The Effect of Air Pollution on Human Capital Development: Evidence from South Korea (Extended Abstract)

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Air pollution is known to affect health outcomes across all age groups, through direct inhalation of toxic matters. Nine million people worldwide could die prematurely by 2060 as a result of current level of air pollution [9]. While the effect of pollution matters on extreme health outcomes are extensively studied [2, 10, 6, 4, 8, 7, 1], little is known about its causal effect on academic performances of students. Considering that academic performance at young age is a strong indicator of human capital development, and future earnings [3], it is important that we evaluate the change in academic performances that originates soley from air pollution.

This project studies the effect of air pollution on educational performance of students in South Korean schools from 2009 to 2016. Specifically, I focus on the effect of particulate matter PM10 that have been consistently increasing in volume since the rapid industrial development in 1990s. Geography of Korea, which has exogenous variation in air pollution levels due to air inflowing from China, and mountainous enough to provide rich variation in air flow levels of different regions, is a perfect setting to study the effect of heterogeneous levels of air pollution on education.

Using instrumental variable (IV) strategy that exploits wind direction as a source of exogenous variation in pollution matters, I uncover the causal effect of air pollution on educational performance of students attending high schools (11th grade), middle schools (9th grade), and elementary schools. Using IV corrects for attenuation bias resulting from measurement error, and omitted variable bias that results from metro areas being strongly correlated with high household income, and high air pollution levels. First stage regression shows strong correlation between air pollution levels and wind direction. To the extent that wind direction is uncorrelated with academic performace except through air pollution($y_{it} \perp WindDir_{it} | PM10_{it}$), the two assumptions of IV are satisfied for this framework, and the estimate that we get from IV analysis will be the causal effect of additional level of $PM10$ on academic performance.

The two stage least squares model I am going to fit is given by:

$$y_{it} = \delta_t + \beta \cdot PM10_{it} + \gamma \cdot X_{it} + \epsilon_{it}$$

where first stage is given by:

$$PM10_{it} = \tilde{\delta}_t + \phi \cdot WindDir_{it} + \xi \cdot X_{it} + e_{it}$$

where y_{it} is the academic performance outcome of a school i at year/month time t. δ_t's are coefficients on year fixed effects. $PM10_{it}$ is the level of particulate matter of 10 micrometer or less in the nearest monitoring site to school i, at time t. X_{it} would be set of baseline covariates that represents demographics, and other characteristics of schools or regions. $WindDir_{it}$ is the absolute distance in degrees from the direction of 270 degrees, the level at which west wind blows. Since wind blowing from west is a strong indicator of increase in air pollutants due to 'yellow dust' phenomenon, I set 270 degrees as the benchmark degree in my analysis. ϵ_{it} is idiosyncratic error term with mean zero.

In addition to fitting the main model, I conduct three falsification tests to validate that my

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result is robust, and that there isn't any other mechanism at play, except for the variation in air pollution level.

Overview of Results

Pulling administrative data from different sources, I make school-level data for years 2009-2016, and match 860 highschools with the nearest air pollution monitoring stations, and the nearest weather monitoring stations in terms of aerial distance. The sources of data include Ministry of Education, National Ambient Air Quality Monitoring Information System, and Koean Meterological Administration.

I estimate IV regression on outcomes share of students who underperformed (overperformed) in Math, Korean, and English. For high school students, I find that increase in the level of PM_{10} increases share of students who underperform for all subjects, and decrease share of students who overperform in all subjects. In particular, a unit ($\mu g/m^3$) increase in average PM_{10} leads to .856 percentage point increase in share of students who underperform in math. Magnitude of the estimate is larger than its OLS counterpart (0.028), and is likely due to the fact that IV fixes measurement error and omitted variable bias that result from strong positive correlation between heavily polluted area and high demand properties. Similarly, a unit increase in average PM_{10} leads to 2.385 decrease in share of students who overperform in math. Its OLS counterpart is not statistically significant, which indicates that downward bias due to omitted variables has been corrected after applying IV. The significance and pattern of results carry through elementary and middle schools test performances.

To validate that the main IV results are robust, I conduct three falsification tests: 1) using college entrance exam results as outcome to test for biased measurement error, 2) using share of students moving in and out of schools as outcome, to test whether moving pattern of students are correlated with air quality, 3) using number of class days as outcome, to rule out the possibility that number of class days is the main mechanism through which air quality affects student performances Currie et al. [5]. The effect of air quality on share of underperforming students remains valid (and statistically significant) when measured with college entrance exam performances, but its effect on share of overperforming students becomes insignificant. The second and third falsification test results are both statistically insignificant, proving that both number of class days and moving pattern of students do not explain the mechanism through which air quality affects student performances.

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