Economic and social impacts of air pollution: A causal inference approach

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A significant motivation for the development of low-cost air pollution monitors is the opportunity to improve the collection and accessibility of high spatial resolution air quality data, which could then be used by planners and policy makers both to mitigate inequities and protect marginalized communities. Although it is well documented that exposure to fine particulate matter (PM2.5) increases the risk of several adverse health outcomes, less is known regarding its effects on educational attainment, long-term earnings, and particularly economic mobility (Khalili et al., Thompson and Heyd, Brokamp et al.). Economic mobility, the economic success of children relative to their parents, varies across the continental U.S. and is highly correlated with segregation and concentrated poverty, income inequality, school quality, family structure, and social capital (Chetty et al. 2014). While prior studies have shown a correlation between poor air quality and reduced economic mobility, to our knowledge, our study is the first comprehensive effort aimed at providing evidence of a causal effect of childhood exposure to $PM_{2.5}$ and future absolute mobility (Swetschinski et al.). Our data are at the finest spatial resolution for which there exist both $PM_{2.5}$ data and long-term economic data – the census tract (approximately 4,000 people per unit).

We obtained data from the Opportunity Atlas dataset which linked childhood family income with future child earnings to create child-guardian pairs for 20.5 million people born between 1978 and 1983 (96.2%). The publicly available data set includes $PM_{2.5}$ concentrations, socio-demographic characteristics, and economic mobility information for US census tracts for the period 1980-2010. Absolute upward mobility (AUM) in this abstract is defined as the income rank percentile a child born to parents at the 25^{th} income rank percentile will reach 30 years later (Chetty et al. 2018). For example, Westminster, Massachusetts has an absolute mobility statistic of 46.034. A child born to parents at the 25^{th} percentile from 1979-1983 in Westminster, MA will on average reach the 46^{th} income percentile as an adult. We applied and compared different methods for causal inference to estimate overall and county-specific causal effects of childhood exposure to $PM_{2.5}$ and AUM controlling for an extensive set of census tract level confounders, such as race, income, temperature, precipitation, and education (Hainmueller, Robins et al., Wu et al.).

Our results showed evidence of a causal relationship between air pollution and economic outcomes among low-income communities with spatial variation. We found that a 1 μg/m3 increase of $PM_{2.5}$ exposure in childhood leads to a statistically significant reduction of AUM by 1.146% (95% confidence interval (CI): 0.834, 1.458) later in life. We also found strong evidence

that these causal effects vary spatially across counties, exhibiting a stronger negative relationship in the Upper Midwest and the Southeast.

The results of this study support the collection of high spatial and temporal resolution air quality monitoring as tools to inform policies to reduce economic disparities in the US. Improving low-cost sensors and measurement tools in neighborhoods with high $PM_{2.5}$ may provide valuable data that can guide stricter regulations to improve air quality with the potential for improving economic outcomes of those communities. While these technologies are vital, robust statistical methodology is needed to assess and interpret their wide scale impacts and to provide additional insights for future work.

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