Does Environmental Policy Affect Income Inequality? Evidence from The Clean Air Act

Akshaya Jha (Carnegie Mellon), Peter H. Matthews (Middlebury College), and Nicholas Z. Muller (Carnegie Mellon and NBER)

January 2018

Motivation

- Prior research demonstrates that the aggregate benefits of air quality regulations far exceed their costs.
- One common argument is that these regulations adversely impacts labor markets.
- Prior research on the labor market impacts of environmental policy is inconclusive (Berman and Bui, 2001; Morgenstern et al., 2002; Greenstone, 2003):
  - Policy boosts labor market outcomes: Exposure to local air pollution decreases labor productivity and increases absenteeism (USEPA, 2011).
  - Policy adversely affects labor market outcomes: Firms must take costly actions in order to comply with stricter environmental regulation.

This Paper

- This paper explores the distributional consequences of the Clean Air Act.
- **Difference-in-Differences:** Annual county-level attainment status with the National Ambient Air Quality Standards (NAAQS)
  - Focus on two specific changes in standards: 2006 $PM_{2.5}$ and 2008 O_3.
  - Prior research suggests large costs from $PM_{2.5}$ and O_3 exposure.
- **Outcomes:** Mean and dispersion of:
  - Household adjusted gross income (IRS).
  - $PM_{2.5}$ and O_3 levels (LUR).
  - Monetary Damages from $PM_{2.5}$ and O_3.
  - Pollution-adjusted income: Market income less pollution damage.

Primary Findings

- The 2006 $PM_{2.5}$ NAAQS reduced the within-county mean and dispersion of both $PM_{2.5}$ and monetary damages from $PM_{2.5}$.
- No statistical impact of 2008 O_3 NAAQS on ozone or damages from ozone.
- Both the 2006 $PM_{2.5}$ and 2008 O_3 NAAQS increased income inequality measured using both market income and pollution-adjusted income.

Implications of these Findings

- The $PM_{2.5}$ NAAQS significantly reduces disparities in exposure and damage.
  - This standard is based on annual averages.
  - But typically targets point sources.
- Despite this, the net effect on income distribution of stricter environmental regulation may be regressive.
  - This finding depends crucially on the initial stringency of environmental policy.
  - Suggestive evidence that 1997 $PM_{2.5}$ NAAQS reduced income inequality.

Data Sources

- Annual zipcode level average adjusted gross income as well as wages and salaries (IRS SOI).
- Annual census block group level average $PM_{2.5}$ and O_3 concentration levels (Center for Air, Climate, and Energy Solutions).
- Annual county-level mortality data used to adjust income for monetary damages from pollution exposure.

Calculating Pollution Damages

Per-capita pollution damages $D_{i,t}$ in county i in year t:

$$D_{i,t} = VSL_t \times M_{i,a,t} \times \frac{1}{1 - exp(\hat{\beta}_s P_{i,t,s})}$$

where:

- VSL_t: value of statistical life.
- $M_{i,a,t}$: baseline mortality rate for age group a.
- $P_{i,t,s}$: concentration level of pollutant s
- $\hat{\beta}_s$: estimate linking pollution to mortality for pollutant s.
- This is the standard approach used by USEPA and others.

National Ambient Air Quality Standards

- The Clean Air Act (CAA) primarily works through the National Ambient Air Quality Standards (NAAQS).
  - Maximum allowable levels of ambient pollution.
  - Monitor-level data aggregated to the county level.
  - Compliance through state implementation plans (SIPs).
- CAA requires periodic reviews of the NAAQS.
  - USEPA gathers new criteria information (scientific literature).
- On occasion, NAAQS are modified.
  - USEPA then issues new attainment designations.
  - Use weighted average of monitoring data -muddles prediction of attainment status by counties or states.

Changing Standards over Time: O_3

Announced	Implemented	Averaging	Level	Form
1979	1979	1-Hour	0.12ppm	$>$ 1 Daily Max
1997	2004	8-Hour	0.08ppm	4^{th}-highest daily max
2008	2012	8-Hour	0.075ppm	4^{th}-highest daily max
2015		8-Hour	0.07ppm	4^{th}-highest daily max

In all cases except 1979 standard, the relevant measure is averaged over three years.

Changing Standards over Time: $PM_{2.5}$

Announced	Implemented	Averaging	Level	Form
1997	2005	24-Hour	$65 \frac{ug}{m^3}$	98th percentile
1997	2005	Annual	$15 \frac{ug}{m^3}$	Arithmetic mean
2006	2009	24-Hour	$35 \frac{ug}{m^3}$	98th percentile
2006	2009	Annual	$15 \frac{ug}{m^3}$	Arithmetic mean
2012	2015	24-Hour	$35 \frac{ug}{m^3}$	98th percentile
2012	2015	Annual	$12 \frac{ug}{m^3}$	Arithmetic mean

In all cases, the relevant measure is averaged over three years.

Empirical Methodology

We use the following difference-in-differences framework:

$$log(Y_{i,t}) = \alpha_i + \gamma_t + \beta_1 NA1_{i,t} + \beta_2 NA2_{i,t} + \epsilon_{i,t}$$

where:

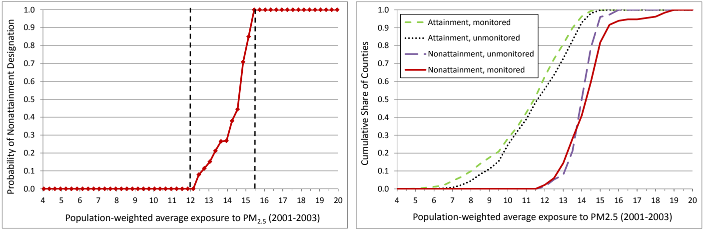
- $NA1_{i,t}$: equals 1 if and only if the county i is out of attainment with the relevant standard in year t.
- $NA2_{i,t}$: equals 1 if and only if the county i is out of attainment with the previous standard in year t.
- α_i: county fixed effects.
- γ_t: year fixed effects.
- Standard errors clustered by county.

Threats To Identification

- We plot up the annual averages of the dependent variable separately for counties that are ever out-of-attainment versus always-in-attainment with the relevant standard.
  - Instances where pre-trends bias the effect away from zero marked with an "X"
  - Magnitudes should be interpreted with caution in all cases.
- Two potential threats:
  - Anticipatory behavior by counties or states.
  - Correlated unobserved variables.

Anticipatory Behavior?

- The process to calculate the “design values” used to determine annual county-level attainment status is complex and opaque.
- Counties and states cannot control pollution from across the border.

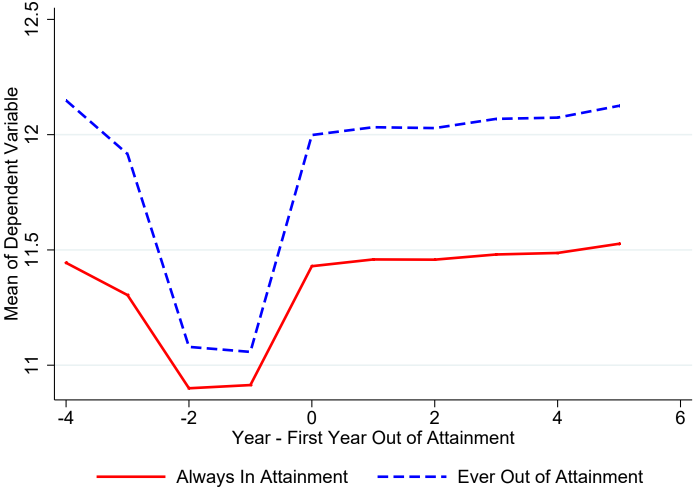


From Bishop, Ketcham, and Kuminoff (2018)

Correlated Unobserved Variables

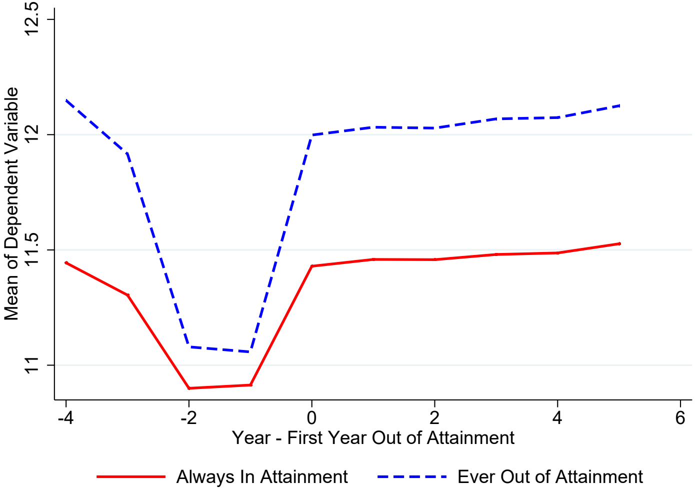
- Non-attainment counties tend to be higher income and more densely populated.
- Shocks that disproportionately impact high versus low income areas or urban versus rural areas may bias our findings.
  - For example: The 2008 Financial Crisis.
- In work in progress: match on pre-2005 income and/or population

Log Income By Attainment Status: 2008 O_3



The 2008 O_3 was implemented in 2012.

Log Income By Attainment Status: 2006 $PM_{2.5}$



The 2006 $PM_{2.5}$ was implemented in 2009.

The Effect of NAAQS Attainment on Income

Dep. Var.	Log(Gini)	Log(Mean)	Log($\frac{90}{50}$)	Log($\frac{90}{10}$)
2008 O_3	0.064***	0.191***,X	0.282***	0.230***
	(0.008)	(0.015)	(0.028)	(0.023)
1997 O_3	-0.029***	-0.007	-0.015	0.001
	(0.008)	(0.014)	(0.020)	(0.015)
Number of Obs.	33,313	33,388	33,368	33,387
R^2	0.815	0.903	0.867	0.879
2006 $PM_{2.5}$	0.061***	0.184***	0.241***	0.182***
	(0.013)	(0.029)	(0.034)	(0.029)
1997 $PM_{2.5}$	-0.060***	-0.119***	-0.207***	-0.156***
	(0.011)	(0.025)	(0.034)	(0.029)
Number of Obs.	30,296	30,358	30,339	30,357
R^2	0.811	0.893	0.855	0.868

The Effect of NAAQS Attainment on Ambient O_3

Dep. Var.	Log(Gini)	Log(Mean)	Log($\frac{90}{50}$)	Log($\frac{90}{10}$)
2008 O_3 NAAQS	-0.004	0.023***	0.020	0.033
	(0.025)	(0.008)	(0.025)	(0.025)
1997 O_3 NAAQS	-0.007	0.0003	-0.052**	0.008
	(0.029)	(0.008)	(0.026)	(0.031)
Number of Obs.	33,715	34,177	33,714	33,715
R^2	0.744	0.842	0.690	0.737

The Effect of NAAQS Attainment on Ambient $PM_{2.5}$

Dep. Var.	Log(Gini)	Log(Mean)	Log($\frac{90}{50}$)	Log($\frac{90}{10}$)
2006 $PM_{2.5}$	-0.084***	-0.044***	-0.126***	-0.124***
	(0.023)	(0.007)	(0.024)	(0.024)
1997 $PM_{2.5}$	-0.050	0.050***	0.030	0.003
	(0.033)	(0.013)	(0.043)	(0.044)
Number of Obs.	30,650	31,070	30,650	30,650
R^2	0.874	0.917	0.775	0.839

The Effect of NAAQS on Pollution-Adjusted Income

Dep. Var.	Log(Gini)	Log(Mean)	Log($\frac{90}{50}$)	Log($\frac{90}{10}$)
2008 O_3	0.123***	0.196***,X	0.320***,X	0.301***,X
	(0.014)	(0.015)	(0.032)	(0.027)
1997 O_3	-0.030**	-0.019	-0.019	-0.023
	(0.012)	(0.018)	(0.024)	(0.019)
Number of Obs.	30,447	30,447	33,147	33,154
R^2	0.836	0.871	0.846	0.859
2006 $PM_{2.5}$	0.112***	0.237***,X	0.344***,X	0.323***,X
	(0.026)	(0.034)	(0.039)	(0.035)
1997 $PM_{2.5}$	-0.081***	-0.158***	-0.240***	-0.237***
	(0.019)	(0.027)	(0.044)	(0.039)
Number of Obs.	27,633	27,633	30,133	30,140
R^2	0.830	0.860	0.832	0.847

Conclusions

- The 2006 $PM_{2.5}$ NAAQS reduces average ambient concentrations and damages.
- The 2006 $PM_{2.5}$ NAAQS reduces the distribution of ambient concentrations and damages.
- Despite this apparent benefit, the NAAQS render the income distribution more unequal.

Conclusions

- The 2008 O_3 NAAQS does not reduce either the mean or dispersion of ambient concentrations and damages.
- O_3 formation (based on precursors VOC and NO_x) is highly nonlinear.
- Annual average O_3 roughly constant over 2005 to 2015.
- Yet we find that the O_3 NAAQS render the income distribution more unequal.

Conclusions

- Our findings should not be interpreted as challenging the longstanding result that the benefits of the Clean Air Act vastly outweigh the cost.
- Given the obstacles to clean identification, we offer our results as suggestive evidence of a regressive effect on labor markets.
- We look forward to your comments and suggestions.