 examines the treatment effects of heat shocks on entrepreneurship conditional on the labor skill required for business operations. *High Labor Skill* is an indicator that equals one if the NAICS4 industry's labor skill is among the top quartile, and zero otherwise. Similar to the labor exposure measure, the industry-level labor skill is calculated as the employment-weighted average of occupational-level skill requirements, based on job zones from the O*NET program. The result shows that the heat-induced decline in entrepreneurship through the labor channel is more pronounced in industries requiring more skilled workers. The finding is consistent with Xiao (2021) and

[2] Annual summer heat shocks are defined as summer months with at least 45 days where temperatures exceed the rolling 90th percentile.

Table 6 in suggesting that physical capital assets are less effective at replacing skilled workers than non-skilled ones, thereby making it more challenging to mitigate heat-induced labor productivity losses. As a result, prospective entrepreneurs are more concerned with entering industries requiring skilled workers because they cannot rely on automation to lower heat-induced labor costs.

C.5 Macroeconomic Effects of Heat Shocks on Total County Income

Figure C.3 presents the macroeconomic effects of heat shocks on county-level total personal income by labor exposure category (1 to 20).

Figure C.1. Treatment Effects of Heat Shocks on Firm-level Labor Productivity: Xiao (2021)

This figure presents the treatment effects of heat shocks on firm-level labor productivity across labor exposure categories (*Labor Exposure = 1 to 20*), as drawn from Xiao (2021).

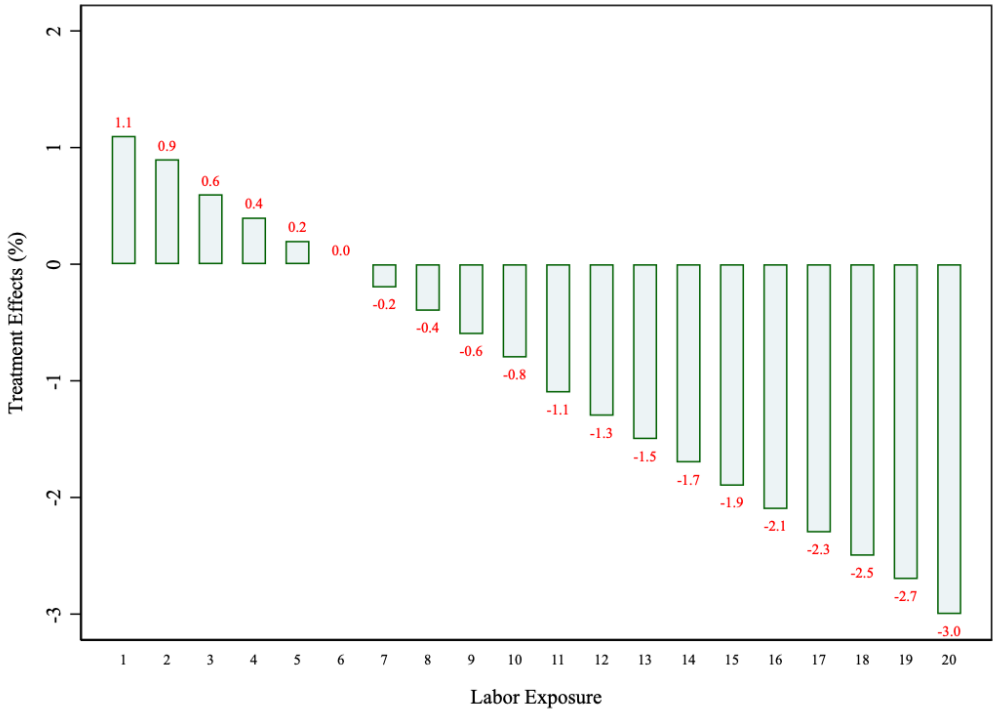
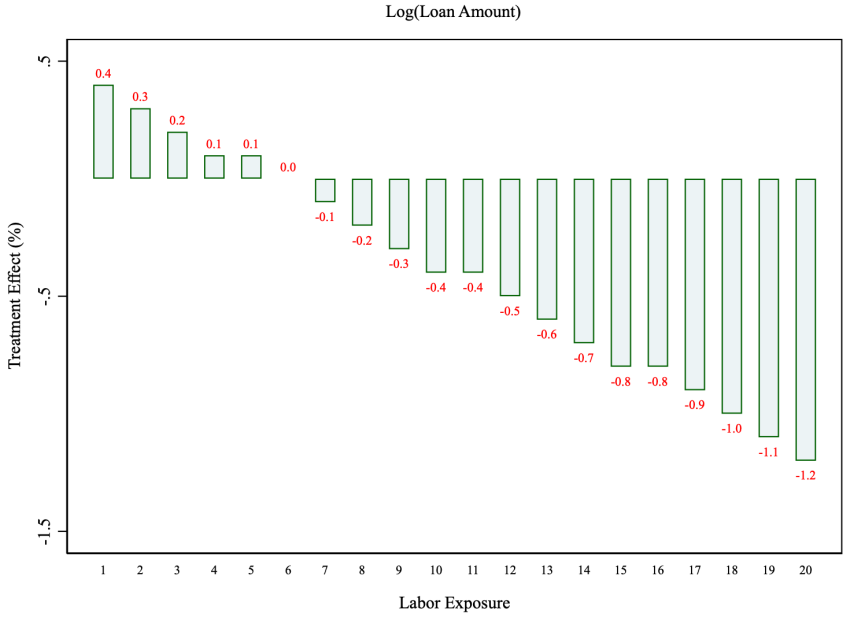


Figure C.2. Heat Shocks and Credit Access

Figure (A) presents the treatment effects of heat shocks on small business loan amount by labor exposure category (1 to 20), based on the estimation in column (5) of Table 8 Panel A. Figure (B) presents the treatment effects of heat shocks on small business loan interest rate by labor exposure category (1 to 20), based on the estimation in column (5) of Table 8 Panel B.

(A) Loan Amount



(B) Loan Interest Rate

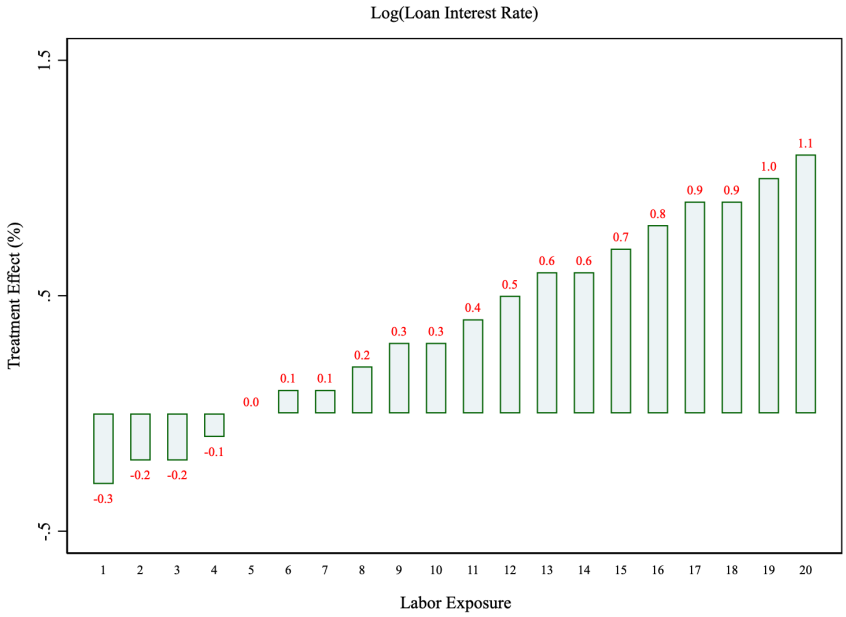


Figure C.3. Macroeconomic Effects of Heat Shocks on Total County Income

This figure presents the macroeconomic effects of heat shocks on county-level total personal income by labor exposure category (1 to 20), based on the estimation in column (4) of Table 12.

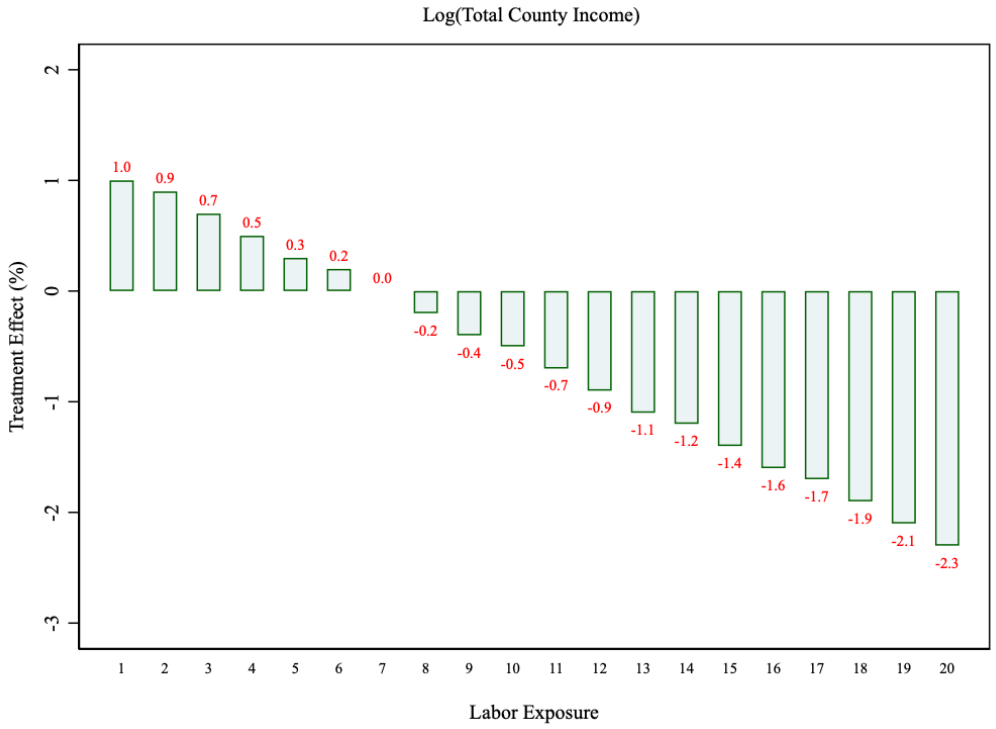


Table C.1. Summary Statistics: Table 8

This table presents summary statistics for variables used in empirical analyses in Table 8. *Log(Loan Amount)* is the natural logarithm of the loan amount. *Log(Loan Interest Rate)* is the natural logarithm of the loan interest rate. *Heat Shocks* is an indicator that equals one if heat shocks defined in Equation (1) occur in the county, and zero otherwise. *Labor Exposure* denotes the NAICS4 industry's exposure to climate risks through the labor channel, defined in Equation (2). *Log(SBA Loan Amount)* is the natural logarithm of the loan amount guaranteed by the SBA. *Log(Maturity)* is the natural logarithm of loan maturity in months. *Log(1+Jobs Supported)* is the natural logarithm of one plus the number of jobs supported by the loan. *Credit Line* is an indicator that equals one if the loan is a revolving line of credit and zero it it's a term loan. *Log(Population)* is the natural logarithm of the county's total population. *Log(Income per Capita)* is the natural logarithm of the county's income per capita. *Unemployment Rate* is the county's unemployment rate. The sample period is from 1999 to 2019, except that *Log(Loan Interest Rate)* is available for 2008 - 2019.

	N	**Mean**	**P25**	**Median**	**P75**	**SD**
Log(Loan Amount)	1,138,184	11.433	10.309	11.415	12.506	1.475
Log(Interest Rate)	557,488	1.853	1.705	1.792	2.015	0.222
Heat Shocks	1,138,184	0.103	0	0	0	0.304
Labor Exposure	1,138,184	10.483	5	10	17	6.433
Log(SBA Loan Amount)	1,138,184	10.961	9.616	10.82	12.142	1.606
Maturity	1,138,184	110.088	63	84	120	75.167
Log(1+Jobs Supported)	1,138,184	1.624	0.693	1.609	2.398	1.114
Credit Line	1,138,184	0.313	0	0	1	0.464
Log(Population)	1,138,184	13.117	12.115	13.285	14.124	1.518
Log(Income per Capita)	1,138,184	10.637	10.431	10.615	10.821	0.31
Unemployment Rate	1,138,184	5.525	4	5	7	2.168

Table C.2. Heat Shocks and Entrepreneurship: Labor Skill

This table presents the treatment effects of heat shocks on entrepreneurship conditional on the labor skill required for business operations. The dependent variable is *Firm Creation*, the natural logarithm of one plus the number of new firms created at the county-by-NAICS4 industry level. The key independent variables are *Heat Shocks*, *Heat Shocks* $\times$ *Labor Exposure*, and *Heat Shocks* $\times$ *Labor Exposure* $\times$ *High Labor Skill*. *Heat Shocks* is an indicator that equals one if heat shocks defined in Equation (1) occur in the county, and zero otherwise. *Labor Exposure* denotes the NAICS4 industry's exposure to climate risks through the labor channel, defined in Equation (2). *High Labor Skill* is an indicator that equals one if the NAICS4 industry's labor skill is among the top quartile, and zero otherwise. Similar to the labor exposure measure, the industry-level labor skill is calculated as the employment-weighted average of occupational-level skill requirements, based on job zones from the O*NET program. Controls include *Labor Exposure*, *High Labor Skill*, other two-way interactions, the natural logarithm of the county's total population (*Log(Population)*), the natural logarithm of the county's income per capita (*Log(Income per Capita)*), and the county's unemployment rate (*Unemployment Rate*). The sample period is from 1999 to 2019. Numbers in parentheses are standard errors. Standard errors are clustered at the county level. ***, **, and * indicate p-values of 1%, 5%, and 10%, respectively.

	Firm Creation	
Heat Shocks	-0.002	
	(0.005)	
Heat Shocks x Labor Exposure	-0.001***	-0.001***
	(0.000)	(0.000)
Heat Shocks x Labor Exposure x High Labor Skill	-0.002***	-0.002***
	(0.001)	(0.001)
Observations	1,243,296	1,243,296
Controls	Yes	Yes
State x Year FE	Yes	No
County x NAICS4 FE	Yes	Yes
NAICS2 x Year FE	Yes	Yes
County x Year FE	No	Yes
Adjusted R^2	0.848	0.864

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