# Too hot to hold: the effects of high temperatures during pregnancy on endowment and adult welfare outcomes

Hu, Zihan and Li, Teng

National University of Singapore, Department of Economics,
National University of Singapore, Department of Economics

1 January 2016

# Too Hot to Hold: The Effects of High Temperatures during Pregnancy on Endowment and Adult Welfare Outcomes

Zihan Hu and Teng Li*

*Department of Economics, National University of Singapore*

February 21, 2016

**Abstract**

We examine the relationships between high temperatures during pregnancy and birth weight and later outcomes using random temperature fluctuations across 131 counties in China. One standard deviation increase of high-temperature days during pregnancy triggers about 0.07 kg lower birth weight, and, in adulthood, a 0.80 cm decrease in height, 0.27 fewer years of schooling, 13.30% less annual earnings, and 8.77%, 10.96%, and 7.31% of one standard deviation lower for evaluated health, word-, and math-test score, respectively. The impacts seem to be concentrated in the second trimester. Such effects should be included in calculations of the costs of global warming. Back-of-the-envelope predictions suggest that at the end of the 21st century, newborns on average will weigh 0.02-0.09 kg less; losses in height and education years will be 0.27-1.05 cm and 0.09-0.35 years, respectively. We also conclude that adverse effects of high temperatures are more likely to be consistent with physiological effects than income effects, because: (i) places with the high proportion of heat-tolerant crop area do not mitigate any estimated temperature sensitivity during pregnancy and (ii) total precipitation and high temperatures in the last year growing season before birth have no significant effects on all outcomes.

*Keywords*: High temperatures during pregnancy, birth weight, adult welfare outcomes, global warming

*Zihan Hu and Teng Li (corresponding author), Department of Economics, National University of Singapore, 1 Arts Link, Singapore 117570. Email: huzihan0716@gmail.com, liteng@u.nus.edu. We thank Alice Chen, Yuyu Chen, Junhong Chu, Olivier Deschenes, Sebastian Galiani, John Ham, Rema Hanna, Jessica Pan, Ivan Png, Slesh Shrestha, Aloysius Siow, Changcheng Song, Xi Xiong, Junjian Yi and Klaus Zimmermann for providing or facilitating helpful comments.

# 1 Introduction

The continued accumulation in the greenhouse gas concentration caused by anthropogenic emissions is associated with global warming. At the end of the 21st century, the average global temperatures are expected to rise by 0.5°F to 8.6°F (Intergovernmental Panel on Climate Change 2013). Estimating the costs that related with these climate changes is of great importance for policy makers to design rational climate change mitigation policies. Although a small set of studies find that hot weather during pregnancy causes adverse effects on birth outcome (Murray et al. 2000; Deschenes et al. 2009), whether the effects are further related to adult outcomes (e.g., health, human capital, etc.) is less known but critical. To fill this gap, in this study we examine the effects of high temperatures on the birth weight, height, health condition, educational attainment, cognitive abilities, and annual income of Chinese born in rural areas between 1950 and 1994.[1]

Combining individual characteristics from the China Family Panel Studies (CFPS) with weather information, we find large effects for high temperatures during pregnancy on birth weight. One standard deviation increase of the number of high-temperature days (around 36 days) leads to a loss of 0.07 kg of birth weight (12.82% of one standard deviation).[2] More importantly, hot weather during pregnancy further triggers significant reductions in adult welfare in multiple dimensions. Adults who experienced one standard deviation more high-temperature days in the prenatal period, are 0.80 cm shorter, attain 0.27 fewer years of schooling, earn 13.30% less annual income, and are 8.77%, 10.96%, and 7.31% of one standard deviation lower for evaluated health, word-, and math-test score. Moreover, the impacts seem to be concentrated in the second trimester.

Such effects, however, have not been taken into account in the costs of global warming yet. Based on the climate projections provided by the National Aeronautics and Space Administration (NASA), we perform back-of-the-envelope predictions for birth- and adult outcomes of individuals born in rural areas of China in 2100. Compared to newborns in 2000, *ceteris paribus*, babies born at the end of the 21st century will weigh 0.02-0.09 kg

[1]Weather information pre-1950 is not available.

[2]The effect on birth weight for individuals born in urban areas is not statistically or economically significant. We therefore focus on a rural sample. See results section for details.

less on average. Further, in adulthood the losses in height and educational attainment will be 0.27-1.05 cm and 0.09-0.35 years, respectively.[3]

We propose two hypotheses that may explain why hot weather affects birth weight. The first explanation draws on evidence from medical research (see Strand et al. 2011 for a detailed review). A pregnant woman may be sensitive to heat stress because: (i) The capacity to lose heat by sweating is lessened due to the reduced ratio of surface area to body mass, (ii) Weight gain triggers more heat production, (iii) The core temperature increases with accumulated fat deposition, and (iv) The increased body composition and metabolic rate of the fetus cause a rise in maternal heat stress (Prentice et al. 1989; Wells and Cole 2002).

Another possibility, referred to as income effects, is that high temperatures affect household resources and nutrition for pregnant women through influencing crop yields– the main income source in rural areas (Hollinger and Angel 2009; Schlenker and Roberts 2009; Burgess et al. 2011). Distinguishing the two possible channels is crucial for policy implications. Two pieces of evidence suggest that income effects are unlikely to be driving our results. First, places with a high proportion of heat-tolerant crop (corn and sugarcane) area do not mitigate any estimated temperature sensitivity during pregnancy. Second, simultaneously controlling for weather conditions during (a) the last year growing season before birth and (b) prenatal period, we find that the former has no significant effect on birth weight or other outcomes.

Our study provides several contributions to the existing literature. First, to our best knowledge, we present the first evidence of the long-term persistent effects of ambient heat shock during the prenatal period on height, health status, schooling years, and other cognitive abilities. Deschenes et al. (2009) use data from 49 states in the US and find that being exposed to days above 85°F during pregnancy has moderate negative effect on birth weight. Whether the effects on birth weight are further related to adult outcomes (e.g., health, human capital, etc.), as the authors claim, is an important–but unanswered– question. In addition, people in developing countries may be more vulnerable to climate

[3]The magnitudes rest on the assumption–when global greenhouse gas emissions peak.

change due to limited access to avoidance behaviors such as air conditioners (Brooks et al. 2005; Feng et al. 2010), which may amplify the impacts of high temperatures. For instance, as late as 2009, each household in rural China owned only 0.12 air conditioning units.[4] Second, our results provide evidence of the potential benefits of greenhouse gas reductions and have important policy implications, especially for developing counties.

Third, our study contributes to a growing literature which studies the relationships between early life conditions and later outcomes (see Currie and Almond 2011 for a comprehensive review). Several influential studies have examined the consequences of early life shocks, such as the influenza pandemic (Almond 2006), famine (Chen and Zhou 2007), civil war (Bundervoet et al. 2009), and hurricanes (Currie and Rossin-Slater 2013), and find that such shocks have persistent and profound effects on well-being in later life. The unusual nature of these events, however, raises concern about the generalizability (Maccini and Yang 2009; Almond and Mazumder 2011). We extend the existing literature by investigating the effects of high temperatures during pregnancy–a typical variation in early life–on birth weight and later outcomes.

Lastly, from a broader perspective, our findings may add to the literature on explaining the positive correlation between latitude and economic development. Many scholars provide convincing evidence that economic activities are correlated with geography indirectly through historical channels (see Wacziarg and Spolaore 2013 for a review). Some studies, however, show alternative direct explanations for such phenomena, e.g., a high burden of disease (Sachs and Malaney 2002) and the pests and parasites that thrive in hot climates (Masters and McMillan 2001). Based on our findings, we may provide another explanation, i.e., high temperatures affect newborn endowment, and further human capital, which is crucial for economic development (Romer 1986).

The next section describes our data and variable definitions. Section III introduces the identification strategy. Section IV presents the main findings, while Section V discusses the possible channels behind the impacts and implements robustness checks. We discuss the implications of our results and conclude in Section VI.

[4]The figure is derived from *China Statistical Yearbook 2010.*

## 2 Data and descriptive analysis

### 2.1 Data source

**Birth weight and welfare outcomes.** Birth weight data is obtained from the China Family Panel Studies (CFPS) 2010, a nationally representative, annual longitudinal survey of Chinese communities, families, and individuals. The studies were launched in 2010 by the Institute of Social Science Survey (ISSS) of Peking University covering 25 provinces, representing 95% of the total population of China (Xie 2012).[5]

The data set provides ample information on demographic status, such as date of birth (month and year), gender, birth place (county), birth order, number of siblings, and parental characteristics–e.g., age, educational attainment, etc. Based on the date of birth, we define each individual's prenatal period as nine months before the birth, or around 270 days in total.[6] The whole period is typically divided into three trimesters. Socio-economic backgrounds information may help us capture family heterogeneity across different areas with different climates.[7]

Many adult outcomes are included in the survey as well–e.g., height, health evaluation, years of schooling, annual income, and word- and math-test score. Two variables reflect individuals' physical conditions: height and health status as evaluated by interviewers. During CFPS conduction, one interviewer is responsible for all objects in one county in general. Therefore, relative to the self-reported health condition, the evaluated health status is more reasonably comparable within each county. Health status ranges from 1 to 7, representing poor to excellent condition. For the sake of interpretation, it is standardized in our empirical analyses. Cognitive abilities are measured by years of schooling and word- and math-test score. In word- and math tests designed by the CFPS, respondents

[5]The 25 provinces are Beijing, Tianjin, Hebei, Shanxi, Liaoning, Jilin, Heilongjiang, Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong, Henan, Hubei, Hunan, Guangdong, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Shaanxi, and Gansu. Figure A.1 in the appendix shows the geographic distribution of the 25 provinces.

[6]The prenatal period is inevitably measured with error, as the exact birthdate and gestational length are not available. The nine-month gestation period is supported by Deschenes et al. (2009). In addition, Patel et al. (2004) find that the median gestational age at delivery is about nine months in Asians. Several robustness checks in the discussion section suggest our results are not sensitive to such measurement error.

[7]For instance, Buckles and Hungerman (2013) find that the relationship between season of birth and later outcomes is driven by maternal characteristics.

are required to read as many Chinese characters as possible and solve basic math questions including arithmetic operation, exponents, logarithms, trigonometric functions, sequence, permutation and combination, etc.[8] The two test scores are standardized as well.

**Temperature and other weather conditions.** The weather data is from the China Meteorological Administration and National Oceanic and Atmospheric Administration (NOAA), including 1509 different weather stations across China. We assign one weather station–the one within 200 meters elevation difference and closest to the county center–to each county. Counties without a weather station within 60 km are excluded.[9] On average, the distance between weather station and county center is about 31.09 km, and the 95th percentile is 57.27 km. Using alternative acceptable matching radii, such as 50 km, 100 km, and 200 km does not change our main results.[10]

To assess the influence of temperature during the prenatal period, the key variable is defined as the number of days with daily maximum temperatures higher than 85°F.[11] Hereafter, we refer simply to "high-temperature" or "hot-weather" days. In our sample, a representative rural pregnant woman is exposed to about 49 hot-weather days out of nine months of pregnancy.

In analysis, we restrict our sample to individuals born in rural areas, which includes 84.05% of the original CFPS sample.[12] Since individuals in rural areas in general work outside frequently and have limited ways to avoid ambient heat, such as air conditioners, they are more likely to suffer from hot weather. Furthermore, observations without exact information on birth place are excluded. The remaining sample contains 3,355 individuals in 131 counties across 25 provinces (see Figure A.1). The 131 counties are matched to 167

[8]See the CFPS (2010) user's manual for a detailed description.

[9]As Figure A.2 shows, we select 60 km as the cutoff point because most of the closest weather stations are within this distance from county center.

[10]Corresponding results are summarized from Table A.2 to Table A.4 in the appendix. We note that the absolute value of most coefficients decreases with matching radii, suggesting that measurement error problem may be exacerbated as matching radii increases.

[11]The definition for high temperatures is similar to Deschenes et al. (2009). Our results are robust to several different temperature thresholds. See main results section for a detailed analysis.

[12]In addition to rural-urban status, we use his or her mother's occupation to identify whether an individual was born in a rural area. If one's mother was a field-crop worker, the individual is also classified as rural. Given the massive rural-urban migration in the last two decades in China, this classification gives us a much larger sample size, compared to using only the rural-urban status of the surveyed place.

weather stations.[13] Sample statistics are summarized in Table 1.

## 2.2 Descriptive regional patterns

If ambient heat stress during the prenatal period is an important determinant of birth weight and further welfare outcomes, we would expect that individuals in warmer regions have lower birth weight and worse welfare outcomes on average. In this subsection, we depict the relationships between temperature, birth weight, and adult outcomes across provinces.

**Birth weight against temperature.** In Figure 1, Panels (a) and (b) plot mean birth weight and low-birth-weight likelihood (<2,500 grams, LBW hereafter) for each province against the number of high-temperature days (>85°F) in a representative gestational period. Relative to the southern provinces (circle markers in Figure 1), provinces in the north (square markers) suffer hot weather less frequently.[14] The regional pattern of birth weight is striking. Typically, babies born in the southern provinces gain less weight, and are more likely to suffer from the LBW. For perspective, Guangdong, Guangxi, and Fujian provinces, located in the southest China, are the warmest areas of China, with around 90 days with a maximum temperature higher than 85°F in a typical year. Compared to a representative baby in China, ones born in these three provinces weigh less by 3.6%, 8.7%, and 11.4%, respectively.

**Temperature against welfare outcomes.** Panels (c)-(f) in Figure 1 suggest that hot weather is further related to welfare losses in adulthood. Panels (c)-(f) plot the mean height, years of schooling, and word- and math-test score, respectively, against the number of hot-weather days for a representative gestational period across provinces.[15] Panel (c) shows that the warmer the area (lower latitudes in general), the more losses in height. This phenomenon in China–the higher the latitude, the taller people–is also documented

[13]In some cases, two weather stations monitor one county's weather conditions in different time periods.

[14]We use an official geographical dividing line–the Huai RiverQin Mountains–to define northern and southern China provinces.

[15]The health evaluations in different provinces are not comparable across provinces, as interviewers are different and probably have different standards for health evaluation. Thus, we do not describe the relationship for health. Beijing is excluded from these panels, since the average schooling years and word- and math-test score of individuals in Beijing are far beyond those in other provinces.

by Buxton (2013). Our findings suggest that low birth weight caused by climate may explain this geographical distribution of height to some extent. Panels (d)-(f) display similar regional patterns for schooling years and word- and math-test score, but with flatter slopes.

## 3 Empirical framework

To exploit how high-temperature exposure during pregnancy affects birth weight and later adult outcomes, we employ the following specification:

$$Y_{ijmt} = \alpha + \beta HighTemp_{ijmt} + X_i\gamma + \mu_j + \mu_j * t + \lambda_t + \eta_m + \epsilon_{ijmt}. \quad (1)$$

Here, $i$ references individual, $j$ presents county, and birth month and year are denoted by $m$ and $t$, respectively. The outcome variables, $Y_{ijmt}$, are birth weight, LBW, and welfare outcomes (height, standardized health evaluation, schooling years, standardized word- and math-test score, and annual income). The variable of interest in equation (1) is $HighTemp_{ijmt}$, the number of hot-weather days during the gestational period. We add a vector of individual characteristics, $X_i$, including gender, birth order, number of siblings, and parental age at delivery and educational attainment, to capture individual heterogeneity.[16] To account for any time-invariant county-level factors, we control for $\mu_j$, a county fixed effect. The vector of the county-specific linear time trend, $\mu_j * t$, are further included, partialling out time-varying characters associated with both dependent and independent variables and are trending linearly during the analysis period. $\lambda_t$ and $\eta_m$ represent birth year and month fixed effects, capturing common shock over years and seasonality patterns. $\epsilon_{ijmt}$ denotes random error term. To allow for the potentially temporal and spatial autocorrelations, standard errors are clustered at the county level.

As suggested by the epidemiological literature, high-temperature exposure in different trimesters may have heterogeneous effects on birth weight. In the following specification,

[16] To avoid sample loss from missing control variables, we impute those missing observations with the sample mean. And we further include corresponding dummy variables indicating missing status in regressions.

we allow for such heterogeneity:

$$Y_{ijmt} \;=\; \alpha + \sum_{T=T_1}^{T_3} \beta_1^T HighTemp_{ijmt}^T + X_i\gamma + \mu_j + \mu_j * t + \lambda_t + \eta_m + \epsilon_{ijmt}, \quad (2)$$

where $HighTemp_{ijmt}^T$ denote the number of hot-weather days in each trimester $T$. $T_1$, $T_2$, and $T_3$ denote the first, second, and third trimester, respectively.

# 4 Main Results

This section reports estimates of the effects of ambient heat stress during pregnancy on birth weight and later-life well-being, such as height, health status, education years, other cognitive abilities, and annual income. Additionally, the heterogeneous effects of high temperatures across trimesters on all outcomes are outlined.

## 4.1 Effect on birth weight

We begin our analysis by presenting the effect of ambient heat during pregnancy on birth weight in Table 2. In columns (1) and (3), we show the effect of high-temperature days on birth weight and LBW incidence for the rural individuals. We find that birth weight is 1.95(=0.0039*500) grams lower for one additional high-temperature day (significant at the 1% level). The effects are not negligible. One standard deviation increase of high-temperature days (36.54 days) leads to a 0.07 kg drop in birth weight, which is about 12.82% of one standard deviation of birth weight.[17] In addition, it increases the risk for LBW by 0.13 percentage points.

To address the concerns about potential omitted variables, we conduct two additional tests to check the validity of the specification. If high-temperature days are considered to be random conditional on those fixed effects, the coefficient should remain unchanged by including demographic controls. The point estimates in columns (2) and (4) are similar to those in columns (1) and (3), respectively. As a more direct test, we regress high-

[17]One concern is that the effect may be tail-driven. Therefore, we winsorize birth weight by 0.1%. Results without winsorizing are similar.

temperature days on individual characteristics with the exact same fixed effects as in the main specification. The coefficients for individual characteristics are far from significant. And the p-value of the joint significance test is 0.34, indicating no explanatory power for those characteristics on high-temperature days. The preceding analyses suggest that our results capture the causal effect of the high-temperature days on birth weight.

In columns (5) and (6), we restrict the sample to those families with multiple children. We create a binary variable, "Youngest", coded as one if a child is the youngest in the family. Its coefficients indicate that the youngest children have better birth outcomes comparing to others. This is possibly because that parents are better at taking care of pregnancy based on their previous pregnancy care experiences. However, another interesting finding is that there seems to be no such learning behavior when it comes to the effects of high temperatures. The interaction terms (Youngest*High Temp Days) are statistically indistinguishable from zero. Such pattern may suggest that in rural China people have not realized the heat effects on newborns or have limited access to avoidance behaviors.

We have thus far defined the "high temperature" as a daily maximum temperature of more than 85°F. We acknowledge that this threshold is arbitrary to some degree. To test the sensitivity of the estimates to the temperature threshold, we apply different thresholds, ranging from 70°F to 90°F. Point estimates and 95% confidence intervals are plotted in Figure 2. The results turn out to be highly robust to different high-temperature day definitions.

### 4.2 Effects on later outcomes

As we find significant effects of high-temperature days on birth weight–a proxy of endowment–it is important to know whether this loss in endowment is serious enough to trigger welfare losses in adulthood.

Columns (1) and (2) in Table 3 show the negative impacts of ambient heat on height and health outcomes. One standard deviation increase in high-temperature days lowers height by 0.80 cm (10.01% of one standard deviation), and decreases evaluated health status by 8.77% of one standard deviation. High-temperature days during pregnancy also have significant effects on cognitive abilities, as measured by schooling years and test scores. The estimates in columns from (3) to (5) in Table 3 show that one standard deviation increase in high-temperature days leads to 0.27 fewer years of schooling (significant at the 10% level) and a 10.96% and 7.31% of one standard deviation decrease in word- and math-test score, respectively. Column (6) indicates that one extra high-temperature day or one standard deviation of high-temperature day is associated with a 0.36(=35.37/9715.96) or 13.30 percent reduction in average annual earnings.[18]

In contrast, high-temperature days have no effect on birth- and later outcomes for urban individuals statistically or economically (even no systematic direction of the impacts and see Table A.1 for related results). This is possibly because living conditions–e.g., housing quality and cooling-tools availability–in urban areas are much better than those in rural areas of China. Also, urban individuals, typically, work outside less intensively and thus are less likely to be exposed to ambient heat directly. Therefore, we will focus on the rural sample from this point on.

Next, we run sensitivity checks by using different definitions of high-temperature days. Panels (a)-(f) in Figure 3 summarize the coefficients and 95% confidence intervals for estimates of height, evaluated health, schooling years, word- and math-test score, and annual income using thresholds from 70°F to 90°F, respectively. As can be seen, the effects of high temperatures during pregnancy are not sensitive to the temperature threshold.

By investigating the effects of ambient heat, we aim to exploit a common shock during pregnancy. If heat adversely affected birth weight only beyond a certain level of accumulated high-temperature days, it would change welfare implications, since great frequency of high-temperature days is not that common. Employing a semi-parametric method, we find no support for the nonlinear effects of high temperatures on birth weight and adult outcomes as displayed in Figure 4.[19] Birth weight, height, evaluated health, schooling years, word- and math-test score, and annual income all decline almost linearly with the number of high-temperature days (fewer than 100 high-temperature days). The

[18]Our sample contains about 16% zero income observations. Replacing the dependent variable with logarithm of income plus one does not change the estimate much.

[19]See the partially linear model in the discussion section for details on the method of semi-parametric regressions.

estimates beyond 100 high-temperature days are not that precise.

### 4.3 Trimester heterogeneity

In subsequent analyses in this section, we allow for heterogeneous effects of ambient heat across trimesters. Table 4 illustrates the effects of high temperatures in each trimester. Column (1) shows that high-temperature days in the second trimester significantly lower birth weight. In addition, one additional hot weather day increases the probability of low birth weight incidence by 0.14 percentage points in both the first and second trimester.

This pattern is, to some extent, consistent across most outcome variables, such as evaluated health, education years, word- and math-test score, and annual income. Heat effects seem larger in the second trimesters on most outcomes. Although the differences between the first (or third) and second trimesters are not statistically significant at traditional levels, they are reasonably large. For perspective, the coefficient of high-temperature days on birth weight in the second trimester is -0.0051–about twice as large as in the first trimester (-0.0026). And such sensitivity to temperature fluctuation during second trimester is also documented by some medical research (Murray et al. 2000; Elter et al. 2004). However, as we do not have precise birth date or gestational length, the trimesters are defined with errors. Therefore, these results should be interpreted cautiously.

## 5 Discussion

### 5.1 Additional temperature measurements

To ensure the preceding results are robust to different temperature measurements, we provide estimates with daily average temperature during pregnancy.[20] We employ partially linear model, allowing the key variable to be nonlinear:

$$Y_{ijmt} = f(X_{ijmt}) + Z\gamma + \epsilon_{ijmt}. \tag{3}$$

[20]We try other measurements as well, e.g., average daily maximum temperature during pregnancy. The results are similar to that using daily average temperature during pregnancy.

where $X_{ijmt}$ represent different temperature measurements during pregnancy, such as daily average temperature and number of hot weather days (in main results section). $f(.)$ is the unspecified nonlinear component, estimated by kernel regression with optimal bandwidth.[21] $Z$ represent other controls and fixed effects in equation (1). To estimate equation (3), we use the Robinson difference estimator (Robinson 1988). As $E(\epsilon|X_{ijmt}, Z) = 0$ implies $E(\epsilon|X_{ijmt}) = 0$, we have:

$$E(Y_{ijmt}|X_{ijmt}) = f(X_{ijmt}) + E(Z|X_{ijmt})\gamma. \tag{4}$$

Combining equations (3) and (4) yields

$$Y_{ijmt} - E(Y_{ijmt}|X_{ijmt}) = (Z - E(Z|X_{ijmt}))\gamma + \epsilon_{ijmt}. \tag{5}$$

The conditional moments are estimated by kernel regression. The OLS estimator of $\gamma$ in equation (5) is $\sqrt{N}$-consistent and asymptotically normal. Equation (4) suggests

$$f(X_{ijmt}) = E(Y_{ijmt}|X_{ijmt}) - E(Z|X_{ijmt})\gamma. \tag{6}$$

Given estimated conditional moments and OLS estimates $\widehat{\gamma}$, $f(.)$ can be consistently estimated by kernel regression. We further perform the significance testing for nonparametric regression proposed by Racine (1997) to check the significant level of the nonparametric relationships.[22]

Panels (a) and (b) of Figure 5 present the birth weight and LBW estimates from equation (3). The y-axis represents the dependent variable partialled out from the parametric fit. The relationships shown in the figure are striking (significant at 1% level): When the daily average temperature during pregnancy rises, birth weight decreases monotonically, and the risk for LBW goes up. The adverse effect increases as temperature goes up, especially after about 55°F.

[21] The Epanechnikov kernel function is applied here.

[22] The null hypothesis of the significance testing is $\frac{\partial E(Y_{ijmt}|X_{ijmt})}{\partial X_{ijmt}} = 0$, i.e., the conditional mean of the dependent variable is orthogonal to the variable of interest.

The effects of high temperatures during pregnancy on adult outcomes are presented in Panels (c)-(h) of Figure 5. All non-parametric relationships are significant at 1% significant level. Once daily average temperature is beyond 60°F, marginal increases in temperature have larger adverse effects on evaluated health, education years, word- and math-test score, and annual income. However, only moderate effects can be detected when average daily maximum temperature is below 60°F.

## 5.2 Physiological vs. income effects

Our results thus far have presented the effects of high temperatures during pregnancy on birth weight and adult outcomes. Two channels may account for such impacts. One possibility is that hot weather has adverse physiological influences on pregnant women due to physical and mental strain.[23] By affecting the pregnant woman's health, heat stress further triggers negative impacts on newborns–e.g., low birth weight. In addition to physiological effects, high temperatures may also cause damage to crop yields (Hollinger and Angel 2009; Schlenker and Roberts 2009; Burgess et al. 2011), which determine family resources in rural areas and influence the newborns endowment through income effects, suggested by Maccini and Yang (2009).

Hollinger and Angel (2009) documents that heat stress is more likely to cause damage to crops when temperatures approach or exceed 32°C (89.6°F). Moreover, the response of crops to hot weather varies. Specifically, C4 plants, including corn, sugarcane, and sorghum, are more adaptable to hot weather due to the efficient way to keep water in hot environment. In contrast, C3 plants (barley, rice, wheat, etc.) are more sensitive to heat stress. Should income effects matter, people living in places where C4 (C3) plants are widely cultivated would be less (more) affected by high temperatures during pregnancy. To test the income channel, we employ the following specification:

$$Y_{ijmt} = \alpha + \beta_1 HighTemp_{ijmt} + \beta_2 C4PlantArea_{pt} + \beta_3 HighTemp_{ijmt} * C4PlantArea_{pt} + X_i\gamma + \mu_j + \mu_j * t + \lambda_t + \eta_m + \epsilon_{ijmt}. \quad (7)$$

[23] For details, see introduction.

Here, $p$ references province. $HighTemp_{ijmt}$ denotes number of days with daily maximum temperature higher than 89.6°F in the first year of life. $C4PlantArea_{pt}$ represents corn and sugarcane area proportion of crop acreage within province.[24] If high temperatures affected people through income channel, we would expect that the coefficient of interaction term $\beta_3$ is significantly positive. As shown in Table 5, the interaction terms are neither statistically significant for any outcomes nor have consistent direction of impacts. And the coefficients for high-temperature days change slightly. The results provide no support for the existence of income effects before birth, consistent with the findings of Maccini and Yang (2009).

Besides temperature, precipitation is another crucial factor for crop yields. If total precipitation in the previous year growing season significantly affected birth weight and other adult outcomes, income effects could not be rules out. To test the effects of weather conditions during growing season, we simultaneously control for high-temperature days during pregnancy and total precipitation during the last year growing season before birth in regressions for all outcomes.[25] We also add high-temperature days during the last year growing season before birth as a control.[26] The first row in Table 6 shows that the coefficients of high-temperature days during pregnancy do not change much, comparing to those in Tables 2 and 3. Also, log rainfall and high temperatures in the last year growing season before birth has no significant impact on any outcome. Based on these results, we conclude that the adverse effects of high temperatures are more likely to be consistent with physiological effects than income effects.

### 5.3 Hot weather in the first year of life

Besides the *in utero* stage, the first few years of life are critical for human capital development as well (Almond et al. 2009; Isen et al. 2014). In this subsection, we explore the

[24]County level plant area data is not available before 1997. Instead, we use the plant area data from Thematic Database for Human-earth System (http://www.data.ac.cn/zrzy/DH55.asp?name=&pass=&danwei=). It provides the plant area of each crop within province from 1949 to 2000. There are two C4 crops (corn and sugarcane) in the dataset. The other 8 crops are C3 plants.

[25]The growing season is from April to September (Deschenes and Greenstone 2007).

[26]The definition of high-temperature days in last year growing season is those with a daily maximum temperature above 89.6°F, similar to that in Table 5.

effects of hot weather in the first year of life on adult outcomes and discuss the possible channels. In regressions, we replace high-temperature days during pregnancy in Equation (7) with those in the first year of life.

As displayed in Table 7, the number of high-temperature days in the first year after birth is negatively associated with all adult outcomes except income. By comparing Table 7 and 5, we notice that the magnitude of the negative effects in the first year after birth is smaller than those *in utero* stage. Interestingly, the positive coefficients of interaction term, except for annual income, indicate that people living in places where the proportion of C4 plant area is high are less affected by heat stress in the first year of life, although not always significantly so. Such evidence implies that high temperatures in the first year of life influence infants possibly through income channel, though we cannot rule out the physiological effects. This finding is similar to what Maccini and Yang (2009) find in their paper, i.e., weather conditions (total precipitation) in the first year of life affect crop yields and further nutrition for children.

### 5.4 Temperature measurement error

Temperature information is obtained from the weather station closest to the birthplace (county's centroid). This measurement may be imperfectly correlated with actual exposure, however, especially for people living far from the weather station. The classical measurement error, in our context, will underestimate these negative effects of high temperatures on all outcomes. To fix this problem, we use temperature information from the second-, third- and fourth-closest weather stations as instruments.[27]

IV estimates are presented in Table 8. Consistent with OLS estimates, coefficients on high-temperature days in IV regressions are statistically significantly different from zero, except for math test score. We notice that the effects of high temperatures on all outcomes are similar to those in OLS estimates. This evidence indicates that temperature measurement error may be not that serious.

To check the sensitivity of our results to the defined gestational length, we switch the

[27]IV estimates are still likely to be understated due to other measurement errors, such as unobserved length of gestational period and misreporting birth month.

nine-month period to eight-month in regressions. Table 9 presents the effects of high-temperature days during the eight months before birth, and we note that most estimates are still statistically significant. The magnitude of some coefficients declines modestly, however, possibly because the eight-month gestational period generates more measurement errors.

### 5.5 Predicting the impacts of climate change on birth weight and adult outcomes

We take our estimated effects of high-temperature days during pregnancy–namely the estimates reported in Tables 2 and 3, and conduct back-of-the-envelope calculations based on climate predictions by NASA with a view to drawing implications from these results. NASA predicts downscaled climate scenarios for the globe by the General Circulation Model (GCM) conducted under the Coupled Model Intercomparison Project Phase 5 (CMIP5).[28] Two of the four greenhouse-gas-emission scenarios, known as Representative Concentration Pathways (RCPs), are included—RCP 4.5 and 8.5.[29] Daily temperature predictions contain projections from 21 climate models and are error-corrected through comparisons performed against the historical data.[30] Hereafter, our predictions rely on the ACCESS1-0 model.[31]

Given that greenhouse gas emissions will peak around 2040 (RCP 4.5 scenario), we predict that, holding all else equal, babies born in rural areas of China in 2100, on average, will weigh 0.02 kg less than those born in 2000 due to global warming. Further, those individuals in adulthood will suffer a 0.27 cm decrease in height and a 0.09 fewer year of schooling. In an even more pessimistic case (RCP 8.5 scenario), birth weight loss will rise

[28]The CMIP5 GCM is supported by the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR5).

[29]The RCPs are possible greenhouse-gas-concentration trajectories adopted by the Intergovernmental Panel on Climate Change (IPCC). Specifically, RCP 4.5 presumes that global annual greenhouse gas emissions (measured in $CO_2$-equivalents) will peak around 2040, then decrease. In RCP 8.5, emissions keep increasing throughout the 21st century.

[30]The 21 models are ACCESS1-0, BCC-CSM1-1, BNU-ESM, CanESM2, CCSM4, CESM1-BGC, CNRM-CM5, CSIRO-MK3-6-0, GFDL-CM3, GFDL-ESM2G, GFDL-ESM2M, INMCM4, IPSL-CM5A-LR, IPSL-CM5A-MR, MIROC-ESM, MIROC-ESM-CHEM, MIROC5, MPI-ESM-LR, MPI-ESM-MR, MRI-CGCM3, and NorESM1-M.

[31]The magnitude of predictions from other models is similar.

sharply to 0.09 kg. Likewise, losses in height and education years will be 1.05 cm and 0.35 years, respectively. The above predictions are based on a strong assumption that all other related factors will remain constant–i.e., the same purchasing power, medical technologies, and access to air conditioners. As other factors are being improved in China, however–especially in rural areas–the effects of global warming may be alleviated.

## 6 Conclusions

In this paper, we find that ambient heat during pregnancy affects birth weight and increases the risk for LBW. We then examine the impacts of high temperatures on height, health status, education attainment, other cognitive abilities, and annual income. The results indicate that high-temperature shocks in early life not only trigger adverse birth outcomes, but have persistent and profound effects on later life. By enduring one additional standard deviation of hot-weather days *in utero* (36.54 days), individuals grow to be 0.80 cm shorter, attain 0.27 fewer years of schooling, earn 13.30% less annual income, and are 8.77%, 10.96%, and 7.31% of one standard deviation lower for evaluated health, word- and math-test score. The impacts seem to be concentrated in the second trimester. Importantly, back-of-the-envelope predictions suggest that at the end of the 21st century, newborns on average will weigh 0.02-0.09 kg less; losses in height and education years will be 0.27-1.05 cm and 0.09-0.35 years, respectively.

In addition, we find the effects of high temperatures are similar across different birth order, implying that people in rural China have limited access to avoidance behaviors or have not realized the heat effects on newborns. This makes our results have important practical significance. We also examine the possible mechanisms behind the adverse effects of hot weather. Since: (i) places with a high proportion of heat-tolerant crops (corn and sugarcane) area do not mitigate any estimated temperature sensitivity during pregnancy and (ii) total precipitation and high temperatures during the last year growing season before birth have no significant effects on both birth weight and later outcomes, we argue that our results are more likely to be driven by physiological effects than income effects.

## References

Almond, D. (2006). Is the 1918 influenza pandemic over? long term effects of in utero influenza exposure in the post 1940 u.s. population. *Journal of Political Economy*, 114(4):672–712.

Almond, D., Edlund, L., and Palme, M. (2009). Chernobyl's subclinical legacy: Prenatal exposure to radioactive fallout and school outcomes in sweden*. *The Quarterly journal of economics*, 124(4):1729–1772.

Almond, D. and Mazumder, B. (2011). Health capital and the prenatal environment: the effect of ramadan observance during pregnancy. *American Economic Journal: Applied Economics*, pages 56–85.

Brooks, N., Adger, W. N., and Kelly, P. M. (2005). The determinants of vulnerability and adaptive capacity at the national level and the implications for adaptation. *Global Environmental Change*, 15(2):151–163.

Buckles, K. S. and Hungerman, D. M. (2013). Season of birth and later outcomes: Old questions, new answers. *Review of Economics and Statistics*, 95(3):711–724.

Bundervoet, T., Verwimp, P., and Akresh, R. (2009). Health and civil war in rural burundi. *Journal of Human Resources*, 44(2):536–563.

Burgess, R., Deschenes, O., Donaldson, D., and Greenstone, M. (2011). Weather and death in india. *Cambridge, United States: Massachusetts Institute of Technology, Department of Economics. Manuscript.*

Buxton, L. D. (2013). *The peoples of Asia*. Routledge.

Chen, Y. and Zhou, L.-A. (2007). The long-term health and economic consequences of the 1959–1961 famine in china. *Journal of Health Economics*, 26(4):659–681.

Currie, J. and Almond, D. (2011). Human capital development before age five. *Handbook of Labor Economics*, 4:1315–1486.

Currie, J. and Rossin-Slater, M. (2013). Weathering the storm: Hurricanes and birth outcomes. *Journal of Health Economics*, 32(3):487–503.

Deschenes, O. and Greenstone, M. (2007). The economic impacts of climate change: evidence from agricultural output and random fluctuations in weather. *The American Economic Review*, pages 354–385.

Deschenes, O., Greenstone, M., and Guryan, J. (2009). Climate change and birth weight. *The American Economic Review*, pages 211–217.

Elter, K., Ay, E., Uyar, E., and Kavak, Z. N. (2004). Exposure to low outdoor temperature in the midtrimester is associated with low birth weight. *Australian and New Zealand Journal of Obstetrics and Gynaecology*, 44(6):553–557.

Feng, S., Krueger, A. B., and Oppenheimer, M. (2010). Linkages among climate change, crop yields and mexico–us cross-border migration. *Proceedings of the National Academy of Sciences*, 107(32):14257–14262.

Hollinger, S. and Angel, J. (2009). Illinois agronomy handbook. *Urbana, IL: University of Illinois Extension*, page 224.

Intergovernmental Panel on Climate Change, A. (2013). Climate change 2013: The physical science basis.

Isen, A., Rossin-Slater, M., and Walker, W. R. (2014). Every breath you take-every dollar you'll make: The long-term consequences of the clean air act of 1970.

Maccini, S. and Yang, D. (2009). Under the weather: Health, schooling, and economic consequences of early-life rainfall. *The American Economic Review*, 99(3):1006–1026.

Masters, W. A. and McMillan, M. S. (2001). Climate and scale in economic growth. *Journal of Economic Growth*, 6(3):167–186.

Murray, L. J., O'reilly, D., Betts, N., Patterson, C., Smith, G. D., and Evans, A. (2000). Season and outdoor ambient temperature: effects on birth weight. *Obstetrics & Gynecology*, 96(5, Part 1):689–695.

Patel, R. R., Steer, P., Doyle, P., Little, M. P., and Elliott, P. (2004). Does gestation vary by ethnic group? a london-based study of over 122 000 pregnancies with spontaneous onset of labour. *International Journal of Epidemiology*, 33(1):107–113.

Prentice, A., Goldberg, G., Davies, H., Murgatroyd, P., and Scott, W. (1989). Energy-sparing adaptations in human pregnancy assessed by whole-body calorimetry. *British Journal of Nutrition*, 62(01):5–22.

Racine, J. (1997). Consistent significance testing for nonparametric regression. *Journal of Business and Economic Statistics*, 15(3):369–378.

Robinson, P. M. (1988). Root-n-consistent semiparametric regression. *Econometrica: Journal of the Econometric Society*, pages 931–954.

Romer, P. M. (1986). Increasing returns and long-run growth. *The Journal of Political Economy*, pages 1002–1037.

Sachs, J. and Malaney, P. (2002). The economic and social burden of malaria. *Nature*, 415(6872):680–685.

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

Strand, L. B., Barnett, A. G., and Tong, S. (2011). The influence of season and ambient temperature on birth outcomes: a review of the epidemiological literature. *Environmental Research*, 111(3):451–462.

Wacziarg, R. and Spolaore, E. (2013). How deep are the roots of economic development? *Journal of Economic Literature*, 51(2):325.

Wells, J. C. and Cole, T. J. (2002). Birth weight and environmental heat load: a between-population analysis. *American Journal of Physical Anthropology*, 119(3):276–282.

Xie, Y. (2012). The user's guide of the china family panel studies (2010). *Beijing: Institute of Social Science Survey, Peking University.*

Table 1: Summary statistics

| Variable | Mean | Std. Dev. | Min. | Max. | N |
|---|---|---|---|---|---|
| Birth Weight (500 grams) | 5.93 | 1.14 | 2 | 12 | 3355 |
| Low Birth Weight Dummy ($<$2,500 grams) | 0.1 | 0.29 | 0 | 1 | 3355 |
| Height (cm) | 164.62 | 7.94 | 65 | 197 | 3355 |
| Standardized Health Evaluation | 0 | 1 | -3.77 | 1.26 | 3355 |
| Education Years | 7.23 | 3.98 | 0 | 16 | 3355 |
| Standardized Word-test Score | 0 | 1 | -2.14 | 1.44 | 3355 |
| Standardized Math-test Score | 0 | 1 | -1.91 | 1.89 | 3355 |
| Annual Income (2010 CNY) | 9715.96 | 13628.08 | 0 | 240000 | 2944 |
| Age | 33.8 | 11.87 | 16 | 60 | 3355 |
| Female | 0.47 | 0.5 | 0 | 1 | 3355 |
| Mother's Education Years | 2.91 | 3.7 | 0 | 16 | 3355 |
| Mother's Age at Birth | 26.85 | 5.91 | 14 | 58 | 3355 |
| Father's Education Years | 5.01 | 4.07 | 0 | 16 | 3355 |
| Father's Age at Birth | 29.31 | 6.61 | 16 | 78 | 3355 |
| Birth Order | 2.08 | 1.44 | 1 | 10 | 3355 |
| Number of Siblings | 2.37 | 1.79 | 0 | 13 | 3355 |
| High Temp Days | 49.45 | 36.55 | 0 | 175 | 3355 |
| High Temp Days (1st trimester) | 15.02 | 21.5 | 0 | 89 | 3355 |
| High Temp Days (2nd trimester) | 17.17 | 22.76 | 0 | 90 | 3355 |
| High Temp Days (3rd trimester) | 17.26 | 23.26 | 0 | 88 | 3355 |

Notes: The sample contains 3,355 individuals in 131 counties across 25 provinces. All individuals in the sample were born in rural areas. High-temperature days are defined as those with a daily maximum temperature higher than 85°F. For convenience of interpretation, evaluated health condition and math- and word-test score are standardized. In the sample, 411 individuals did not report annual income. 167 weather stations are assigned to the 131 counties. In some cases, two weather stations monitor one county's weather conditions in different time periods.

Table 2: The impacts of high temperatures during pregnancy on birth weight

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Dependent Variable | Birth Weight | Birth Weight | LBW | LBW | Birth Weight | LBW |
| High Temp Days | -0.0039*** | -0.0038*** | 0.0013*** | 0.0013*** | -0.0039** | 0.0013*** |
| | (0.0014) | (0.0014) | (0.0004) | (0.0004) | (0.0015) | (0.0004) |
| Youngest Child | | | | | 0.1933** | -0.0527** |
| | | | | | (0.0927) | (0.0259) |
| Youngest*High Temp Days | | | | | -0.0006 | 0.0004 |
| | | | | | (0.0015) | (0.0004) |
| Female | | -0.2821*** | | 0.0111 | -0.2677*** | 0.0090 |
| | | (0.0400) | | (0.0108) | (0.0420) | (0.0112) |
| Mother's Education Years | | 0.0093 | | -0.0022 | 0.0096 | -0.0018 |
| | | (0.0062) | | (0.0016) | (0.0071) | (0.0019) |
| Mother's Age at Birth | | -0.0048 | | 0.0016 | -0.0053 | 0.0018 |
| | | (0.0056) | | (0.0017) | (0.0066) | (0.0019) |
| Father's Education Years | | 0.0082 | | -0.0028* | 0.0081 | -0.0025 |
| | | (0.0061) | | (0.0016) | (0.0067) | (0.0018) |
| Father's Age at Birth | | -0.0033 | | 0.0005 | -0.0030 | 0.0003 |
| | | (0.0049) | | (0.0015) | (0.0053) | (0.0016) |
| Birth Order | | 0.0586** | | -0.0096 | | |
| | | (0.0263) | | (0.0078) | | |
| Number of Siblings | | -0.0504** | | 0.0030 | -0.0147 | -0.0038 |
| | | (0.0211) | | (0.0061) | (0.0179) | (0.0058) |
| County FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Cohort FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Birth Month FE | Yes | Yes | Yes | Yes | Yes | Yes |
| County-Specific Linear Trend | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 3355 | 3355 | 3355 | 3355 | 3008 | 3008 |
| R-Squared | 0.266 | 0.286 | 0.199 | 0.206 | 0.284 | 0.209 |

Notes: An observation is an individual born in a rural area. In columns (5) and (6), 347 one-child families are excluded. High-temperature days are defined as with daily maximum temperature higher than 85°F. Ordinary least squares estimates for all columns. Standard errors in parentheses, clustered by county. ***Significant at 1%, **significant at 5%, *significant at 10%.

Table 3: The impacts of high temperatures during pregnancy on adult outcomes

| Dependent Variable | (1)<br>Height | (2)<br>Health | (3)<br>Education | (5)<br>Word-test | (6)<br>Math-test | (4)<br>Income |
|---|---|---|---|---|---|---|
| High Temp Days | -0.0219*** | -0.0024** | -0.0074* | -0.0030** | -0.0020* | -35.3650** |
| | (0.0074) | (0.0011) | (0.0043) | (0.0013) | (0.0011) | (16.2898) |
| Female | -10.1294*** | -0.1925*** | -0.9162*** | -0.2396*** | -0.2681*** | -6,614.4116*** |
| | (0.2654) | (0.0390) | (0.1590) | (0.0456) | (0.0457) | (657.0830) |
| Mother's Education Years | 0.0804** | 0.0151*** | 0.1208*** | 0.0221*** | 0.0276*** | 156.0700* |
| | (0.0355) | (0.0055) | (0.0196) | (0.0045) | (0.0048) | (91.9736) |
| Mother's Age at Birth | 0.0060 | 0.0001 | 0.0312* | -0.0010 | 0.0071 | -3.6918 |
| | (0.0376) | (0.0044) | (0.0171) | (0.0049) | (0.0046) | (77.3887) |
| Father's Education Years | 0.0097 | 0.0094* | 0.1294*** | 0.0254*** | 0.0311*** | 160.4061** |
| | (0.0339) | (0.0048) | (0.0190) | (0.0044) | (0.0047) | (62.4441) |
| Father's Age at Birth | 0.0125 | 0.0014 | -0.0194 | 0.0023 | -0.0054 | -48.5715 |
| | (0.0398) | (0.0040) | (0.0154) | (0.0043) | (0.0041) | (57.7561) |
| Birth Order | -0.0011 | 0.0051 | 0.0864 | -0.0272 | 0.0004 | 382.5112 |
| | (0.1180) | (0.0228) | (0.0756) | (0.0199) | (0.0189) | (323.0805) |
| Number of Siblings | -0.0044 | 0.0007 | -0.0800 | 0.0339* | -0.0010 | -338.8402 |
| | (0.1067) | (0.0189) | (0.0640) | (0.0177) | (0.0164) | (245.6708) |
| County FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Cohort FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Birth Month FE | Yes | Yes | Yes | Yes | Yes | Yes |
| County-Specific Linear Trend | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 3355 | 3355 | 3355 | 3355 | 3355 | 2944 |
| R-Squared | 0.560 | 0.402 | 0.434 | 0.432 | 0.418 | 0.293 |

Notes: An observation is an individual born in a rural area. High-temperature days are defined as ones with daily maximum temperature higher than 85°F. The dependent variables of column from (1) to (6) are height, standardized evaluated health, education years, standardized word-test score, standardized math-test score, and annual income, respectively. Ordinary least squares estimates for all columns. Standard errors in parentheses, clustered by county. ***Significant at 1%, **significant at 5%, *significant at 10%.

Table 4: The impacts of high temperatures during pregnancy on birth weight and adult outcomes by trimester

| | (1) | (2) | (3) | (4) | (5) | (7) | (8) | (6) |
|---|---|---|---|---|---|---|---|---|
| Dependent Variable | Birth Weight | LBW | Height | Health | Education | Word-test | Math-test | Income |
| High Temp Days (1st trimester) | -0.0026 | 0.0014** | -0.0222* | -0.0009 | -0.0025 | -0.0026 | -0.0015 | -12.4171 |
| | (0.0019) | (0.0006) | (0.0130) | (0.0017) | (0.0061) | (0.0016) | (0.0017) | (29.2571) |
| High Temp Days (2nd trimester) | -0.0051*** | 0.0014** | -0.0258*** | -0.0032*** | -0.0122** | -0.0033** | -0.0025* | -56.4659*** |
| | (0.0018) | (0.0005) | (0.0088) | (0.0012) | (0.0052) | (0.0015) | (0.0014) | (18.9256) |
| High Temp Days (3rd trimester) | -0.0014 | 0.0007 | -0.0109 | -0.0016 | 0.0008 | -0.0025 | -0.0010 | -1.3589 |
| | (0.0020) | (0.0005) | (0.0126) | (0.0021) | (0.0065) | (0.0018) | (0.0015) | (32.8863) |
| Demographic Controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| County FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Cohort FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Birth Month FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| County-Specific Linear Trend | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 3355 | 3355 | 3355 | 3355 | 3355 | 3355 | 3355 | 2944 |
| R-Squared | 0.286 | 0.207 | 0.560 | 0.403 | 0.434 | 0.433 | 0.418 | 0.294 |
| P-value (1st=2nd) | 0.275 | 0.979 | 0.818 | 0.267 | 0.166 | 0.646 | 0.558 | 0.200 |
| P-value (3rd=2nd) | 0.121 | 0.366 | 0.292 | 0.487 | 0.085 | 0.653 | 0.388 | 0.168 |

Notes: An observation is an individual born in a rural area. High temperature days are defined as ones with daily maximum temperature higher than 85°F. Each trimester consists of three months. The dependent variables of column from (1) to (6) are height, standardized evaluated health, education years, standardized word-test score, standardized math-test score, and annual income, respectively. Demographic controls include gender, birth order, number of siblings, and parents' education years and age at delivery. Ordinary least squares estimates. Standard errors in parentheses, clustered by county. ***Significant at 1%, **significant at 5%, *significant at 10%.

Table 5: Does high proportion of heat-tolerant crops mitigate the adverse effects of high temperatures during pregnancy on all outcomes?

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| Dependent Variable | Birth weight | LBW | Height | Health | Education | Word-test | Math-test | Income |
| High Temp Days | -0.0030 | 0.0017*** | -0.0196* | -0.0026 | -0.0086* | -0.0041*** | -0.0030** | -56.6123** |
| | (0.0019) | (0.0005) | (0.0101) | (0.0016) | (0.0051) | (0.0014) | (0.0013) | (25.4483) |
| C4 Plant Area(%) | 1.3857 | -0.1651 | -5.1040 | -0.5213 | -8.8786*** | -1.7134** | -1.0210 | 8,698.6962 |
| | (1.0135) | (0.2945) | (5.6749) | (1.0110) | (3.2368) | (0.8065) | (0.7678) | (7,594.0710) |
| High Temp Days*C4 Plant Area(%) | -0.0054 | -0.0048 | -0.0849 | 0.0073 | 0.0405 | 0.0132 | 0.0130 | 122.4388 |
| | (0.0164) | (0.0038) | (0.0805) | (0.0104) | (0.0531) | (0.0135) | (0.0129) | (213.3299) |
| Demographic Controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| County FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Cohort FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Birth Month FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| County-Specific Linear Trend | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 3352 | 3352 | 3352 | 3352 | 3352 | 3352 | 3352 | 2944 |
| R-Squared | 0.285 | 0.207 | 0.561 | 0.402 | 0.435 | 0.433 | 0.417 | 0.294 |

Notes: An observation is an individual born in a rural area. C4 Plant Area represents corn and sugarcane area proportion of crop acreage within province. High-temperature days are defined as ones with daily maximum temperature higher than 89.6°F. Three observations are missed from the main regression sample, because crop area information is somehow missing for Shanghai in 1993. Demographic controls include gender, birth order, number of siblings, and parents' education years and age at delivery. Ordinary least squares estimates. Standard errors in parentheses, clustered by county. ***Significant at 1%, **significant at 5%, *significant at 10%.

Table 6: The effects of precipitation and high temperatures in the last year growing season before birth on all outcomes

| Dependent Variable | (1)<br>Birth Weight | (2)<br>LBW | (3)<br>Height | (4)<br>Health | (5)<br>Education | (7)<br>Word-test | (8)<br>Math-test | (6)<br>Income |
|---|---|---|---|---|---|---|---|---|
| High Temp Days | -0.0033** | 0.0009* | -0.0197** | -0.0022* | -0.0082 | -0.0028* | -0.0022* | -36.3377** |
| | (0.0015) | (0.0005) | (0.0093) | (0.0011) | (0.0053) | (0.0015) | (0.0013) | (18.1924) |
| Prec. in Growing Season(-1) | 0.0172 | -0.0026 | 0.6329 | 0.0484 | 0.1854 | -0.0033 | -0.0089 | -8.3782 |
| | (0.0753) | (0.0201) | (0.4616) | (0.0647) | (0.2230) | (0.0687) | (0.0641) | (1,122.0235) |
| HTD in Growing Season(-1) | -0.0015 | 0.0011 | -0.0028 | -0.0014 | 0.0010 | -0.0020 | -0.0010 | 13.3250 |
| | (0.0017) | (0.0010) | (0.0135) | (0.0018) | (0.0059) | (0.0017) | (0.0017) | (31.9036) |
| Demographic Controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| County FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Cohort FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Birth Month FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| County-Specific Linear Trend | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 3207 | 3207 | 3207 | 3207 | 3207 | 3207 | 3207 | 2802 |
| R-Squared | 0.295 | 0.212 | 0.562 | 0.408 | 0.434 | 0.428 | 0.414 | 0.298 |

Notes: An observation is an individual born in a rural area. HTD in Growing Season(-1) means high-temperature days ( $89.6^\circ$F) in the last year growing season. Prec. in Growing Season(-1) denotes log precipitation in the last year growing season. High-temperature days are defined as ones with daily maximum temperature higher than $89.6^\circ$F. 147 observations are missed from the main regression sample, because weather information before their birth years is not available. Demographic controls include gender, birth order, number of siblings, and parents' education years and age at delivery. Ordinary least squares estimates. Standard errors in parentheses, clustered by county. $^{***}$Significant at 1%, $^{**}$significant at 5%, $^{*}$significant at 10%.

Table 7: The effects of high temperatures in the first year of life on later outcomes

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Dependent Variable | Height | Health | Education | Word-test | Math-test | Income |
| High Temp Days(+1) | -0.0009 | -0.0053*** | -0.0065 | -0.0036* | -0.0023 | 3.6787 |
| | (0.0113) | (0.0018) | (0.0083) | (0.0022) | (0.0020) | (29.5836) |
| C4 Plant Area(%) | -7.8861 | -1.2012 | -9.6311*** | -2.0976*** | -1.1814 | 15,210.4087 |
| | (5.9337) | (1.0494) | (3.3865) | (0.7932) | (0.7761) | (9,974.7403) |
| C4 Plant Area(%)*High Temp Days(+1) | 0.0364 | 0.0402** | 0.0703 | 0.0293* | 0.0190 | -257.4117 |
| | (0.1077) | (0.0160) | (0.0680) | (0.0169) | (0.0178) | (300.8619) |
| Demographic Controls | Yes | Yes | Yes | Yes | Yes | Yes |
| County FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Cohort FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Birth Month FE | Yes | Yes | Yes | Yes | Yes | Yes |
| County-Specific Linear Trend | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 3350 | 3350 | 3350 | 3350 | 3350 | 2942 |
| R-Squared | 0.559 | 0.402 | 0.435 | 0.432 | 0.417 | 0.293 |

Notes: An observation is an individual born in a rural area. C4 Plant Area represents corn and sugarcane area proportion of crop acreage within province. High Temp Days(+1) is defined as number of days with daily maximum temperature higher than 89.6°F in the first year of life. Five observations are missed from the main regression sample due to missing weather or crop data. Demographic controls include gender, birth order, number of siblings, and parents' education years and age at delivery. Ordinary least squares estimates. Standard errors in parentheses, clustered by county. ***Significant at 1%, **significant at 5%, *significant at 10%.

Table 8: IV estimates of high temperatures on birth weight and adult outcomes

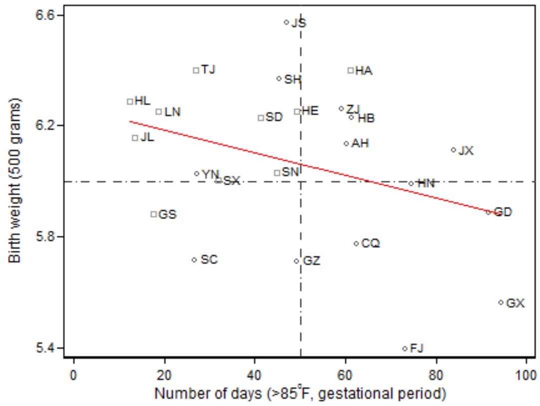
| Dependent Variable | (1) Birth weight | (2) LBW | (3) Height | (4) Health | (5) Education | (6) Word-test | (7) Math-test | (8) Income |
|---|---|---|---|---|---|---|---|---|
| High Temp Days | -0.0033* | 0.0012*** | -0.0220*** | -0.0020** | -0.0111** | -0.0032** | -0.0018 | -52.3305** |
| | (0.0019) | (0.0004) | (0.0071) | (0.0010) | (0.0056) | (0.0015) | (0.0012) | (24.1350) |
| Demographic Controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| County FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Cohort FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Birth Month FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| County-Specific Linear Trend | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 3009 | 3009 | 3009 | 3009 | 3009 | 3009 | 3009 | 2622 |
| R-Squared | 0.296 | 0.217 | 0.572 | 0.402 | 0.421 | 0.415 | 0.416 | 0.295 |

Notes: An observation is an individual born in a rural area from 127 counties across 25 provinces. High-temperature days are defined as ones with daily maximum temperature higher than 85°F. We use the weather information from the second-, third-, and fourth-closest weather stations as IVs to run 2SLS. Counties without four weather stations within 200 km are excluded form the main sample. Demographic controls include gender, birth order, number of siblings, and parents' education years and age at delivery. Standard errors in parentheses, clustered by county. ***Significant at 1%, **significant at 5%, *significant at 10%.

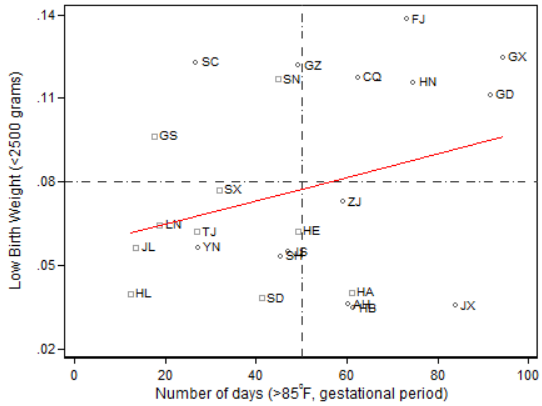
Table 9: The effects of high temperature during eight months before birth on all outcomes

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| Dependent Variable | Birth Weight | LBW | Height | Health | Education | Word-test | Math-test | Income |
| High Temp Days | -0.0027** | 0.0009** | -0.0180*** | -0.0026** | -0.0071* | -0.0029** | -0.0018* | -36.4256*** |
| | (0.0013) | (0.0004) | (0.0067) | (0.0010) | (0.0041) | (0.0012) | (0.0011) | (13.7918) |
| Demographic Controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| County FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Cohort FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Birth Month FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| County-Specific Linear Trend | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 3355 | 3355 | 3355 | 3355 | 3355 | 3355 | 3355 | 2944 |
| R-Squared | 0.285 | 0.205 | 0.560 | 0.403 | 0.434 | 0.433 | 0.418 | 0.293 |

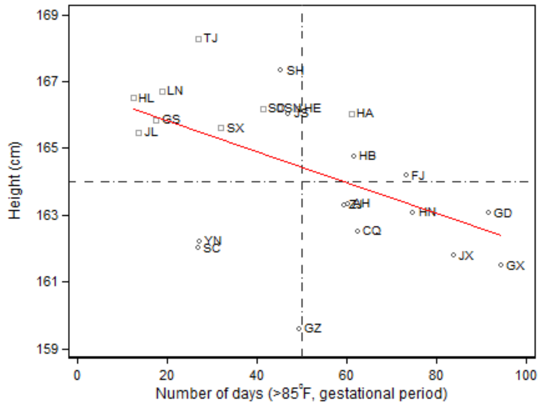
Notes: An observation is an individual born in a rural area. High temperature days are defined as ones with daily maximum temperature higher than 85°F during the eight months before birth. Demographic controls include gender, birth order, number of siblings, and parents' education years and age at delivery. Ordinary least squares estimates. Standard errors in parentheses, clustered by county. ***Significant at 1%, **significant at 5%, *significant at 10%.



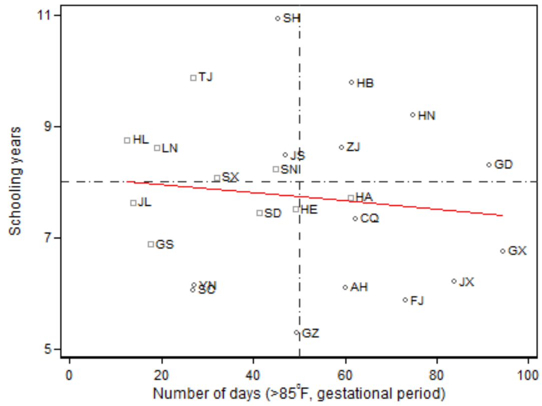

(a) Birth weight



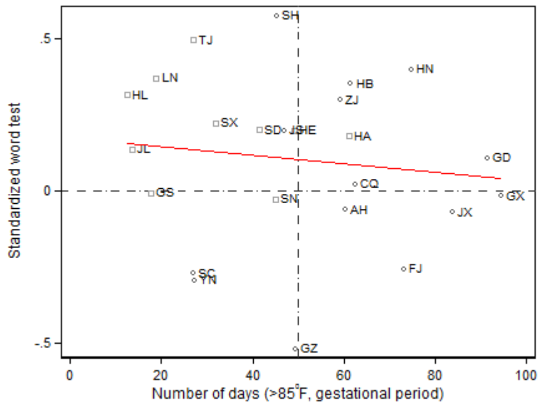

(b) LBW



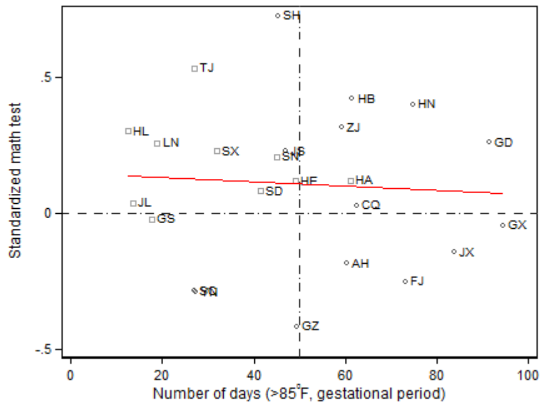

(c) Height




(d) Education years

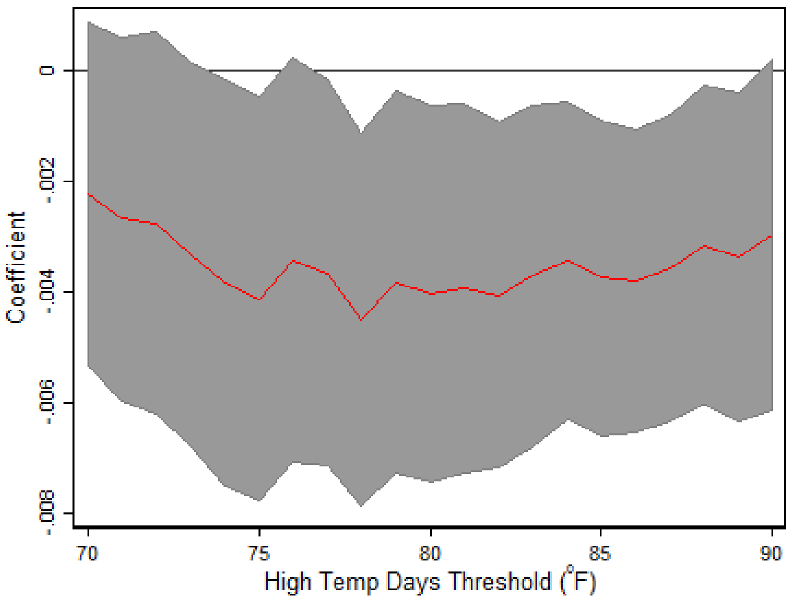



(e) Word-test score

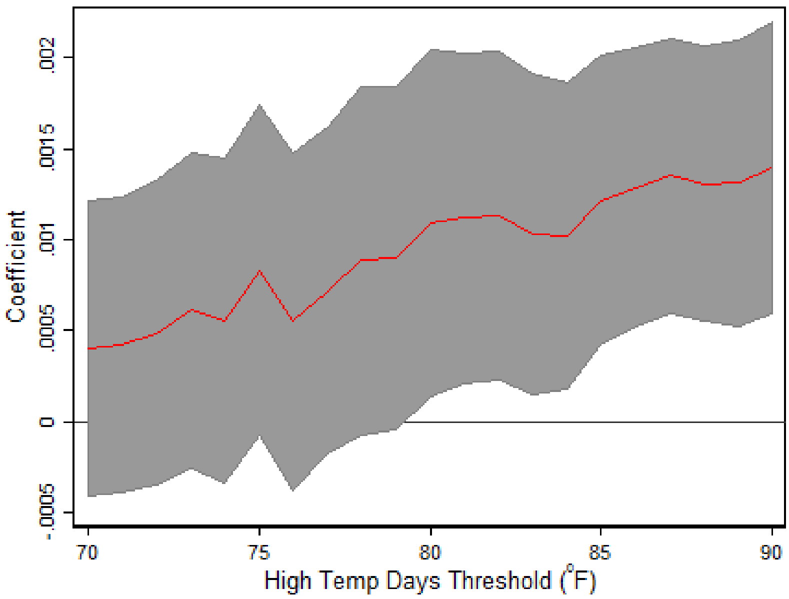



(f) Math-test score

Figure 1: Birth weight and adult outcomes against number of high-temperature days (>85°F) for typical gestational period by province. Square and circle markers represent provinces in the north and south, respectively.

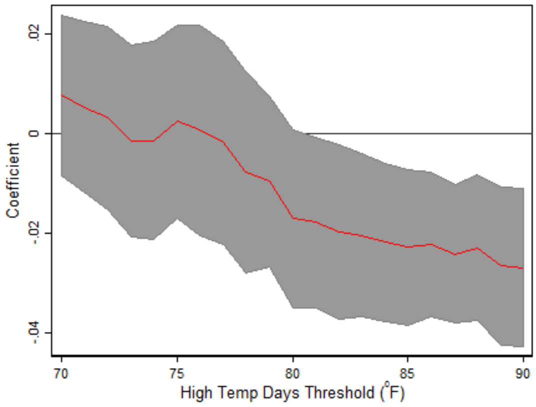



(a) Birth Weight

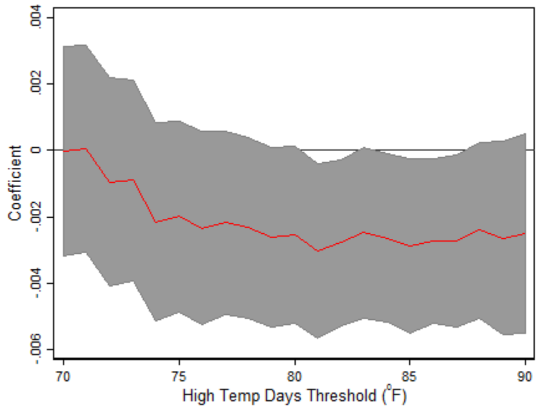



(b) LBW

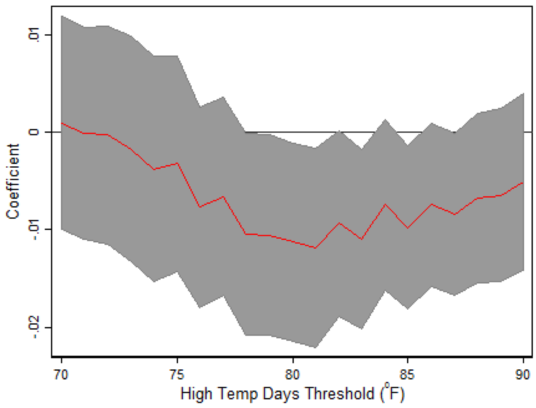
Figure 2: The coefficients of high temperature days (>85°F) on birth weight (500 grams) and LBW incidence from regressions using different definitions of high-temperature day. The red line denotes the point estimates on different high-temperature day thresholds. The gray area presents 95% confidence interval.



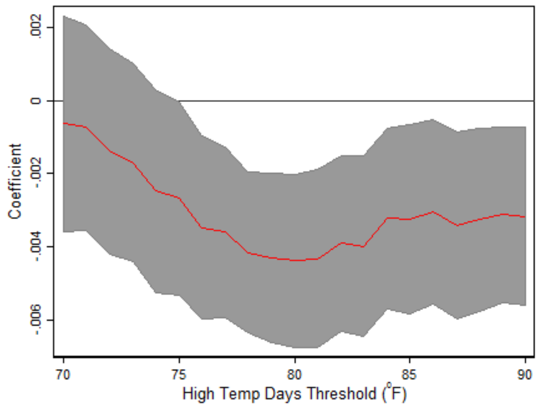

(a) Height



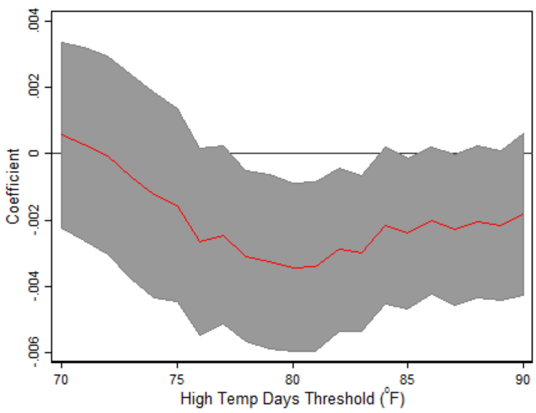

(b) Evaluated health



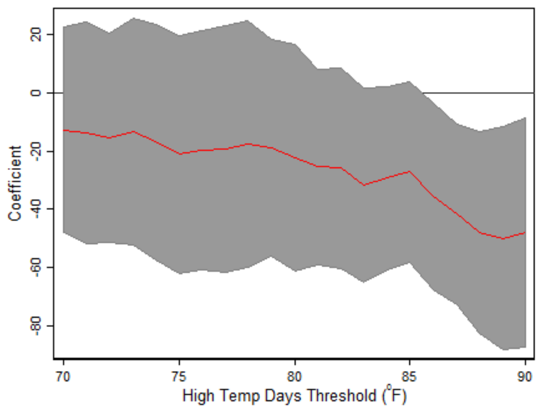

(c) Schooling years




(d) Word-test score

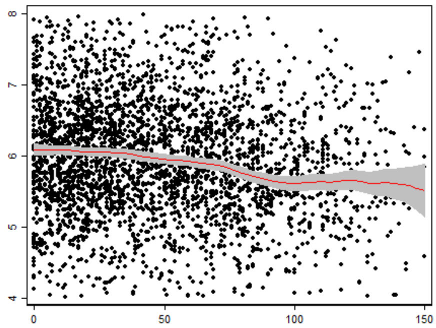



(e) Math-test score

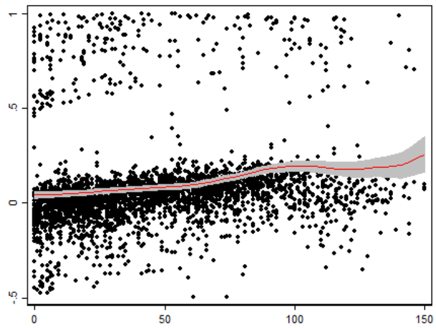



(f) Income

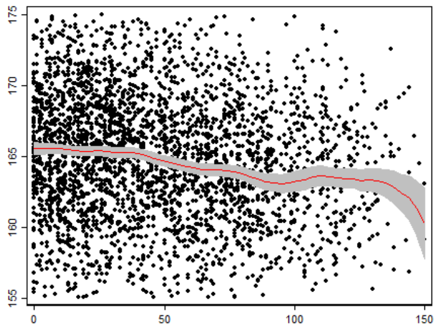
Figure 3: Coefficients of high-temperature days (>85°F) on adult outcomes from regressions using different definitions of high-temperature day. The red line denotes the point estimates on different high-temperature-day thresholds. The gray area denotes the 95% confidence interval.



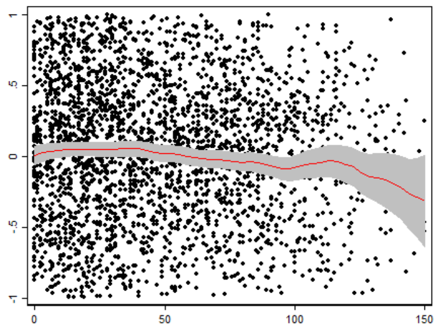
(a) Birth weight



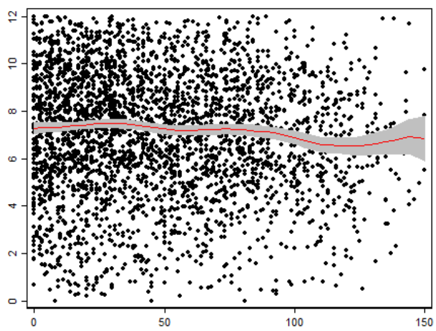
(b) LBW



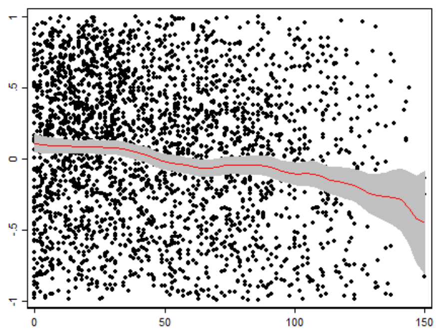
(c) Height



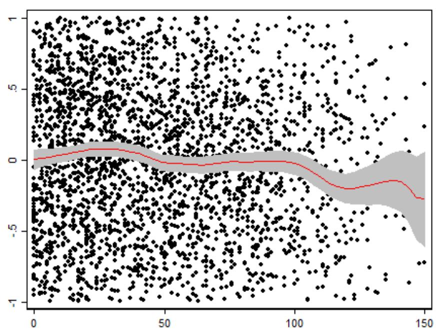
(d) Evaluated Health



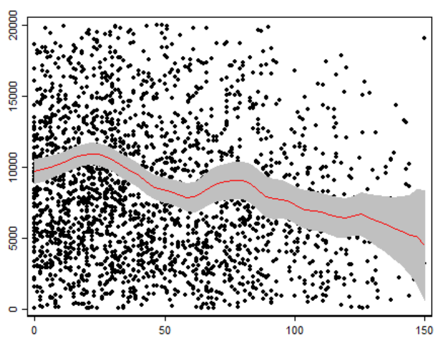
(e) Schooling years



(f) Word-test score

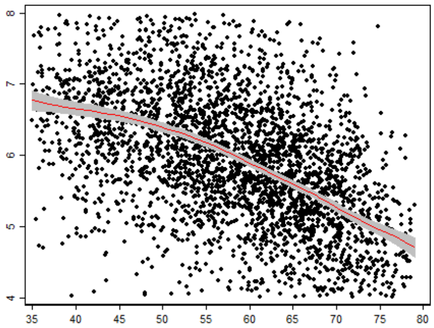


(g) Math-test score

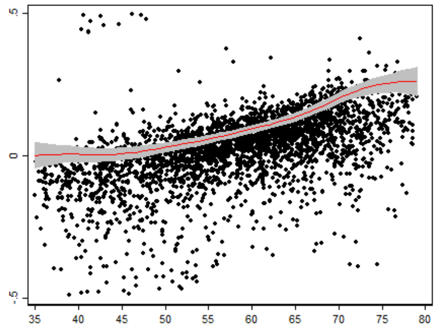


(h) Income

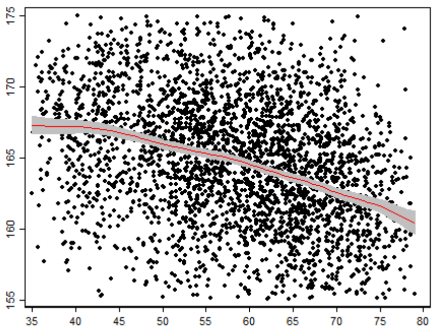
Figure 4: High-temperature days (>85°F) during pregnancy against birth weight and adult outcomes. Specifications: The solid line shows the fitted partially linear model, and the gray area denotes the 95% confidence interval.



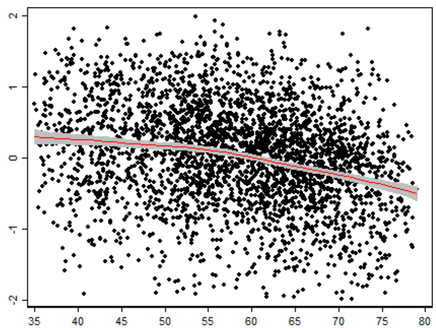
(a) Birth Weight



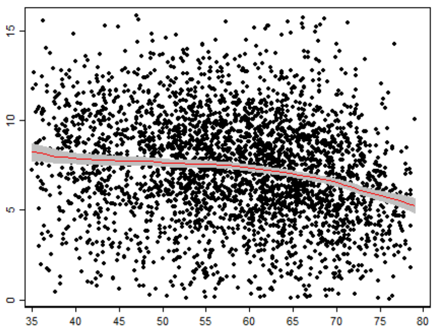
(b) LBW



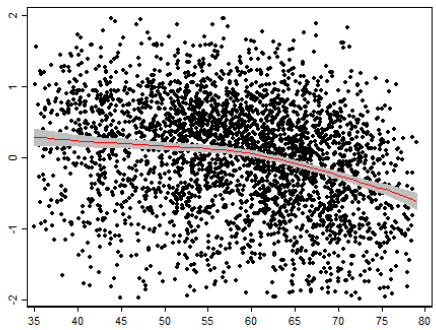
(c) Height



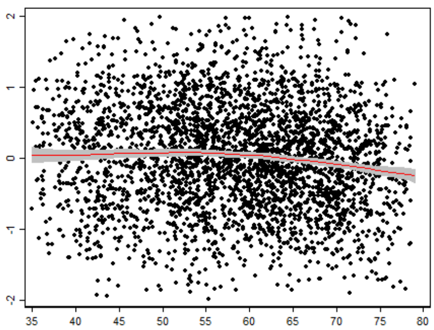
(d) Evaluated Health



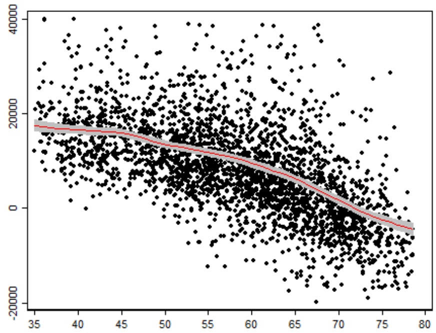
(e) Schooling years



(f) Word-test score



(g) Math-test score



(h) Income

Figure 5: Daily average temperature (°F) during pregnancy against birth weight and adult outcomes. Specifications: The solid line shows fitted partially linear model, the gray area presents 95% confidence interval.

# A Appendix

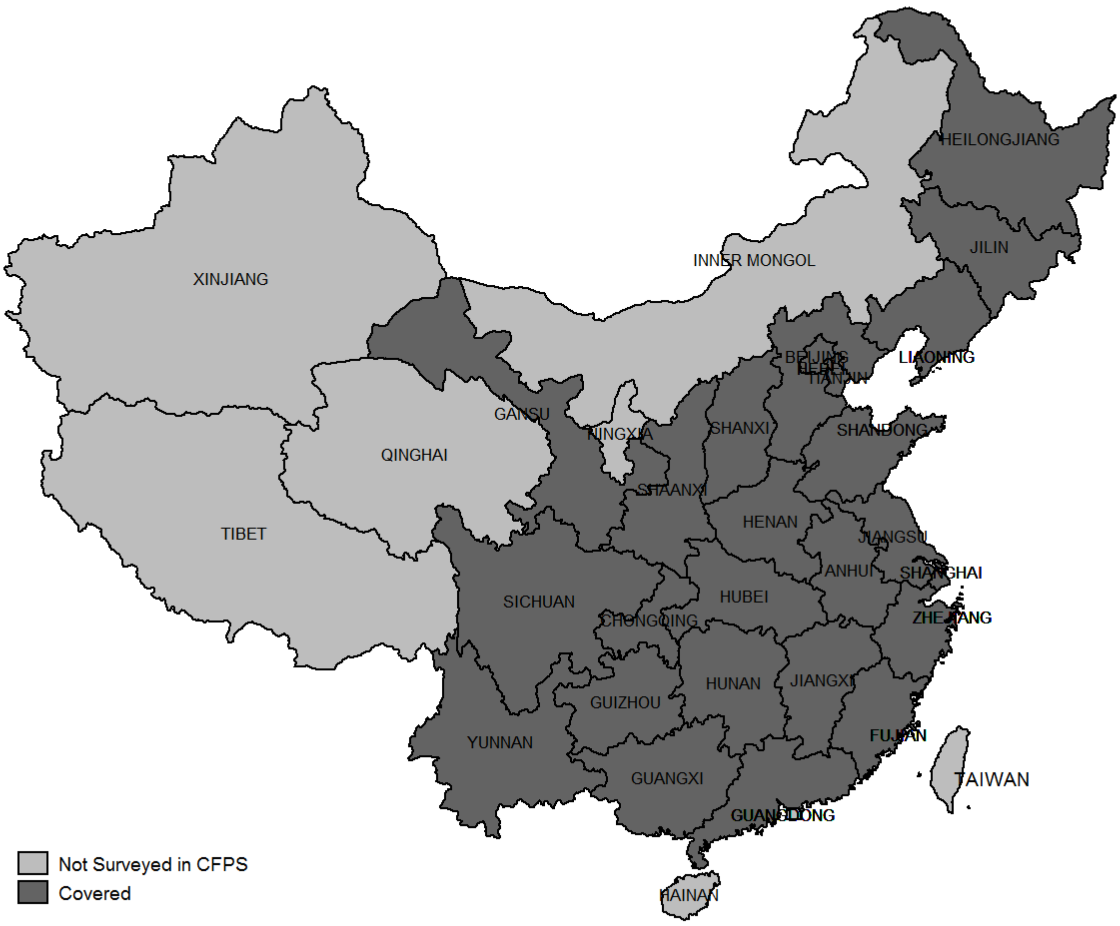



Figure A.1: Provinces covered in the CFPS sample.

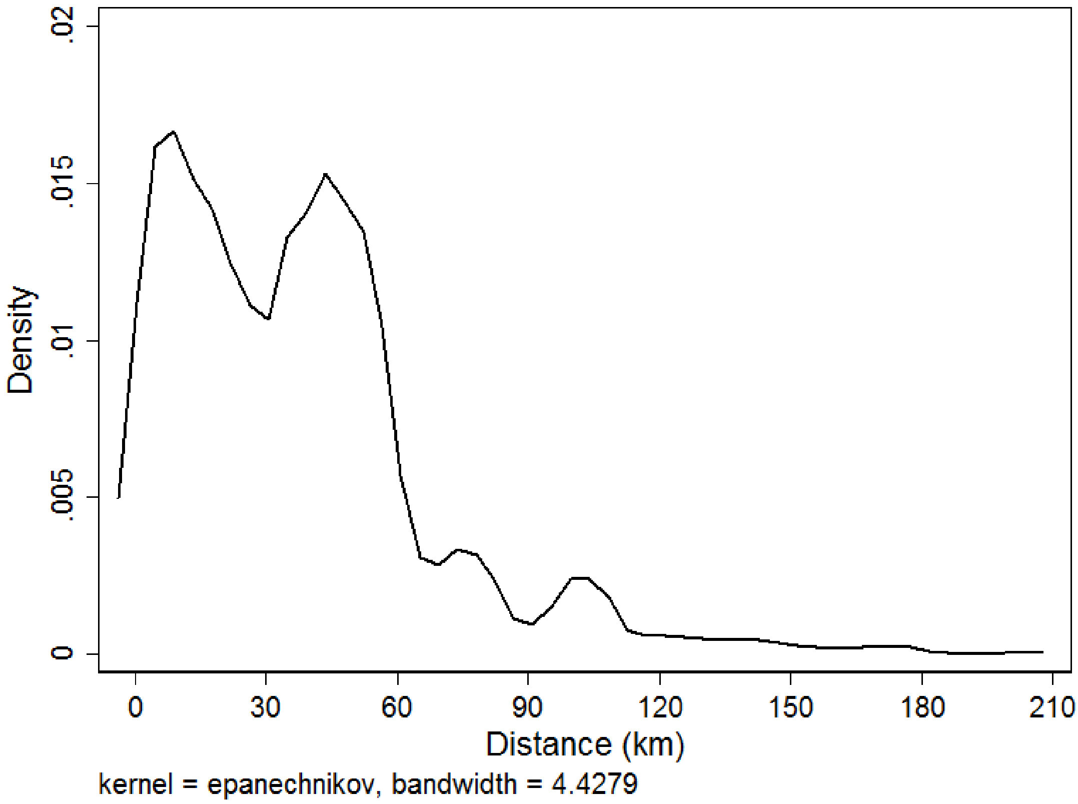



Figure A.2: Distribution of distance between the closest weather station and county center.

Table A.1: The impacts of high temperatures on all outcomes for urban born individuals

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| Dependent Variable | Birth Weight | LBW | Height | Health | Education | Word-test | Math-test | Income |
| High Temp Days | 0.0029 | -0.0004 | 0.0181 | -0.0007 | -0.0041 | -0.0023 | 0.0005 | 52.5038 |
| | (0.0023) | (0.0005) | (0.0119) | (0.0021) | (0.0063) | (0.0024) | (0.0020) | (47.6134) |
| Female | -0.2750*** | 0.0277* | -11.5046*** | 0.0171 | 0.2409 | 0.0726 | -0.0648 | -5,288.7589*** |
| | (0.0612) | (0.0151) | (0.3339) | (0.0464) | (0.1667) | (0.0539) | (0.0520) | (1,186.6124) |
| Mother's Education Years | -0.0010 | -0.0017 | 0.0245 | 0.0148** | 0.0886*** | 0.0145* | 0.0268*** | 359.9341* |
| | (0.0109) | (0.0023) | (0.0452) | (0.0067) | (0.0218) | (0.0081) | (0.0072) | (185.8597) |
| Mother's Age at Birth | -0.0024 | 0.0024 | -0.0147 | -0.0036 | -0.0023 | -0.0038 | -0.0013 | 438.2617** |
| | (0.0132) | (0.0026) | (0.0522) | (0.0102) | (0.0304) | (0.0084) | (0.0083) | (207.3131) |
| Father's Education Years | 0.0032 | -0.0001 | -0.0274 | 0.0054 | 0.0812*** | 0.0196*** | 0.0244*** | 357.4355* |
| | (0.0104) | (0.0023) | (0.0470) | (0.0075) | (0.0226) | (0.0072) | (0.0065) | (199.9600) |
| Father's Age at Birth | -0.0063 | -0.0005 | -0.0115 | 0.0005 | 0.0309 | 0.0027 | 0.0056 | -184.0219 |
| | (0.0115) | (0.0019) | (0.0376) | (0.0077) | (0.0232) | (0.0084) | (0.0074) | (188.6019) |
| Birth Order | 0.0961** | -0.0128 | -0.0227 | -0.0015 | 0.1362 | 0.0674* | 0.0234 | -372.0955 |
| | (0.0422) | (0.0121) | (0.2113) | (0.0402) | (0.1435) | (0.0395) | (0.0425) | (830.3295) |
| Number of Siblings | -0.0616 | 0.0054 | -0.1020 | 0.0023 | -0.4746*** | -0.0849** | -0.0536 | -1,008.3163 |
| | (0.0565) | (0.0154) | (0.3012) | (0.0467) | (0.1403) | (0.0415) | (0.0465) | (987.0486) |
| County FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Cohort FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Birth Month FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| County-Specific Linear Trend | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 1562 | 1562 | 1562 | 1562 | 1562 | 1562 | 1562 | 1252 |
| R-Squared | 0.274 | 0.247 | 0.688 | 0.458 | 0.569 | 0.486 | 0.527 | 0.385 |

Notes: An observation is an individual born in an urban area. High-temperature days are defined as ones with daily maximum temperature higher than 85°F. The dependent variables of column from (1) to (8) are birth weight, low birth weight incidence, height, standardized evaluated health, education years, standardized word-test score, standardized math-test score, and annual income, respectively. Ordinary least squares estimates for all columns. Standard errors in parentheses, clustered by county. ***Significant at 1%, **significant at 5%, *significant at 10%.

Table A.2: Robustness checks of the impacts of high temperatures on all outcomes using weather stations within 50 km radius

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| Dependent Variable | Birth weight | LBW | Height | Health | Education | Word-test | Math-test | Income |
| High Temp Days | -0.0042*** | 0.0011*** | -0.0184** | -0.0020* | -0.0073 | -0.0025* | -0.0021 | -41.5803** |
| | (0.0015) | (0.0004) | (0.0089) | (0.0011) | (0.0047) | (0.0013) | (0.0013) | (18.2655) |
| Demographic Controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| County FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Cohort FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Birth Month FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| County-Specific Linear Trend | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 2760 | 2760 | 2760 | 2760 | 2760 | 2760 | 2760 | 2411 |
| R-Squared | 0.314 | 0.227 | 0.573 | 0.372 | 0.447 | 0.445 | 0.430 | 0.309 |

Notes: An observation is an individual born in a rural area. Each county is matched to the nearest weather station within 50 kilometers. High-temperature days are defined as ones with daily maximum temperature higher than 85°F. The dependent variables of column from (1) to (8) are birth weight, low birth weight incidence, height, standardized evaluated health, education years, standardized word-test score, standardized math-test score, and annual income, respectively. Ordinary least squares estimates for all columns. Standard errors in parentheses, clustered by county. ***Significant at 1%, **significant at 5%, *significant at 10%.

Table A.3: Robustness checks of the impacts of high temperatures on all outcomes using weather stations within 100 km radius

| Dependent Variable | (1)<br>Birth weight | (2)<br>LBW | (3)<br>Height | (4)<br>Health | (5)<br>Education | (6)<br>Word-test | (7)<br>Math-test | (8)<br>Income |
|---|---|---|---|---|---|---|---|---|
| High Temp Days | -0.0031** | 0.0009*** | -0.0185*** | -0.0021** | -0.0051 | -0.0026** | -0.0018 | -27.7112* |
| | (0.0012) | (0.0003) | (0.0067) | (0.0010) | (0.0040) | (0.0012) | (0.0011) | (14.8562) |
| Demographic Controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| County FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Cohort FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Birth Month FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| County-Specific Linear Trend | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 3701 | 3701 | 3701 | 3701 | 3701 | 3701 | 3701 | 3271 |
| R-Squared | 0.281 | 0.188 | 0.550 | 0.406 | 0.451 | 0.473 | 0.438 | 0.278 |

Notes: An observation is an individual born in a rural area. Each county is matched to the nearest weather station within 100 kilometers. High-temperature days are defined as ones with daily maximum temperature higher than 85°F. The dependent variables of column from (1) to (8) are birth weight, low birth weight incidence, height, standardized evaluated health, education years, standardized word-test score, standardized math-test score, and annual income, respectively. Ordinary least squares estimates for all columns. Standard errors in parentheses, clustered by county. ***Significant at 1%, **significant at 5%, *significant at 10%.

Table A.4: Robustness checks of the impacts of high temperatures on all outcomes using weather stations within 200 km radius

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| Dependent Variable | Birth weight | LBW | Height | Health | Education | Word-test | Math-test | Income |
| High Temp Days | -0.0028** | 0.0008** | -0.0195*** | -0.0023** | -0.0047 | -0.0024** | -0.0017* | -24.4805* |
| | (0.0012) | (0.0003) | (0.0061) | (0.0009) | (0.0039) | (0.0010) | (0.0010) | (13.8467) |
| Demographic Controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| County FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Cohort FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Birth Month FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| County-Specific Linear Trend | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 3996 | 3996 | 3996 | 3996 | 3996 | 3996 | 3996 | 3546 |
| R-Squared | 0.279 | 0.183 | 0.542 | 0.391 | 0.451 | 0.479 | 0.443 | 0.270 |

Notes: An observation is an individual born in a rural area. Each county is matched to the nearest weather station within 200 kilometers. High-temperature days are defined as ones with daily maximum temperature higher than 85°F. The dependent variables of column from (1) to (8) are birth weight, low birth weight incidence, height, standardized evaluated health, education years, standardized word-test score, standardized math-test score, and annual income, respectively. Ordinary least squares estimates for all columns. Standard errors in parentheses, clustered by county. ***Significant at 1%, **significant at 5%, *significant at 10%.