

## 1 Introduction

Climate change is wreaking havoc on our lives through severe natural disasters. Over the past two decades, disaster-affected reported direct economic losses totaling USD 2,908 billion, of which climate-related disasters accounted for 77% or USD 2,245 billion (Wallemacq et al., 2018). In the increasing trend of climate-related disasters, wildfires are no exception. Climate change causes warming and drying, which increases fire fuel aridity and creates a more favorable fire environment. Over the past 20 years, wildfires and volcanic activity affected 6.2 million people and resulted in approximately 2,400 deaths worldwide due to suffocation, injuries, and burns (Wallemacq et al., 2018).

The objective of this study is to investigate the impact of wildfires on pollution and pregnancy outcomes. In addition, the marginal willingness to pay (MWTP) for wildfire mitigation is calculated following Rosen (1974) and Roback (1982) by estimating both hedonic house price and hedonic wage equations.

## 2 Identification strategy

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

$$\ln Wildfire_{it} = \alpha Lightning_{it} + Weather'_{it} \kappa + X'_{it} \lambda + v_i + \xi_t + v_{it}, \quad (1)$$

$$Y_{it} = \beta \ln Wildfire_{it} + Weather'_{it} \gamma + X'_{it} \zeta + \eta_i + \theta_t + \varepsilon_{it}, \quad (2)$$

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.

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).

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### 3 Results

Table 1 reports IV estimates of the effects of wildfires on pollution and pregnancy outcomes. Columns 1 to 5 use pollutants as outcomes and columns 6 to 7 use pregnancy outcomes as outcomes. The daily effects of a 1 km<sup>2</sup> increase in wildfires are 2.5 ppm for CO, 313 ppb for NO<sub>2</sub>, 234 μ/m<sup>3</sup> for PM<sub>10</sub>, 131 μ/m<sup>3</sup> for PM<sub>2.5</sub>, and 248 ppb for O<sub>3</sub> at the average of the sample. These effects significantly exceed the National Ambient Air Quality Standards set by US Environmental Protection Agency. In terms of pregnancy outcomes, a 1 standard deviation increase of wildfires reduces birth weight by 104 grams and shortens gestational age by 2.1 days at the average of the sample. The results show that wildfire has adverse effects on air quality and pregnancies.

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

	Pollution					Pregnancy outcomes	
	CO	NO <sub>2</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	O <sub>3</sub>	BW	GA
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Ln wildfire size	0.344*** (0.059)	1.045*** (0.112)	0.569*** (0.082)	0.698*** (0.069)	0.276*** (0.035)	-7.022*** (1.952)	-0.021* (0.011)
County FE	X	X	X	X	X	X	X
Period FE	X	X	X	X	X	X	X
Weather Controls	X	X	X	X	X	X	X
Kleibergen-Paap F-stat.	50.487	60.995	149.466	102.264	163.225	50.575	50.575
Mean (Dep. var.)	-1.242	1.836	2.817	2.050	3.385	8.095	3.654
SD (Dep. var.)	0.813	0.997	0.683	0.682	0.441	0.023	0.008
Counties	298	373	594	831	909	576	576
Obs.	1062762	1335224	1187980	1825470	3556517	103080	103080

Notes: Columns 1 to 5 use the logarithm of pollutants' concentrations as an outcome and columns 6 to 7 use birth weight (grams) and gestational age (weeks) as an outcome. All of them are IV estimates. The observational unit is at the county-date level for columns 1 to 5 and at the county-month level for columns 6 to 7. All estimations include weather controls, county fixed effects, and time fixed effects. Standard errors clustered by county are shown in parentheses. \* $p < 0.1$ , \*\* $p < 0.05$ , \*\*\* $p < 0.01$ .

In addition to the pollution and health effects, this study calculates the welfare losses due to wildfire based on the theoretical framework of Rosen (1974) and Roback (1982). The results indicate that at the individual-level MWTP estimate for a 1 km<sup>2</sup> reduction in wildfires is USD 145,524 (SE = 44,243) and the county-level MWTP estimate is USD 11,965,228 (SE = 1,892,493). The estimates show that wildfires cause significant losses of welfare, which has implications for environmental and public health policy.

### References

- Roback, Jennifer**, "Wages, Rents, and the Quality of Life," *Journal of Political Economy*, December 1982, 90 (6), 1257–1278.
- Rosen, Sherwin**, "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition," *Journal of Political Economy*, January 1974, 82 (1), 34–55.
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