森林火災が大気汚染、子供の健康に与える影響

Wildfires, Pollution, and Pregnancy Outcomes: Evidence from Lightning-Initiated Wildfires

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1 Introduction

Wildfires pose a new challenge to air pollution. $PM_{2.5}$ decreases over most of the US, but increases in wildfire-prone areas. In addition, the risk of wildfires is increasing due to climate change. Climate change causes warming and drying, which increases fire fuel aridity and creates a more favorable fire environment. The objective of this study is to investigate the impacts of wildfires on air pollution and health.

2 Identification strategy

This study employs a novel identification strategy using lightning as an instrumental variable (IV). The first- and second-stages are

$$Y_{it} = \beta \ln Wildfire_{it} + X_{it}\zeta + \eta_i + \theta_t + \varepsilon_{it} \tag{1}$$

$$\ln Wildfire_{it} = \alpha Lightning_{it} + X_{it}\lambda + \nu_i + \xi_t + \upsilon_{it}, \tag{2}$$

where $\ln Wildfire_{it}$ is a logarithm of wildfire size, $Lightning_{it}$ is the number of lightning strikes, $Weather_{it}$ is a vector of weather variables. This study uses two key outcomes (Y_{it}). The first key outcome is a set of pollutants. The pollutants used in this study are particulate matter (PM), carbon monoxide (CO), nitrogen oxides (NO_x), and ozone (O_3), as well as a variety of volatile organic compounds (VOCs). The second outcome is pregnancy outcome, which includes birth weight and gestational age.

Lightning has favorable characteristics as an instrument for wildfire. Lightning is a common weather phenomenon and lightning ignition causes wildfires throughout the US. At the same time, the location of a lightning strike and the timing of the ignition are difficult to predict and are uncorrelated with determinants of pollution and health.

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Data sources are the United States Forest Service (wildfire), the North American Regional Reanalysis (weather), the National Lightning Detection Network (NLDN), the Environmental Protection Agency (pollution), the Centers for Disease Control (pregnancy outcomes).

3 Results

The OLS results in columns 1 and 5 indicate that wildfires are positively associated with birth weight and negatively associated with gestational age. For the sample mean of wildfire size, a 1 SD increase in wildfires (i.e., 21.2 km^2) is associated with a 2.345 grams increase in birth weight. The same increase in wildfires is associated with a decrease in gestational age of 0.016 weeks.

However, the ignorable effects of wildfires appear to show the child health benefits of agricultural income when comparing between OLS and IV estimates. The IV estimation in column 2 shows that wildfires have negative and significant effects on birth weight. The results indicate that a 1 SD increase in wildfires reduces 118.1 grams at the average of the wildfires. In addition, the same increase in the size of wildfires reduces the gestation period by 0.377 weeks. Columns 3 and 7 present the results including additional weather controls, and they have negligible impacts on the IV estimates.

Columns 4 and 5 of Table 1 report the effects of wildfires on the number of low birth weight (below 2500 grams) and preterm (below 38 weeks) births. A 1 SD increase in wildfires increases the incidence of low birth weight by 37.17 per 1,000 and the incidence of preterm birth by 69.93 per 1,000.

Table 1: Wildfires and Pregnancy Outcomes (OLS & IV), 2003-2018

	Birth Weight (Grams)			Low Birth Weight per 1,000	Gestational Age (Weeks)			Premature per 1,000
	OLS	IV	IV	IV	OLS	IV	IV	IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Ln Wildfire Size	0.094	-4.875	-4.750	1.495	-0.001	-0.015	-0.015	2.814
	(0.083)	(1.852)	(1.904)	(0.788)	(0.000)	(0.012)	(0.012)	(1.699)
County FE	X	X	X	X	X	X	X	X
Year-Month FE	X	X	X	X	X	X	X	X
Fire Weather Controls	X	X	X	X	X	X	X	X
Other Weather Controls			X	X			X	X
Kleibergen-Paap F-stat.		35.752	34.678	34.678		34.678	34.678	34.678
Mean (Dep. Var.)	3279.471	3279.471	3279.471	78.304	38.628	38.628	38.628	116.910
SD (Dep. Var.)	76.443	76.443	76.443	76.443	0.302	0.302	0.302	0.302
Counties	576	576	576	576	576	576	576	576
Obs.	103080	103080	103080	103080	103080	103080	103080	103080
R^2	0.673	0.661	0.662	0.334	0.504	0.497	0.497	0.350

Notes: The dependent variables are county average birth weight (grams), county total number of low birth weight per 1,000, county average gestational age (weeks), and county total preterm births per 1,000. The observational unit is at the county-month level. All estimations include fire weather controls, county fixed effects, and year-month fixed effects. Standard errors clustered by county are shown in parentheses.