Gender, Weather Shocks, and Labor Supply Decisions: Evidence from Urban Colombia

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Abstract

Extreme heat affects labor supply through increased absenteeism, lower productivity, and changes in work-time allocation. However, there is limited evidence on the role of gender as a moderating factor, even though men are more represented in outdoor and weather-exposed occupations worldwide. This paper uses microdata from urban workers in Colombia to estimate the gender-differentiated effects of extreme temperatures on short-term labor supply and time use. I find that one additional day with maximum temperatures above 33°C reduces weekly working hours for women by about 20 minutes, with no significant effect for men. In addition, women spend more time on unpaid domestic work during hot days, while men's time allocation remains largely unchanged, suggesting that employed women reallocate time from paid to unpaid activities in response to heat. I shed light on the factors underlying these differences by examining both the direct effects of occupational exposure and sector-specific shocks, as well as the indirect effects of increased caregiving demands during hot days.

Keywords: Gender, climate change, daily temperatures, workers, Colombia

JEL Classification: D13 J16 Q54

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1 Introduction

Heatwaves, cold days, and floods are extreme weather events that are becoming increasingly frequent, severe, and harmful as global warming accelerates at an unprecedented rate (IPCC 2023). These short-term, unexpected climatic phenomena are associated with negative economic impacts, including losses in economic output, agricultural productivity, and labor productivity (Dell, Jones, and Olken 2014). By 2030, more than 2% of total working hours worldwide are projected to be lost annually, either because it is too hot to work or because workers must slow down. These productivity losses could amount to 2,400 billion USD, with disproportionately pronounced effects in lower- and middle-income countries (ILO 2019). Even within countries, the impact can be especially high in cities or urban areas due to the absorption of solar heat by buildings and roads (IPCC 2023).

The effects of climate change on human societies and the ability to mitigate and adapt to them are moderated by social factors, including gender (World Health Organization 2014). Climate change is therefore not gender neutral, as vulnerability to extreme weather events such as heat is influenced by both physiological factors, such as age and health status, and exposure factors, such as occupation and socio-economic conditions, which differ between women and men.

In this paper, I estimate the short-term relationship between extreme temperatures and the labor supply of urban workers, focusing on gender differences. I combine high-resolution daily temperature data from ERA5 with detailed labor market and time-use data from the Gran Encuesta Integrada de Hogares (GEIH) for 2008–2019 in 23 largest cities in Colombia. The data allow me to examine how employed women and men adjust their weekly working hours in response to extreme heat, controlling for weather conditions, demographic and labor market characteristics, and a rich set of fixed effects to account for unobserved factors.

I find statistically significant evidence of gender-differentiated effects of extremely high temperatures on hours worked, but not in response to cooler-than-usual temperatures. Using alternative temperature bins and functional forms, I show that, at the aggregate level, employed men do not adjust their working hours, whereas employed women do. Specifically, an additional day with a maximum temperature above 33°C is associated with an average reduction of 0.33 hours worked in the same week for employed women, with no corresponding effect observed for men. On the other hand, when considering time spent on unpaid domestic work, such as the sum of household chores, childcare, and eldercare, I also find empirical evidence showing that women, and not men, increase time spent on these nonmarket activities on hot days (+27°C). Overall, this suggests that, at the aggregate level, only employed women reallocate time from paid to unpaid work during heat waves in urban Colombia

To investigate potential explanations behind these gendered results, I analyze heterogeneous effects across job market characteristics that differ between women and men, such as work location, economic sector, and job flexibility. I find that differential exposure across gender does not drive the main results. Gender gaps in paid hours are relevant among workers in gender-balanced industries, such as manufacturing and professional services, but at different temperature bins. Most importantly, I observe that both women and men employed in the public sector reduce their labor supply, with the largest coefficients observed (0.6 hours per week with temperatures above 33°C), suggesting that sector-specific workplace policies, such as early office shutdowns, health and safety measures, or early school dismissals, may be relevant in this context. However, is it not the only channel or explanation because those women employed in the private sector are also decreasing their labor supply.

I also examine whether the presence of young children under 14 in the household is relevant for women, in a context where unpaid care work is unequally distributed by gender and where vulnerable dependents, such as children and the elderly, face higher health risks during heatwaves. Under moderately high temperatures (27–33°C), the gender-differential effects are driven by employed women living with children, suggesting that caregiving responsibilities contribute to the observed differences. However, at very high temperatures (33°C and above), women without children also increase, more than men, their time spent on unpaid work mainly on household chores, suggesting that they might be more at home because heat directly affects their labor supply and daily activities.

To my knowledge, this is the first paper providing empirical evidence of gender differential effects on labor supply and time use under heatwaves in a urban setting. Therefore, I contribute to the papers analyzing the effects of temperature extremes on labor supply using time use and labor force surveys in high-income (Graff Zivin and Neidell 2014,Garg, Gibson, and Sun 2019, Rode et al. 2022 and middle and low-income countries (Schwarz 2018; Garg, Gibson, and Sun 2019; Minoru 2023). Most of these papers show an inverted-U-shaped relationship between labor supply and daily temperatures in high-risk, weather-exposed industries (i.e., agriculture, mining, construction, and manufacturing), where extreme hot and cold days reduce labor supply. However, with the exception of Garg, Gibson, and Sun 2019, none consider gender-differential effects in the developing world. My work is closely related to this study but differs in context, as they find that female agricultural workers in China reduce their working hours more than men, without reallocating time to other non-market activities.

My result is consistent when the inverse U-shape pattern for all workers, but I do not find that the high-risk workers drive this result. Furthermore, I am pioneering in the use of microdata from Colombia to examine these effects in a tropical country, where temperature variations are relatively small, but climate change has already increased and is expected to further rise the number of extremely hot days.

I also contribute to the growing literature analyzing the gendered effects of climate change (Afridi, Mahajan, and Sangwan 2021; Fruttero et al. 2024; Hidalgo-Arestegui et al. 2024) by examining how short-term weather shocks amplify gender differences in paid and unpaid work in an urban setting. Most existing studies have focused on the agricultural context, where extreme weather, such as drought, generates negative income shocks for farm households due to reductions in agricultural productivity, and show that men have better outside options than women in India when seeking jobs off the farm over longer time spans (typically monthly or seasonal shocks). However, little is known about how these mechanisms operate in urban contexts, where short-term effects are more closely linked to health and productivity, and where the burden of caregiving disproportionately falls on women, particularly during periods of extreme heat, thereby requiring immediate reallocation of time across market and non-market activities.

Finally, I contribute to research analyzing the non-health impacts of environmental shocks in developing countries (Aragón, Miranda, and Oliva 2017; Hanna and Oliva,2015; Hoffmann and Rud 2024). Most of them have focused on air pollution, while I focus on weather shocks, and they show that high levels of PM2.5 affect the hours worked of individuals in Mexico (Hoffmann and Rud 2024) and Peru (Aragón, Miranda, and Oliva 2017).In particular, this last paper shows that under moderate levels of air pollution, workers in households with susceptible dependents such as young children and elderly adults reduce their labor supply, suggesting caregiving as a possible mechanism. I also find empirical evidence consistent with this channel.

The remainder of the paper is organized as follows. Section 2 presents background on the context and describes the data sets used in the analysis. Section 3 outlines the empirical framework and the hypotheses regarding the parameters. Section 4 presents the baseline results. Sector 5 presents the heterogeneous effects and potential mechanisms, and Section 6 concludes.

2 Context and Data

2.1 Context

Colombia is a tropical country with diverse topography, located in the northwest corner of South America along the equator. Climate change is expected to bring both higher temperatures and colder extremes, depending on the region, as well as more frequent extreme weather events such as heat waves, droughts, and floods (World Bank 2023).

This regional variation is particularly relevant to the cities I am considering in the empirical analysis, which fall into two distinct climatic zones: coastal cities and those located in the Andes Mountains. I am excluding cities in the Amazon jungle. These two regions experience different weather patterns, primarily influenced by their proximity to the sea and elevation. Coastal cities lie below 1,000 meters above sea level and have a semi-arid climate, characterized by warm temperatures and low precipitation. In contrast, high-altitude cities, situated above 1,000 meters, tend to have cooler, wetter climates with seasonal rainfall occurring in spring and early summer.

Historical temperature data for the entire country show that the number of days with maximum temperatures above 30°C has increased over the past few decades. Figure A1 presents expert climate projections (CMIP6) across different scenarios, indicating that this upward trend in hot days will continue due to climate change. [1]

Therefore, climate-controlled environments play a vital role in reducing current and future human exposure to extreme temperatures during heat waves. In tropical countries such as Colombia, air conditioners and fans are commonly used in regions with consistently hot weather. Even though 97.7% of Colombian households have access to electricity, air conditioning penetration is low at 4.7 % nationwide and approximately 15% in coastal regions. In contrast, access to fans is more widespread, with 37.7% nationwide and 89.5% in municipalities near sea level (Encuesta de Calidad de Vida, 2018). Nevertheless, there is limited information or official statistics on air conditioning or heating technology adoption at the industrial level or in office workplaces.

[1] The sixth phase of the Coupled Model Intercomparison Project (CMIP6) data forms the basis for the Intergovernmental Panel on Climate Change Assessment Reports and uses a 0.25º x 0.25º (25 km x 25 km) resolution.

2.1.1 Gender gaps

Gender gaps in both the labor market and non-market activities are significant in Colombia. On one hand, women's labor force participation is lower than men's, with an employment gap of approximately 26 percentage points (DANE 2022). Regarding the gender pay gap, a comparison of median monthly wages among full-time workers reveals a difference of about 4%, which is relatively small compared to other middle-income countries (see OECD citation). However, this number ignores the fact that women are more likely to hold vulnerable positions, such as part-time, self-employed, or informal jobs. When considering that, the gender pay gap is around 30%. These patterns are consistent with gender disparities in market work observed in other Latin American countries (Berniell, Fernández, and Krutikova 2024).

On the other hand, a significant proportion of women, approximately 30%, are inactive or outside the labor force because they are engaged full time in unpaid care work, typically caring for children or elderly adults. The burden of caregiving responsibilities and domestic chores falls primarily on women. The gender gap in unpaid non-market work is about 22 hours per week , and it is even greater among married women and those with children (Berniell, Fernández, and Krutikova 2024).

Examining how employed women and men in urban areas adjust their time allocation in response to short-term exogenous weather events is crucial for understanding the extent to which climate change has exacerbated or mitigated gender inequalities in paid and unpaid work. This is especially important in contexts where the adoption of heating or air conditioning is very low, making direct heat exposure and indirect effects through its impact on other household dependents, particularly relevant to consider when thinking about adaptation to climate change.

2.2 Data

I combine data from two sources to construct a dataset integrating labor market outcomes, time use, and weather information for employed individuals residing in the 23 largest cities in Colombia.

Labor Force Survey. I extract labor market data covering the period from 2008 to 2019 from the Gran Encuesta Integrada de Hogares (GEIH), collected by Colombia's National Department of Statistics (DANE). The GEIH is a monthly cross-sectional household survey that is representative of the 23 main cities in the country and is the primary source of labor market information in Colombia. It also collects information on time spent on other types of unpaid activities, such as household chores or caring for children and the elderly, and provides detailed demographic and socio-economic characteristics of all household members.

I restrict the sample to paid employed individuals aged between 15 and 65 years.[2] I define the main outcome of interest as the hours worked for employed women and men during the reference week (i.e., the last week before the interview date) in a given municipality.[3] Additionally, I consider job characteristics (e.g., full-time status, formality, firm size), occupation, economic sector, number of jobs, work location (home/indoor/outdoor), and individual and household characteristics such as age, education level, and number and presence of children under five years old.

I also consider time allocation information for the sample of employed individuals. The secondary outcomes of interest relate to participation in any unpaid activity (such as household chores or caring for children or elderly individuals), also referred to as the extensive margin. Conditional on participation, I examine the total weekly hours spent on unpaid work, defined as the sum of hours devoted to childcare, eldercare, and household chores.

Weather data. I extract daily maximum temperature and precipitation data from the ERA5 Climate Reanalysis Dataset, which is developed by the European Centre for Medium-Range Weather Forecasts (ECMWF). This reanalysis dataset integrates records from ground stations, satellites, and other sources with a climate model to generate a global gridded weather dataset at a $0.25^{\circ} \times 0.25^{\circ}$ spatial resolution. I consider cell-weighted measures to aggregate the daily weather time series from 2008 to 2019 at the city and weekly levels. Finally, using the GEIH reference week date, I match the weekly weather information to each city, where individuals live.

Reanalysis data have been increasingly adopted by applied economists because they provide accurate weather information over long periods at high levels of spatial resolution. However, the choice of a weather dataset is an important decision because, while weather datasets agree on the average value of weather variables across space (i.e., places that are on average hot or cold), they do not fully agree on the timing or magnitude of deviations from this mean, which is the source of identifying variation in panel data studies (Auffhammer et al. 2013.). For that reason, in the robustness checks I consider multiple weather datasets constructed using different approaches, as suggested by Dell, Jones, and Olken 2014.

[2]Excluding unpaid workers in both family and non-family businesses reduces the initial sample by approximately 5%.

[3]The GEIH data is publicly available at the departmental level (second-level administrative division). However, the reference week is confidential information. I was granted access to it at one of DANE's offices.

2.3 Descriptive Statistics

Labor Force Survey. Table 4 presents summary statistics for the final sample of urban workers used in the empirical analysis, including tests for gender differences in means. Only 2% of employed workers report zero hours worked in the reference week, and conditional on working, they spent an average of 46.16 hours per week. Women work 8.37 fewer hours per week than men on average. The gender monthly income gap is approximately 176,951 COP, which is about 22.07% relative to men's income. Around 45% of women are self-employed versus 52% of men. Women are slightly more likely to be informal workers (61% vs. 59%), with 50% holding part-time jobs compared to only 29% of men, and they are also more likely to hold secondary jobs (7% vs 5%).

In terms of non-market work outcomes, there are pronounced gender differences. Only 17% of employed men participate in child care, compared to 33% of employed women; conditional on participation, the gender gap is about 8 hours per week. Regarding household chores participation, 89% of women spend time on these tasks versus 48% of men, with a gender gap of approximately 10 hours per week spent on these activities.

Considering individual characteristics, the average age is 38 years, with women being slightly older than men. Additionally, the proportion of women with secondary education is much higher (41% vs. 31%). When examining the presence of children under 5 years old in the household, there are no statistically significant gender differences.

Weather data. Figure 1 illustrates the average weekly distribution of daily maximum temperatures across eight temperature categories (or bins) during the 2008–2019 period. These categories include days with mean temperatures below 15°C, above 30°C, and six intermediate bins, each spanning 3°C. Each bar represents the average number of days per week that an individual experiences within each bin. In the modal bin, between 24°C and 27°C, the average number of days is 1.25, while at the extremes (below 15°C and above 30°C), the averages are 0.125 and 0.625 days, respectively. These temperature bins are the preferred functional form for empirically modeling their impact on labor supply, as they allow for capturing non-linearities.

	Variable	All	Women	Men	Diff (M–W)
Paid work	Work (hours/week)	46.16	41.65	50.02	8.37***
Unpaid Work	Childcare (%)	0.25	0.33	0.17	-0.15***
	Childcare (hours/week)	18.22	21.29	13.21	-8.08***
	Household chores (%)	0.67	0.89	0.48	-0.40***
	Household chores (hours/week)	13.74	17.62	7.56	-10.06***
Job characteristics	Monthly income (COP)	718,741.25	624,886.94	801,838.85	176,951.91***
	Hourly income (COP)	3840.71	3666.92	3994.58	327.66***
	Self-employed (%)	0.49	0.45	0.52	0.06***
	Informal (%)	0.60	0.61	0.59	-0.02***
	Works outdoors (%)	0.26	0.12	0.39	0.27***
	Works indoors (%)	0.63	0.70	0.56	-0.14***
	Has a secondary job (%)	0.06	0.07	0.05	-0.02***
Controls	Age (years)	38.05	38.19	37.93	-0.26***
	Post-secondary education	0.35	0.41	0.31	-0.10***
	Child under 5 in household	0.31	0.31	0.31	0.00
	Num. of children under 5	0.39	0.38	0.39	0.01***
No. of observations		3,101,927	1,441,267	1,660,660	3,101,927

Table 1: Descriptive statistics for employed individuals by gender

3 Empirical Framework

3.1 Baseline results

To investigate how extreme temperatures impact the short-term labor supply and time use of women and men workers in urban areas, I estimate the following empirical model with weather bins, based on Deschenes and Greenstone (2007) and Hsiang (2016) using OLS:

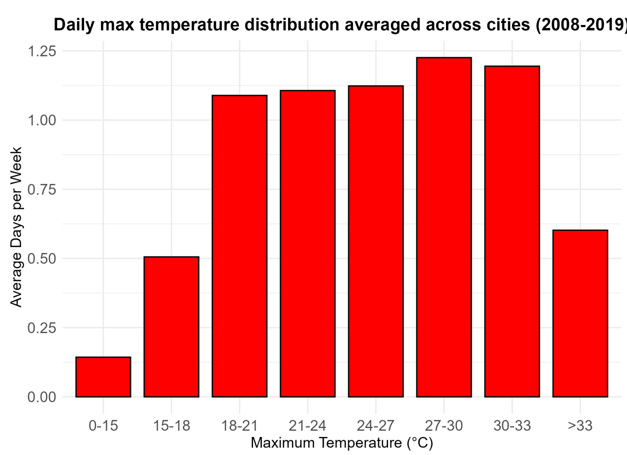


Figure 1: Distribution of Weekly Daily Maximum Temperatures (C), 2008–2019

$$\begin{aligned}\mathrm{y}_{ict} = \alpha + \sum_{k=1}^{K} \beta_k \text{Temperature Bin}_{ct}^{k} + \mu_k \text{Female}_i \times \sum_{k=1}^{K} \text{Temperature bin}_{ct}^{k} \\ + \phi_c + \chi_t + \psi \mathbf{X}_i + \epsilon_{ict}\end{aligned} \tag{1}$$

where the unit of observation is individual (worker) i in city c during the reference week t. $y_{i,m,t}$ refers to the labor market or time use outcomes, for instance, extensive margin (participation or non-participation) or the intensive margin (weekly time spent) on paid market work and unpaid domestic activities.

The weather variables are assumed to have a nonlinear relationship with labor supply. For instance, if the weather variable is temperature, then $\text{TempBin}_{m,t}^{k}$ denotes the number of days in city c during week t when the maximum daily temperature falls within the k^{th} bin, out of a total of K bins, each spanning 3°C. The temperature bin ranging from 21°C to 24°C is defined as the reference bin. The coefficient of interest, β_k, measures the impact on working hours when substituting a day from the reference bin with a day from temperature bin k.

$\mathbf{X}_i$ includes individual level controls such as age, educational level, marital status, number of children under 5 years old living in the household, and job characteristics such as economic sector, employment type (salaried vs. self-employed), firm size, number of jobs, work location, and occupation group. City and time fixed effects are represented by ϕ_m and χ_t, respectively. Time fixed effects include week-of-year and year dummies in the baseline specifications, and I also consider different combinations of weekly, monthly, and yearly dummies to account for seasonality in the robustness checks. Standard errors are clustered at the city level to address correlation within cities over time.

Hypotheses about the parameters. The parameter of interest, β_k , capture the direct effect of short-term temperature variations on individuals employed in Colombia. Based on the previous empirical evidence that extreme temperatures affect labor supply in the short-term, one might expect $\beta_k < 0$ for all individuals, regardless of gender. Most importantly, I am interested in testing the gender differential effect represented by $\mu_k \neq 0$. On one hand, given that men are typically employed in climate-exposed or high-risk industries (e.g., construction), if they face greater exposure to extreme weather, one would expect $\mu_k > 0$, indicating that women reduce their labor supply less than men. On the other hand, considering that women mostly bear the burden of caregiving responsibilities at home, if vulnerable dependents become sick and require care under heatwaves or extreme temperatures, this will indirectly affect mothers' and women's labor supply. Therefore, one would expect $\mu_k < 0$, indicating a greater reduction effect for them.

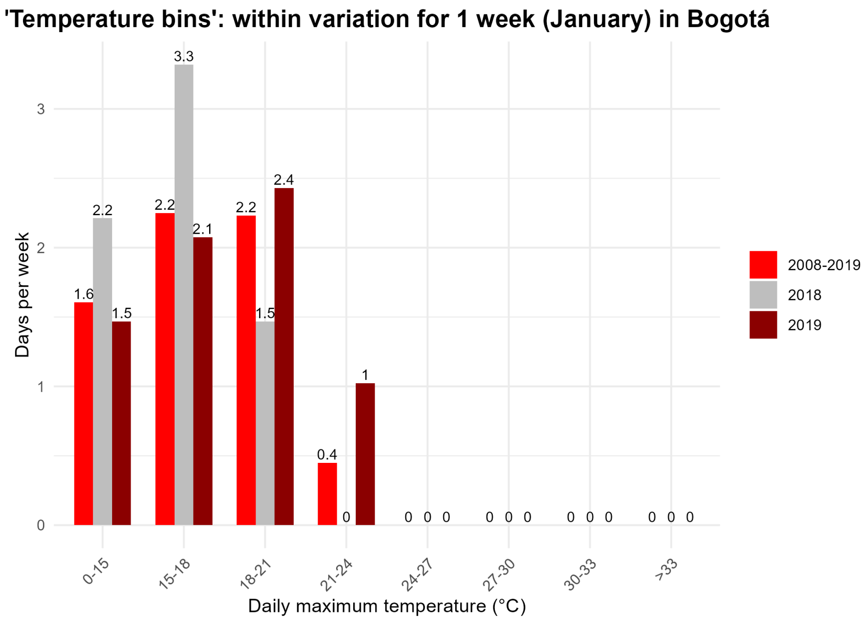


Figure 2: Distribution of Maximum Temperatures During the First Week of January in Bogotá: 2008–2019 Average, 2018, and 2019

Identification strategy. The identification strategy relies on within-location daily variation in weather over the years, which can be considered plausibly random, conditional on city and time fixed effects. For instance, Figure 2 shows the daily maximum temperatures in the city of Bogotá during the first week of January. Focusing on the first bin (temperatures below 15 degrees), the red bars indicate that, on average, there were 1.6 days with such temperatures between 2008 and 2019. The grey bars show that in 2018, the realized number of days below 15 degrees was 2.2, while the dark red bars represent the values for 2019. Overall, when analyzing the entire distribution, it appears that the first week of January 2019 in Bogotá was warmer than usual, whereas 2018 was colder than usual.

3.2 Heterogeneous effects

To examine whether the gender differential effects are particularly relevant for certain groups of urban workers, for instance, those in outdoor jobs, weather-exposed economic sectors, or with specific characteristics such as living with children or elderly people, I run the following triple interaction regressions:

$$
\begin{aligned}
y_{ict} = \alpha &+ \sum_{k=1}^{K} \beta_k \text{Temperature Bin}_{ct}^{k} + \gamma\, \text{Gender}_i + \delta\, z_i \\
&+ \sum_{k=1}^{K} \mu_k (\text{Gender}_i \times \text{Temperature Bin}_{ct}^{k}) + \sum_{k=1}^{K} \eta_k (z_i \times \text{Temperature Bin}_{ct}^{k}) + \theta\, (\text{Gender}_i \times z_i) \\
&+ \sum_{k=1}^{K} \phi_k (z_i \times \text{Gender}_i \times \text{Temperature Bin}_{ct}^{k}) \\
&+ \phi_c + \chi_t + \psi \mathbf{X}_i + \epsilon_{ict}
\end{aligned} \tag{2}
$$

The coefficients β_k capture the effect of an additional day in temperature bin k on labor supply, relative to the reference bin (21–24°C) for men in the baseline group ($z = 0$), while μ_k capture the additional effect for women in the same baseline group ($z = 0$). The coefficients η_k measure how the characteristic z modifies the effect of temperature bins among men, and ϕ_k represents the triple interaction of interest, capturing how the gender differential varies across values of z and temperature bins. For simplicity, I plot the marginal effects for women and men across all groups of z to allow for an intuitive interpretation of the results.

4 Main Results

4.1 Effects on Paid Work

Benchmark specification. First, I estimate Equation 1 without including gender interactions with the temperature bins, because I am interested in the β coefficient to test a benchmark specification commonly used in the literature. As expected, I find that maximum temperature has a negative, non-linear relationship with labor supply among all urban workers (Figure 4). This finding aligns with the existing literature that documents an inverted U-shaped relationship, in which deviations from the "optimal" local temperature range (21–24°C) reduce labor supply. Specifically, an additional day with a maximum temperature below 18°C, relative to a day in the reference bin, is associated with a reduction in working time of 0.15 hours per week (approximately 9 minutes), whereas an additional day with temperatures above 33°C is associated with a decrease of about 10 minutes worked in Colombia.

Although the effect is relatively modest, its magnitude and sign are consistent with empirical findings from studies in other developing countries (see Minoru 2023; Garg, Gibson, and Sun 2019). However, comparing these estimates with those from studies in developed countries (e.g., Graff Zivin and Neidell 2014; Rode et al. 2022) is not straightforward, as

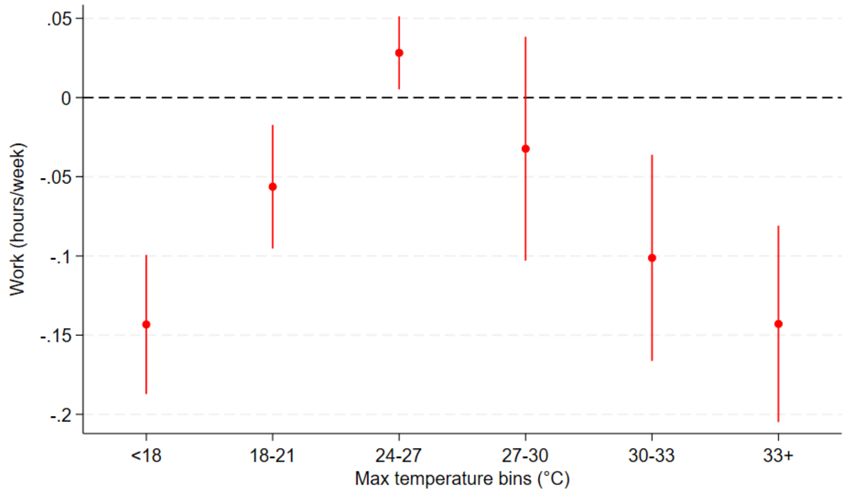


Figure 3: Total effect of maximum temperature on working time for urban workers

my analysis focuses on urban areas rather than rural populations or entire countries. Furthermore, some of the empirical evidence relies on daily hours worked rather than weekly time-use.

Gender differentials effects on working time. Figure 4 shows the total effect of maximum temperature on the labor supply of employed women and men, based on the estimates from Equation (1), which includes the gender interaction term with weather bins. The inverted U shaped pattern remains consistent for women but not for men. An additional day with maximum temperatures above 27°C is associated with a significant reduction in the intensive margin of labor supply for women, about 0.33 hours worked per week at the top of the temperature distribution, while the effects for men are not statistically different from zero. This pattern suggests that high temperatures have gender differentiated effects on labor supply among urban workers.

On the other hand, both men and women reduce their working time by approximately 0.1 to 0.2 hours per week when experiencing cooler-than-optimal temperatures (the lower end of the temperature distribution). This is a small effect and should be interpreted with caution, as it does not necessarily reflect cold health-related productivity shocks, but rather workers spend more time on paid work when temperatures are in the optimal range (21–24°C).

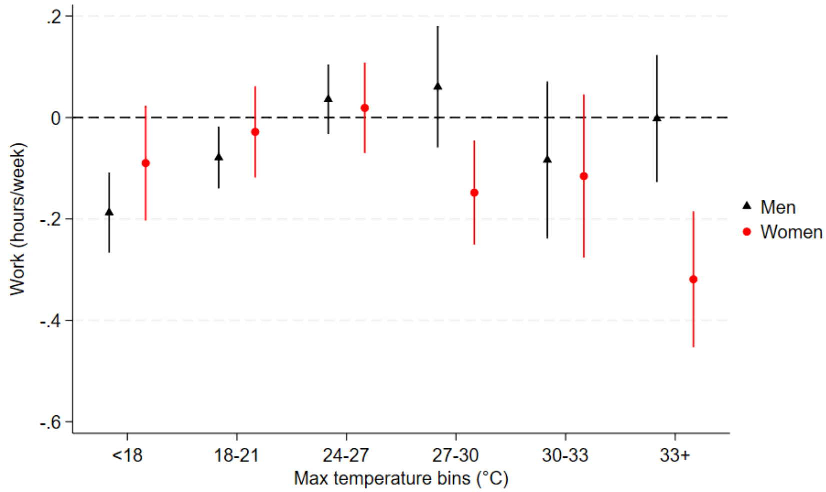


Figure 4: Total effect of maximum temperature on working time for men and women.

4.2 Effects on Unpaid work

Total unpaid work. Figure 5 presents marginal effects of extreme temperatures on time spent doing unpaid domestic work at both the extensive margin (participation) and intensive margin (hours per week) for employed women and men.

An additional day with temperatures above 27°C is associated with a 1 pp increase in the probability that employed women engage in any unpaid work, while no statistically significant effect for men. In contrast, an additional day with temperatures below 21°C, which is cooler than the optimal temperature, appears to raise men's participation by 1 pp while lowering women's participation at the bottom of the distribution. This pattern is striking and clearly visible in the left panel of the figure.

Most importantly, conditional on participation, I find gender-differential effects on unpaid work under high temperatures. Each additional day with temperatures above 27°C increases women's time spent on unpaid activities by approximately 0.4 hours per week, whereas men, on average, reduce their time in these activities, although this decrease is not significantly different from zero at the 5% significance level.

Time spent on unpaid work by activity. To disentangle which unpaid activities women spend more time on during hot days, Figure 6 presents the estimated coefficients from Equation (1), where the outcomes are time spent on household chores, childcare, or eldercare, for the sample of workers participating in at least one of these activities. The overall coefficients suggest that household chores and childcare, rather than eldercare, account

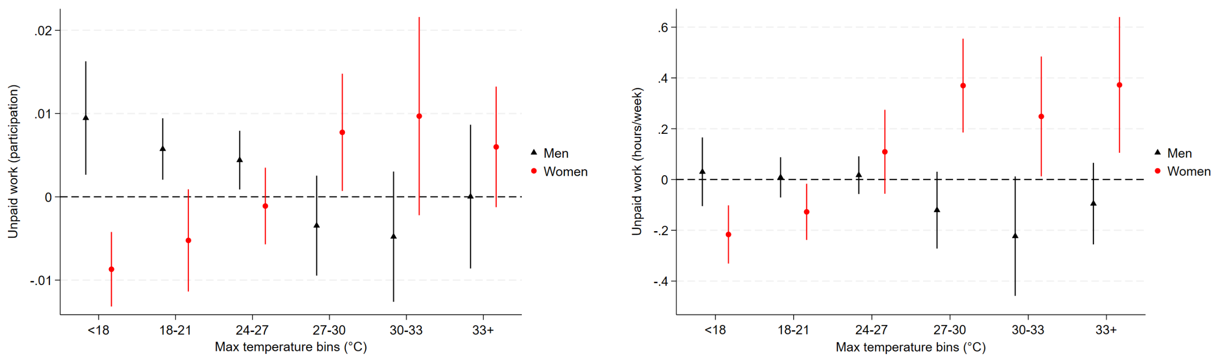


Figure 5: Effects of temperature on unpaid domestic work participation (left panel) and weekly time spent on unpaid work (right panel) for women (red) and men (black). Vertical lines represent 95% confidence intervals. The temperature bin 21-24°C is the omitted category.

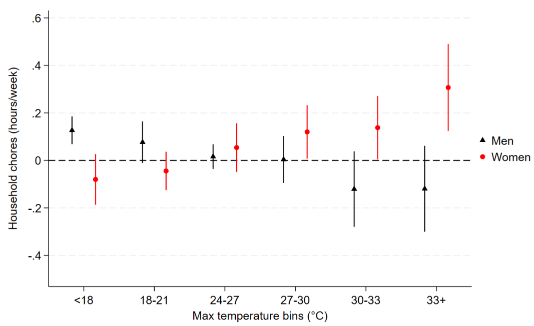
for most of the gender differential effects at high-temperature bins (above 27°C). The coefficients on household chores remain positive and significant, with the largest effect observed at the highest temperature levels, where women spend approximately 0.33 additional hours per week on unpaid activities. Childcare effects are largest in the 27–30°C bin, although the effect loses significance at the very top of the temperature distribution. The magnitude of the effects on eldercare is very modest (less than 0.02 hours per week for men), reflecting the fact that very few workers perform this activity, which also results in larger standard errors.

Overall, the findings suggests that employed women reallocate working time toward unpaid care activities, such as childcare and domestic work under heatwaves. The effects are larger in magnitude for indirect care activities, including tasks like cooking, cleaning, and doing laundry, compared to direct care activities such as feeding children. In contrast, men workers show little change in their time allocation, indicating a potential exacerbation of gender gaps in response to high temperatures.

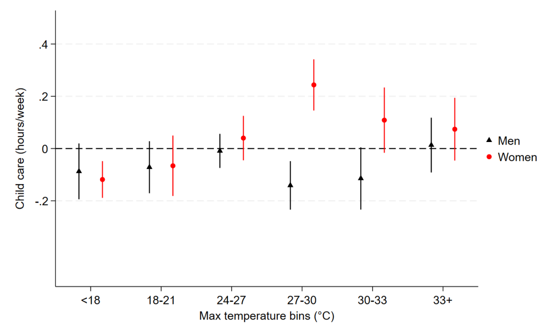
4.3 Robustness checks

The baseline results are robust to different functional forms of maximum temperature and alternative specifications of temporal controls (fixed effects).

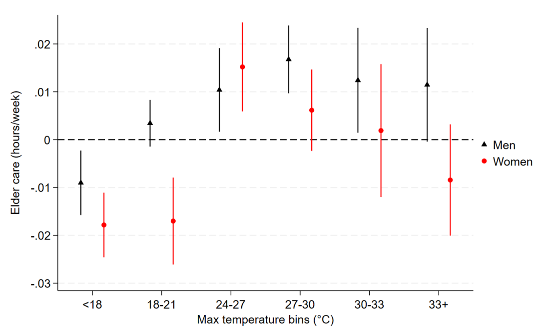
Figure A.4.1 presents the results of estimating Equation 1 using second- and third-order polynomials of temperature. Table A3 examines the number of hot days per week, where temperatures above 27°C are classified as hot days (Column 1) and those below 18°C as cold days (Column 2); Column 3 includes both hot and cold days in the same regression. Figure A5 presents results using 11 temperature bins in 2°C increments, showing that the



Household chores (hours/week)



Childcare (hours/week)



Eldercare (hours/week)

Figure 6: Gendered effects of temperature on time allocated to household chores, childcare, and eldercare

U-inverted-shaped pattern remains evident. Overall, across all specifications, the findings suggest gender-differentiated effects under high temperatures but not during cooler than usual temperatures, consistent with the main results.

Table A.4.2 shows estimates of the labor supply response using the baseline temperature bins, varying the combination of city and time fixed effects to account for trends and seasonality. The results are similar to the baseline estimates in Column 1.

5 Potential channels explaining gender differential effects

In this section, I examine potential mechanisms that may explain why women, but not men, reallocate time toward unpaid work and away from paid activities on hot days. On the one hand, this pattern may reflect a labor supply response driven by gender differences in labor market exposure to weather, sector-specific shocks, and varying degrees of job flexibility across genders. On the other hand, during heat waves, vulnerable individuals, such as children and elderly adults, may experience a higher health risk, creating a greater demand for care. Since these caregiving responsibilities disproportionately fall on women, they may need to allocate more time to unpaid care, which can lead to a reduction in time spent on paid work.

5.1 Heterogeneous effects of gendered labor supply responses

Work location exposure. Women and men tend to work in different locations and are therefore they might be differently exposed to weather conditions. For example, men are more likely to work in physically demanding outdoor jobs, such as construction sites or street vending, whereas a higher proportion of women work indoors, either at home, in factories, or in offices (Figure A2).

Figure 5 presents the heterogeneous effects from estimating Equation (2), with the triple interaction terms including work location, as reported by the individuals. I find that the gender differential effects under very high temperatures are primarily driven by women whose workplace is indoor, who reduce their working hours by 0.28 more than men for each additional hot day above 33°C. Women performing their jobs outdoors reduce their working hours by 0.4 hours per week for an additional day above 33°C. Overall, this suggests that gender differences in paid work adjustment under heat are not solely related to differential

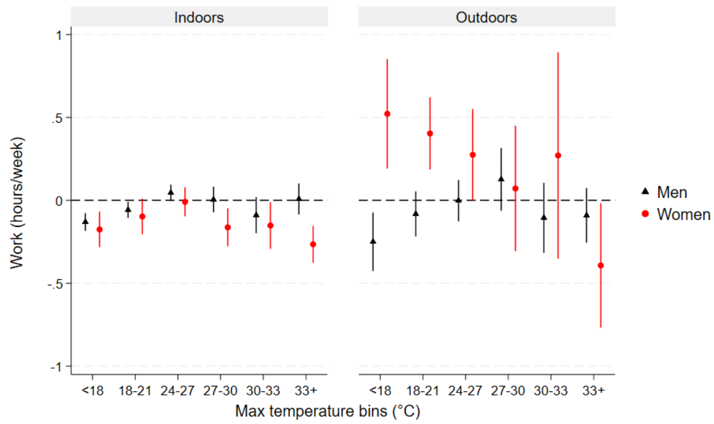


Figure 7: Heterogeneous effect by work location

exposure.

Job flexibility. The types of jobs that men and women hold differ along many dimensions (Berniell, Fernández, and Krutikova 2024). Women are more likely to engage in self-employment, informal work, or part-time jobs, which are typically associated with flexible schedules. Such flexibility allows them to adjust their working hours more easily in the presence of other time constraints or economic shocks. Therefore, understanding which types of workers drive the gender differential effect under heat exposure is crucial.

Figure 8 presents the marginal effects for women and men by employment status (salaried vs self-employed), used as a proxy for flexibility. I find that both salaried and self-employed workers reduce their weekly labor supply by 0.10 hours in the highest bin (33+°C); however, this reduction is statistically insignificant. In addition, there is no evidence of a gender differential effect within these groups, suggesting that this margin may not explain the overall gender gap.

Figure 9 presents the marginal effects obtained from estimating Equation (2) for women and men, distinguishing between informal and formal employment, with formality defined as contributing to the social security system. The inverted U-shaped pattern of labor supply in response to cooler or hotter temperatures is evident for both women and men in formal jobs. However, there are some gender differential effects at the 10% level in the highest temperature bin (33+°C). Among informal workers, the gender gap persists, with informal men increasing their weekly working time by less than half an hour, while informal women show no significant change. Informal workers lack social and market protection and are therefore among the most vulnerable.

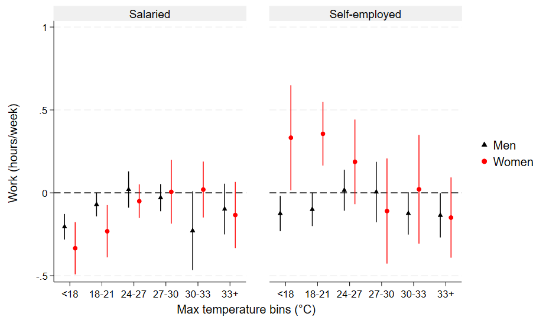


Figure 8: Heterogeneous effect by self-employment status

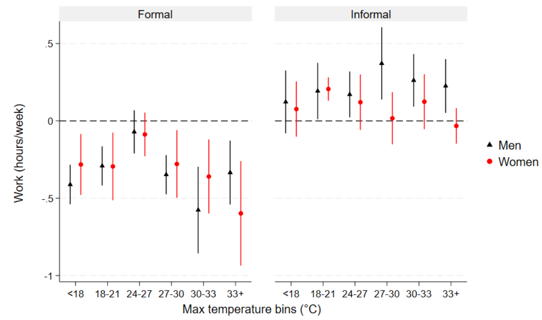


Figure 9: Heterogeneous effect by informality status

Economic sector exposure. I also use information on the economic sector of occupation for each individual to examine whether specific sectors drive the baseline gender differences in labor supply under high temperatures, considering that men and women may self-select into different sectors, such as men in construction and women in services (Figure A3). Figure 10 presents the heterogeneous effects estimated from Equation (1) by economic sectors. The gendered effect of reduced hours worked above 27 degrees Celsius is similar across sectors in terms of direction (negative), although it is not always statistically significant.

In male-dominated sectors that are more likely to involve outdoor work, such as agriculture, extractive industries and utilities (primary sector), construction, and transportation, both women and men work less on an additional day above 33°C relative to 21–24°C. However, there are no statistically significant gender differences, which may be related to the low proportion of women in these sectors or because these sectors are the most weather-exposed, affecting both genders in a similar way.

In gender-balanced sectors, such as manufacturing, which likely involve more indoor work, I observe pronounced gender differences beginning at the 27-degree Celsius bin, but not in the highest bin. In female-dominated sectors, such as professional services, the baseline results in the highest temperature bin remain consistent: women reduce their labor supply, while men show no effect. Interestingly, in the public sector, both women and men decrease their labor supply on hotter days, but some gender differential effects are still observed.

It is important to highlight that the coefficients for high-temperature bins (above 27 degrees Celsius) are smaller in magnitude and some cases, statistically insignificant in sectors that are more likely to experience reduced product or service demand during heatwaves, such as retail, hospitality, and low-productivity services. In contrast, the coefficients are larger and statistically significant in sectors less exposed to short-term demand fluctuations, such

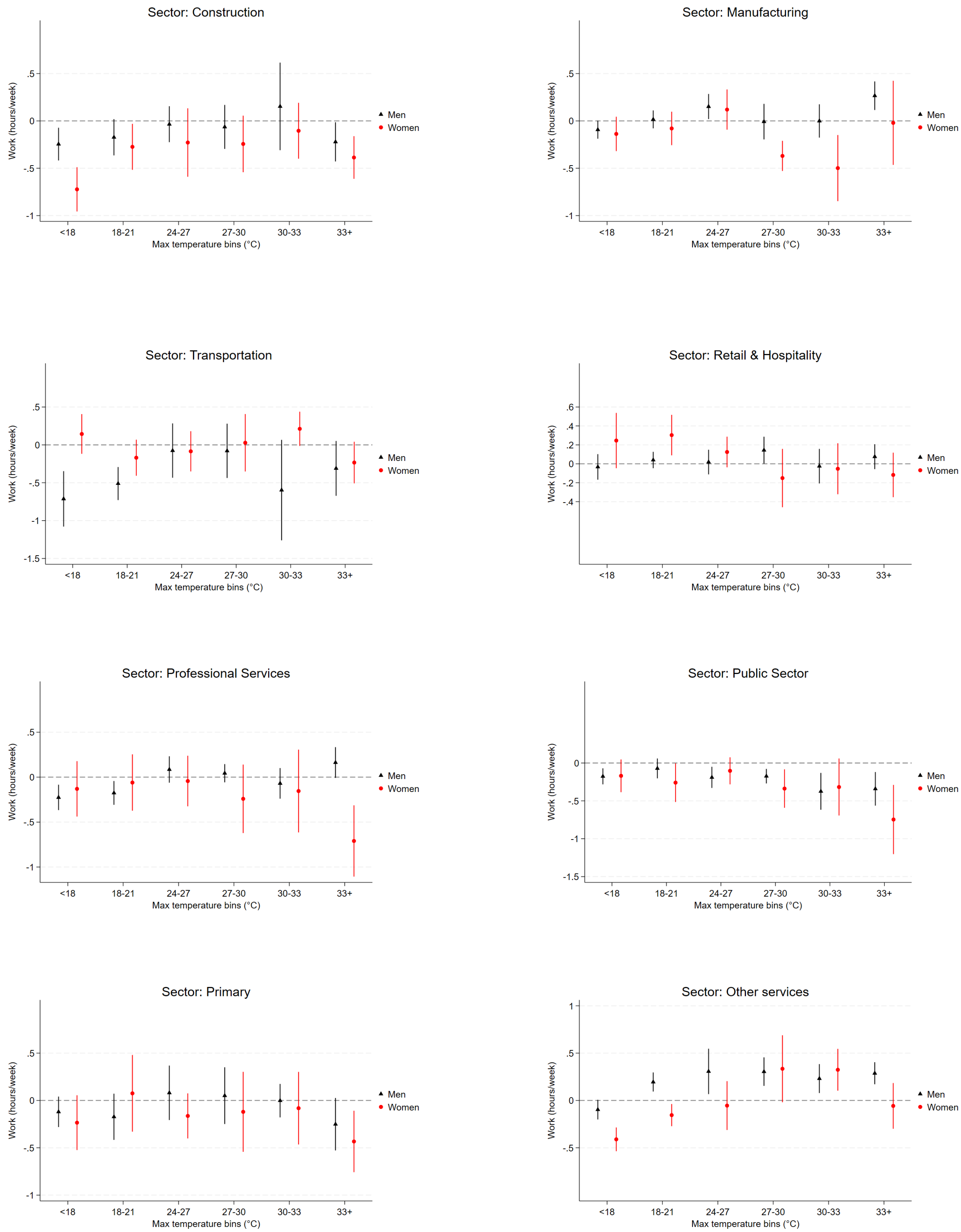


Figure 10: Heterogeneous effects by economic sector

as professional services and the public sector. This pattern suggests that the overall gender differences in working hours under heat waves are unlikely to be driven by a decline in labor demand associated with extreme temperatures.

On the other hand, women and men employed in the public sector reduce their labor supply during hot days (Figure 10). This may not be driven by their own decisions but by workplace disruptions, such as school closures in the education sector or early office shutdowns due to health and safety concerns. The coefficient for this sector is statistically significant and also among the largest for both genders.

While these results point toward institutional disruptions, school closures due to heatwaves are relatively uncommon in Colombia. According to official reports, climate-related disruptions to schooling are mostly associated with drought conditions in rural areas, in contrast to other regions of the world where heatwaves more frequently trigger such interruptions (UNICEF 2025). It is still possible that in hotter cities, where many public and private schools do not have air conditioning, early-dismissal policies allow students to go home earlier on very hot days. However, the overall decrease in labor supply that I observe is not driven only by the education system but by the public sector in general, which suggests that a broader institutional response may be at play.

5.2 Heterogeneous effects by household composition

Presence of children in the household. Are women increasing the time spent on unpaid work during heatwaves to fulfill caregiving responsibilities?. If vulnerable dependents become sick or stay more indoors during periods of environmental shocks (Aragón, Miranda, and Oliva 2017), one would expect women to reduce hours worked to fulfill increasing care demands. Therefore, it is important to assess whether the gender differential in unpaid hours worked during extremely hot days is driven by, or is only relevant for, women living with young children (under 5 years old) or school-age children (under 14 years old). To test this, I estimate Equation (2), where z is a dummy variable indicating the presence of children of different ages.

Figure 11 shows the differential effects of temperature shocks on hours spent on unpaid activities for women living with or without children under 14, conditional on participating in any unpaid activity. Women living with children spend about 0.5 more hours per week at moderately high temperatures (27–30°C) and about 0.25 more hours per week at 30–33°C. Women without children also increase their unpaid work by about 0.5 hours per week, but

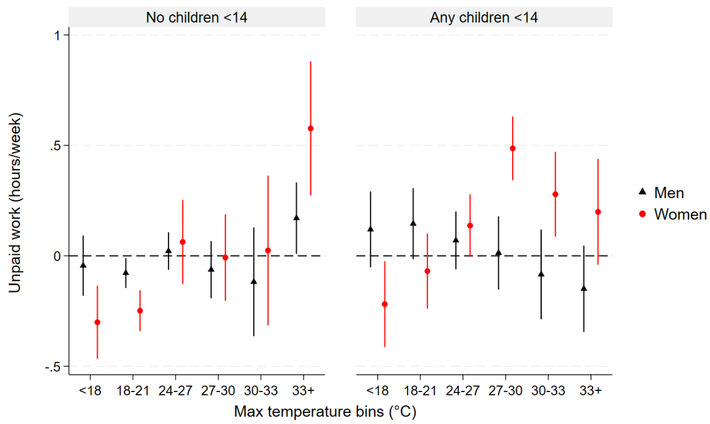


Figure 11: Heterogeneous effect by presence of children under 14 in the household

only on very hot days (above 33°C). Interestingly, men without children also increase their unpaid work by about 0.2 hours per week when exposed to very high temperatures.

In addition to this, I estimate the same regression for the outcome of paid hours worked for women and men in households with and without children under 14, and the are gendered differential effects remain for those with and without children as shown in Figure A6. This suggests that caregiving responsibilities, particularly for young children, is not the only mechanism driving the overall gender differential effect on time use.

Presence of elderly adults. Figure A7 presents the marginal effects of equation (2), where I introduce heterogeneity by the presence of an elder adult (65+) in the household. Estimated coefficients suggests that living with an elder adult does not differentially affect the increase in women's unpaid work, in other words, having an elderly person at home, who could potentially require more care during heat waves, is not relevant in this case. This is also consistent with Figure 6, where elderly care does not explain most of the increase in absolute terms.

6 Conclusion

In this paper, I provide empirical evidence on the short term effects of high temperatures on the labor supply of urban workers from a gender perspective. This is important for understanding how climate change, through more frequent days with high temperatures, is contributing to the widening of gender gaps in time use in urban labor markets.

By combining labor force survey data with daily weather information for workers living in the 23 largest cities in Colombia, I find a significant and sizable negative effect of extreme temperatures on hours worked. The effects are nonlinear and heterogeneous, showing that employed women, and not men, adjust their labor supply differently during heatwaves. Specifically, only women reduce their working hours by approximately 0.33 hours per week for each additional day with temperatures above 33°C. I also find that high temperatures have gender-differential effects on unpaid hours worked, conditional on engaging in these activities. Women spend more time on these tasks than men, especially in household chores and childcare. Overall, this suggests a time reallocation from weekly paid work to unpaid work for women but not for men in the short-term at the aggregate level.

In addition, I explore several potential mechanisms that link high temperatures to changes in labor supply and time use across genders. First, I examine whether labor-market factors such as gender segregation by work location, economic sector, or job flexibility account for the observed gap. I find that the gender gap remains substantial even among individuals working in the same workplace and in gender-balanced industries such as manufacturing, professional services, and the public sector. Job flexibility, measured by self-employment, also does not explain the gap.

Second, considering household structure, I show that women living with children under the age of 14, used as a proxy for caregiving responsibilities, drive the increase in unpaid work at moderately high temperatures (27–33°C). Even women without children spend more time on unpaid chores at very high temperatures (33°C and above), which suggests that caregiving for children plays a central role in shaping unpaid work responses, but it is not the only factor contributing to women's reductions in paid work during heatwaves.

However, this study has a few important limitations. First, it focuses exclusively on the short-term impacts of extreme weather and does not examine potential long-term consequences. Second, due to data constraints, I am unable to analyze other relevant outcomes such as labor productivity or health-related impacts. Prior research indicates that these dimensions are also important for understanding the broader effects of climate change on the economy and how these impacts are moderated by gender.

A Appendix

A.1 Weather data

Aggregating weather data from grid-to municipality level. Given daily records of precipitation and temperature at the grid level from the ERA5 dataset, I aggregate this data from the grid level to the city level, which is the administrative unit relevant for socio-economic analysis. Since my objective is to model the effect of heat, cold, and extreme rainfall on workers, and these phenomena occur at the local (individual) level rather than at a larger administrative unit (country or department) level, it is crucial to follow the next steps : 1. transform the raw weather data at a daily time unit into the terms of the model specification (polynomials, bins, cubic splines) and 2. then aggregate it at the municipality using a weighting scheme also know as transformation-before-aggregation.[4]

Functional form. I will consider measures in levels, e.g. degrees Celsius for temperature or millimeters for precipitation, and then bins to account for nonlinear effects following the approach of Deschênes and Greenstone (2011). This last method considers the frequencies at which the weather realizations fall into different bins. For example, temperature may be accounted for via several regressor, each counting the number of days in the reference week with temperatures within prespecified degree ranges (e.g., 15–20°C, 20–25°C, etc.) (Dell, Jones, and Olken 2014).

Weighted Approach. It is important to consider a weighted aggregation of gridded data for specific regions (cities). To accomplish this, for each municipality, I calculate the average of the values from each grid cell, weighting each term according to two measures. Firstly, the proportion that the cell represents of the total surface area of the municipality. Secondly, the proportion that the cell represents of the population within the region. This allows for a more accurate representation of the data by giving more weight to areas with higher population density in a given municipality. For the second option, I plan to use the Gridded Population of the World (GPW) collection, which models the distribution of human population (counts and densities) on a continuous global raster surface in 2005, 2010 and 2015. [5]

[4]Following the practical guide to Climate Economics : https://climateestimate.net/content/weighting-schemes.html

[5]https://sedac.ciesin.columbia.edu/data/collection/gpw-v4

A.2 Data restrictions

Missing information. The initial sample consists of 8,576,023 individuals living in 4.2 million households, spanning the years 2008 to 2019, with approximately 60,000 individuals observed each month. I restrict the sample to households with information on the reference week (i.e., when the data were collected), resulting in the deletion of 14,417 individual observations. Additionally, I retain only households residing in urban capital cities, excluding those for which the urban municipality cannot be identified, leading to the removal of 415,876 observations. After these restrictions, the final sample includes 7,554,211 individuals in 2,171,285 households.

Sample of interest. For the sample of individuals employed at the time of the survey, I restrict the analysis to those of working age (between 15 and 64 years old) who have a paid main job (excluding unpaid family workers or those unpaid by others).[6]This includes 3,101,927 workers: 1,441,267 women (46.47%) and 1,660,660 men (53.53%).

A.3 Descriptive statistics

Table A1: Top 10 Most Common Occupations for Women (Percent)

Code	Occupation	Percent (%)
45	Street vendors, door-to-door sellers, shop employees	13.04
54	Domestic service personnel (not elsewhere classified)	11.54
41	Business owners / Shop owners	8.23
53	Cooks, waiters, bartenders, and related workers	6.68
13	Teachers	6.13
55	Building guards, cleaners, and related workers	5.66
79	Tailors, dressmakers, upholsterers, and related workers	4.46
57	Hairdressers, beauty specialists, and related workers	3.83
39	Administrative workers (not elsewhere classified)	3.74
33	Accounting clerks, cashiers, banking service workers	3.68

[6]Around 94,610 workers are unpaid, of whom 66% are women.

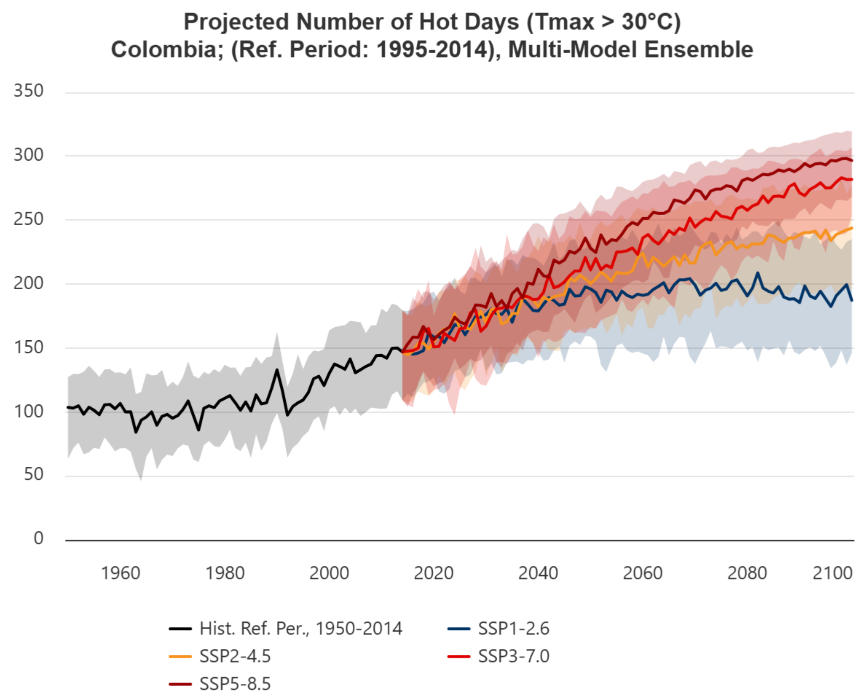


Figure A1: Projection of the annual number of days with maximum temperatures exceeding 30◦C in Colombia, 1950–2100. Figure extracted from the Climate Change Knowledge Portal, World Bank (2024)

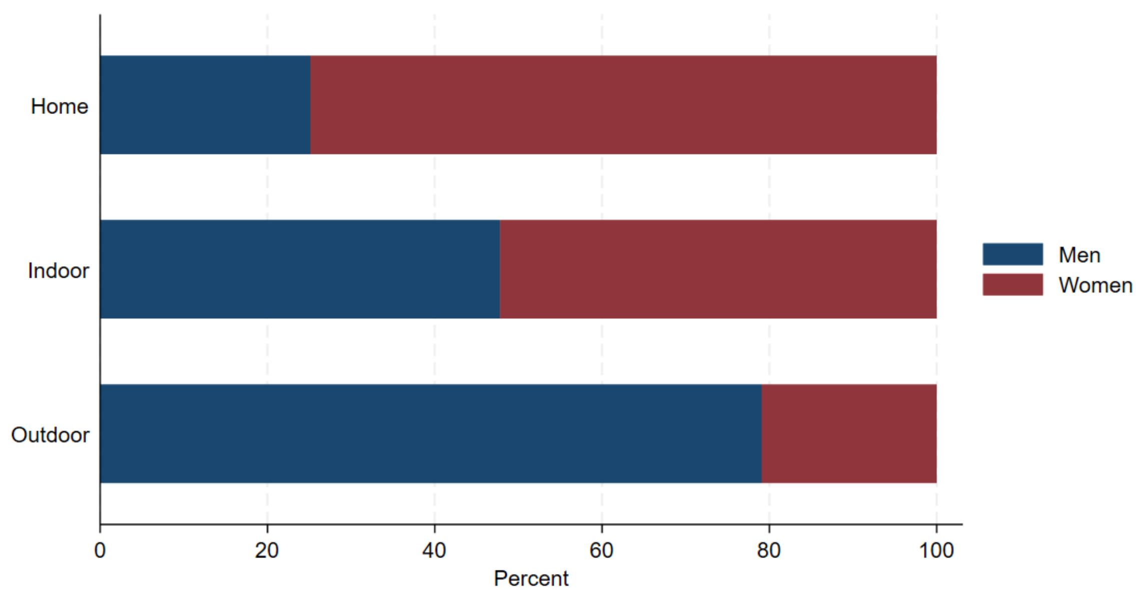


Figure A2: Gender distribution by work location

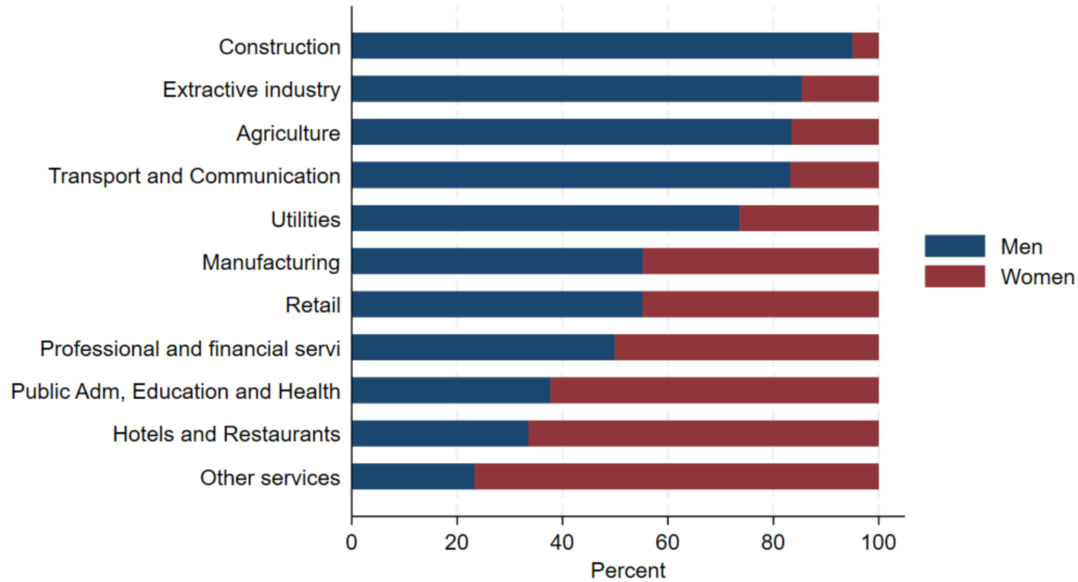


Figure A3: Gender distribution by economic sector

Table A2: Top 10 Most Common Occupations for Men (Percent)

Code	Occupation	Percent (%)
98	Drivers and transport vehicle operators	12.43
95	Construction workers	9.96
45	Street vendors, door-to-door sellers, shop employees	7.76
41	Business owners / Shop owners	6.92
58	Protection and security services personnel	6.08
97	Freight handlers, material movers, earthworks workers	4.66
39	Administrative workers (not elsewhere classified)	3.20
3	Technicians	3.17
21	Directors and senior managers	2.93
13	Teachers	2.89

A.4 Robustness checks

A.4.1 Alternative functional forms

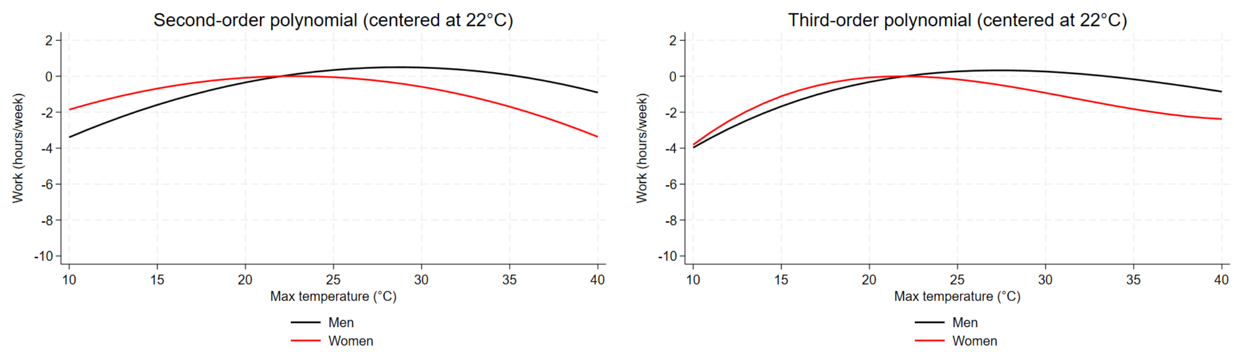


Figure A4: Changes in weekly hours worked per person (women and men) due to changes in daily maximum temperature. Labor supply–temperature relationships are estimated using Equation 1, with different functional forms (second and third-order polynomials). Each point on the parametric curve represents the change in weekly labor supply resulting from an additional day at the daily maximum temperature indicated on the x-axis, relative to a 20 °C day, for men (black) and women (red).

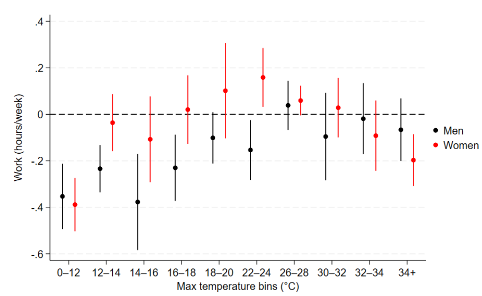


Figure A5: Total effect of maximum temperature on working time for men and women, using 11 bins of 2°C each, with the reference bin being 20–22°C.

	(1) Work (hours/week)	(2) Work (hours/week)	(3) Work (hours/week)
Hot Days	0.048		0.032
	(0.066)		(0.081)
Female=1 x Hot Days	-0.203***		-0.151*
	(0.067)		(0.084)
Cold Days		-0.269***	-0.221***
		(0.075)	(0.078)
Female=1 x Cold Days		0.218***	0.120
		(0.070)	(0.077)
Observations	2975184.000	2975184.000	2975184.000
Mean of Dep. Variable	46.441	46.441	46.441

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A3: Total effect of maximum temperature on working time for men and women, based on the number of hot days (column 1), cold days (column 2), and both types combined (column 3).

A.4.2 Alternative specifications of temporal controls (Fixed effects)

	(1) Work (hours/week)	(2) Work (hours/week)	(3) Work (hours/week)	(4) Work (hours/week)	(5) Work (hours/week)	(6) Work (hours/week)
¡18	-0.188***	-0.235***	-0.187***	-0.194***	-0.167***	-0.105***
	(0.038)	(0.044)	(0.038)	(0.033)	(0.032)	(0.033)
18-21	-0.079**	-0.133***	-0.115***	-0.097***	-0.085**	-0.019
	(0.029)	(0.041)	(0.032)	(0.032)	(0.031)	(0.031)
24-27	0.036	0.052*	0.055	0.025	0.030	-0.045
	(0.033)	(0.030)	(0.034)	(0.038)	(0.038)	(0.029)
27-30	0.061	0.098	0.090	0.084	0.091	-0.087
	(0.058)	(0.060)	(0.058)	(0.060)	(0.054)	(0.097)
30-33	-0.084	-0.037	-0.035	-0.017	-0.007	-0.283**
	(0.075)	(0.078)	(0.088)	(0.081)	(0.082)	(0.123)
33+	-0.002	0.056	0.042	0.060	0.067	-0.236**
	(0.060)	(0.065)	(0.064)	(0.059)	(0.056)	(0.105)
Female=1 × ¡18	0.098	0.098	0.098	0.098	0.098	0.097
	(0.078)	(0.078)	(0.078)	(0.078)	(0.078)	(0.078)
Female=1 × 18-21	0.051	0.049	0.051	0.052	0.051	0.050
	(0.057)	(0.058)	(0.058)	(0.058)	(0.058)	(0.057)
Female=1 × 24-27	-0.017	-0.018	-0.017	-0.016	-0.018	-0.017
	(0.071)	(0.071)	(0.071)	(0.071)	(0.071)	(0.071)
Female=1 × 27-30	-0.209***	-0.209***	-0.208***	-0.205**	-0.205**	-0.211***
	(0.073)	(0.074)	(0.074)	(0.074)	(0.074)	(0.073)
Female=1 × 30-33	-0.032	-0.032	-0.031	-0.030	-0.030	-0.031
	(0.133)	(0.133)	(0.133)	(0.134)	(0.134)	(0.133)
Female=1 × 33+	-0.317***	-0.317***	-0.316***	-0.317***	-0.317***	-0.315***
	(0.103)	(0.103)	(0.103)	(0.104)	(0.103)	(0.103)
R-squared	0.135	0.136	0.133	0.133	0.134	0.134
Observations	3004819.000	3004819.000	3004819.000	3004819.000	3004819.000	3004819.000
Mean of Dep. Variable	46.427	46.427	46.427	46.427	46.427	46.427
City FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes		-	-	-	-
Month FE	-	-	-	-	-	-
Week FE	Yes	Yes	-	-	-	
Region×Year FE	-	-	-	Yes	Yes	-
Region×Month FE	-	-	Yes	Yes	Yes	-
Region×Week FE	-	-	-	-	-	Yes
YearxMonth FE	-	Yes	Yes	-	-	-

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

A.5 Additional graphs

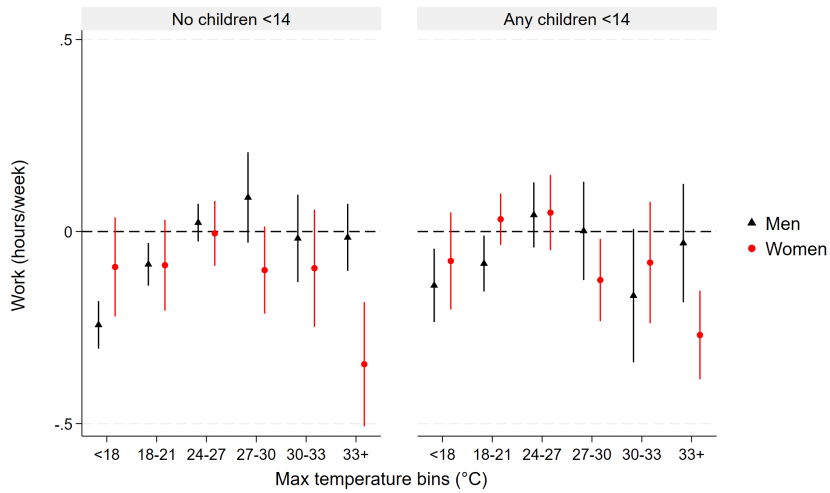


Figure A6: Heterogeneous effects on paid work by the presence of children (¡14)

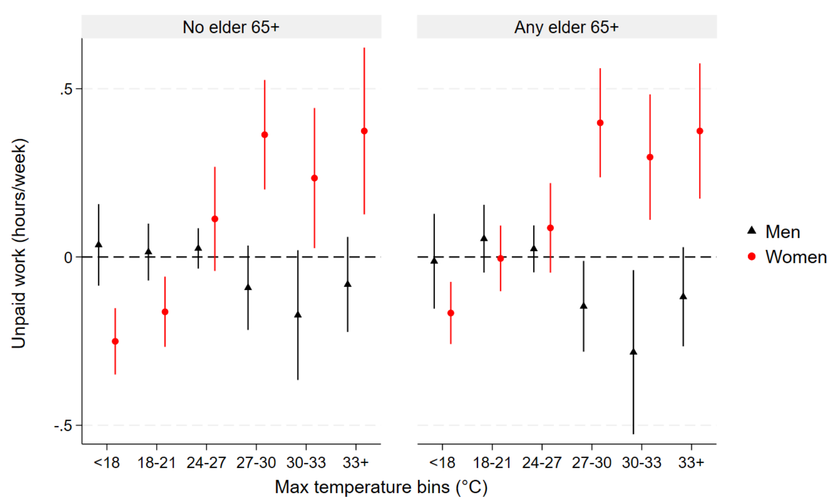


Figure A7: Heterogeneous effects on unpaid work by the presence of older adults (65+)

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