# Climate Change and Fertility

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**Abstract**

Climate change may affect future population dynamics. A growing body of evidence suggests that exposure to abnormally hot days reduces birthrates. However, the existing literature focuses either on countries with high levels of air conditioning (AC), or countries with very low incomes. Therefore, there is a noticeable gap in our understanding of the effect of temperatures in high-income countries with low AC penetration, where the effect of temperature shocks on fertility should be more pronounced. In this paper, we use administrative data for continental Spain from 2010 to 2016 to identify the causal effect of temperature on birthrates. We demonstrate that warm (25-30°C) and hot days (>30°C) decrease TFR in Spain, and that the estimated decrease is higher than the effects estimated in previous literature for the United States. Our results suggest that estimates of the global impact of climate change on population dynamics are understated, and that temperature increases may exacerbate population ageing in Europe and the social and economic problems of low fertility.

## 1 Introduction

Climate change is expected to affect population dynamics. Yet while extensive literatures examine the effect of extreme temperatures on mortality (Carleton et al., 2020) and migration (Hoffmann et al., 2021), the impact of extreme temperatures on fertility has been less researched. Only four studies exist – two from the US, one from South Korea, and one pooling data from sub-Saharah Africa – all of which showed reductions in fertility after abnormally hot days (Barreca et al., 2018; Lam & Miron, 1996; Cho, 2020; Thiede et al., 2022).

However, it is widely hypothesized that the presence of air conditioning (AC) may mitigate the effect of abnormally hot days on fertility. In the two high income countries for which evidence of the effect of temperature on birth rates exists, AC penetration (as defined by the number of household with AC) is exceptionally high, meaning they may significantly understate the effect of temperature on fertility for the majority of people. For example, the US and South Korea have the 2nd and 3rd highest AC penetration rates globally, at 90% and 86%, surpassed only by Japan at 91% (Santamouris, 2016). In contrast, in Europe AC penetration is only 5%. Therefore, there is a noticeable gap in our understanding of the effect of temperatures in high-income countries with low AC penetration, where the effect of temperature shocks on fertility should be more pronounced.

In this study, we contribute to the literature on the impact of climate change on population processes by investigating how extreme temperatures affect fertility in a high-income country with low AC penetration. We focus on continental Spain. Spain, being settled in the Mediterranean area, is expected to experience the highest increase in temperatures in Europe (Cramer et al., 2018). In fact, studies highlighted Spain to be the European country that will experience the highest increase in heatwave-related deaths (Forzieri et al., 2017) and to observe the largest decrease in life expectancy due to climate change (Hauer & Santos-Lozada, 2021) in the future. In addition, Spain has one of the largest diversities of ecological zones in Europe. Consequently, Spain is a particularly interesting case to estimate the effects of climate change on fertility.

# 2 Data and Empirical strategy

## 2.1 Natality Data

We construct province-by-month total fertility rates (TFR) and birth counts (2010-2016) combining two data sources: population-level birth registers and population figures, which are both provided by the Spanish Statistical Institute (*Instituto Nacional de Estadistica - INE*). Birth registers collect information on virtually all births in Spain, including socio-demographic characteristic of the parents and delivery information. Population figures are reported by sex, age and province of residence every semester, and are generated by INE from vital, migration, and citizenship acquisition statistics. From these data, we construct our main outcome variables. First, we use birth counts and population by age (15-49) to create province-by-month TFRs between January 2010 and December 2016. TFR is obtained by the sum of each age-specific fertility rate (ASFR) for each age group between 15 and 49.

## 2.2 Meteorological Data

We use gridded meteorological data provided by the E-OBS and freely available in the the Copernicus Data Store (CDS). The E-OBS meteorological data is gathered by a network of weather stations present in Europe and the daily values are interpolated reaching a resolution of 0.1 (Cornes et al., 2018). The meteorological information is available from 1950 to 2021 and on variables such as mean temperature, relative humidity, wind speed, precipitation, and surface shortwave downwelling radiation. In our analysis, we include all such information and construct the province-by-day meteorological measures calculating the average values of the daily grid values falling within the administrative boundaries of each province. Moreover, for the temperature data, we constructed eight temperature bins for each month.[1] and count the number of days per month in which the daily temperature falls within these ranges. Conversely, for the remaining meteorological data we average the daily values to create the monthly mean.

Additionally, we gather monthly information on vegetation provided by the CDS and air pollution estimates distributed by the Atmospheric Compositional Analysis Group(ACAG). The vegetation measure we use is the the Leaf Area Index (LAI) that is a common measure of plant canopy present in a specific area extracted using satellite observations. Conversely, for air pollution we use Particulate Matter 2.5µg/m$^3$ (PM2.5) that is widely used in epidemiological studies focusing on the negative impact of air quality on health. The estimates leverage measurements of local stations and satellite observations combined using chemical transport modelling to cover the whole territory (Hammer et al., 2020). Both the LAI and PM2.5 measurements are at a resolution of 1km grid and we average the values falling within each province to compute the province-monthly estimates.

## 2.3 Empirical Strategy

We use OLS fixed effects models where our outcome of interest is monthly TFR in each province, and our variables of interest are temperature as captured by our temperature bin variables. The

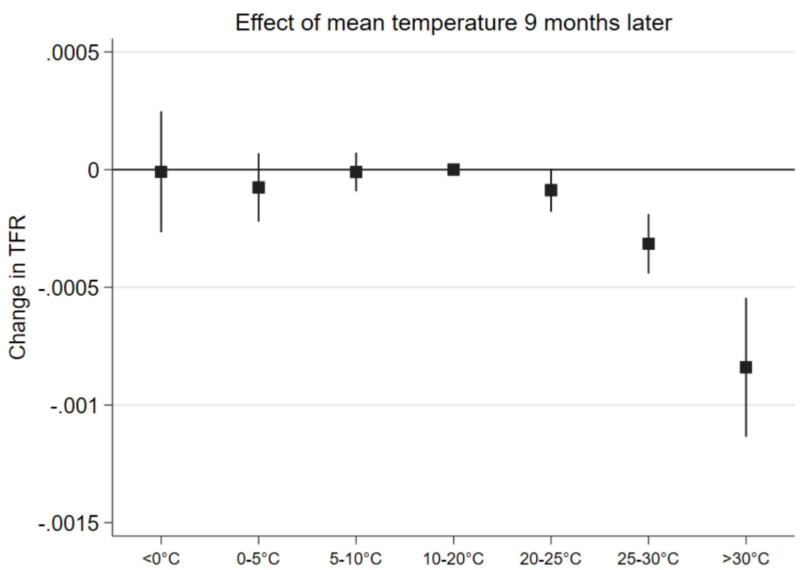
[1] Specifically, $<0$°C; 0 to 5°C; 5 to 10°C; 10 to 15°C; 15 to 20°C; 20 to 25°C; 25 to 30°C; and $>$ 30°C

temperature bin 15-20°C is set at the reference level and is excluded from the model. Moreover, we use province-by-year and province-by-month FE and a quadratic trend for the province century month of conception. Overall, the use of these FE allows us to account for province specific seasonal trends that could bias our estimates and provide a causal estimate of the association.

# 3 Results and Discussion

In figure 1 we show the relationship between the exposure to the temperature bins and TFR. More precisely, we observe a negative effect of hot days on TFR, with the highest estimates observed for the temperature bin > 30°C. In figure 2 we observe the exposure 9 months and 10 months before to be the most critical. Similarly, we observe in figure 3 for the temperature bin 25-30°C. Overall, the results highlight exposure to hot days – but not cold days – decreases TFR nine and ten months later.

Figure 1: Estimated coefficients with 95% confidence intervals of the temperature variables on fertility.




In further analysis, we will investigate the heterogeneous effects of high temperatures on fertility in Spain. More precisely, we will analyse how age and socioeconomic status stratify the effect of temperature on reproductive behavior in the population. Moreover, we will provide predictions on how climate change could further exacerbate the observed effect of temperature on fertility using data on forecasted temperatures based on different climate change scenarios.

Figure 2: Estimated coefficients with 95% confidence intervals of the temperature variable >30°C on fertility.

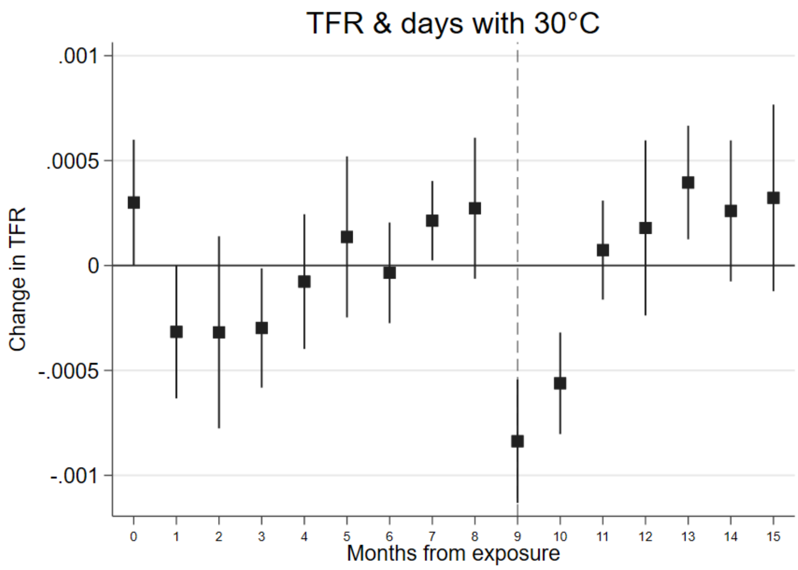
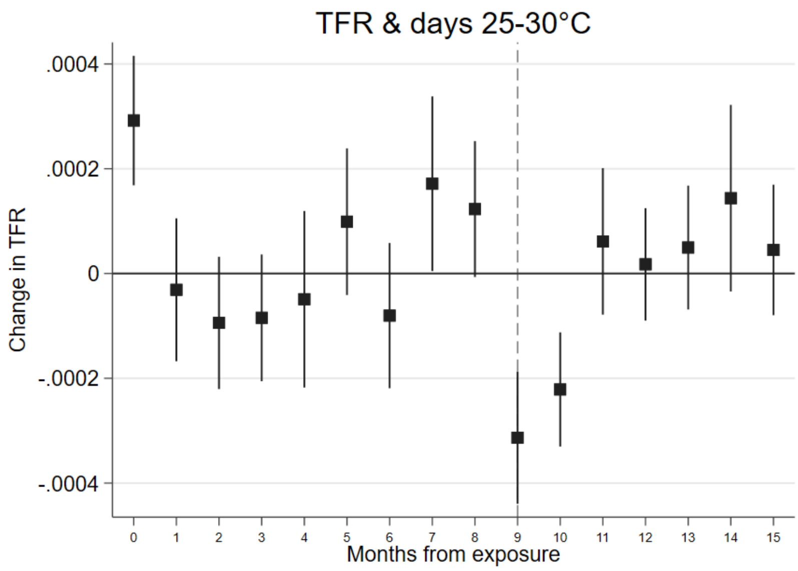



Figure 3: Estimated coefficients with 95% confidence intervals of the temperature variable 25-30°C on fertility.



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