

What Have We Learned from Economic Studies of the Clean Air Act?

**Joseph Aldy, Maximillian Auffhammer, Maureen Cropper,
Arthur Fraas, Richard Morgenstern**

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Outline of the Talk

- What have we learned from *ex post* studies about the impact of the CAA on emissions and ambient air quality?
- What have we learned about the health and other benefits that can causally be attributed to the CAA?
- What have we learned about the costs of the CAA?
- What do we not know about the CAA?



Impact of the CAA Air Quality & Emissions

- **What we would like to know is how much of the large improvements in ambient air quality since 1970 can be attributed to the CAA**
- **Most of the literature focuses on whether levels of the criteria pollutants fell faster in Non-Attainment than in Attainment areas**
- **There is also a literature on the impact of the CAA on emissions by regulated firms**
 - **Most literature is post-1987 (once TRI and NEI become available)**
 - **Some studies of individual industries (pulp & paper, iron & steel)**
 - **Shapiro and Walker (2018) impact on manufacturing emissions, 1990-2008**



Impact of the CAA on Ambient Air Quality

- **Ambient PM Fell Faster in Non-Attainment than in Attainment Counties**
 - 1970 – 1980: TSP fell by 9-10 $\mu\text{g}/\text{m}^3$ (11-12%) more in NA counties
 - 1990 – 2000: PM10 fell 7-9 $\mu\text{g}/\text{m}^3$ (11-13%) more at monitors out of attainment
 - 2000 – 2013: PM2.5 fell by 1.24 $\mu\text{g}/\text{m}^3$ (69%) more in NA counties
- **1977 CAAA and NOx Budget Programs Reduced Ambient Ozone**
 - 1977 – 1987: Maximum July Ozone fell 8% faster in NA counties
 - 2003 – 2007: High ozone days fell by 35% in counties subject to NOx BP
- **1990 – 1992: SO₂ fell 7-11% faster in NA than in Attainment counties**
- **New studies rely on satellite data (Currie, Voorheis, Walker 2020)**



But Not All Rules Improved Air Quality

- However, some regulations on reformulated gasoline did not reduce O_3
- Reid Vapor Pressure regulations were NOT effective in reducing ozone
 - In states where refiners were given flexibility in which VOCs to remove from gasoline, many chose butane (the cheapest) which did not reduce O_3
- Reformulated Gas regulations had a modest effect on reducing O_3
 - And their effectiveness depended on local NO_x controls
- Regulations issued by the California Air Resources Board were, however effective
 - Because they specified which VOCs to reduce



Health Benefits Attributable to the CAA

- **EPA RIAs measure health impacts using observational studies**
 - **Impact of PM and ozone on mortality and morbidity**
- **Economists have demonstrated causal impacts of air pollution on mortality and morbidity**
 - **These studies use a variety of instruments for air pollution (Chay and Greenstone, Deryugina et al., Currie et al., Schlenker & Walker)**
- **We reviewed only those studies using CAA regulations to instrument for air pollution**
 - **The three on the next slide link the CAA to new measures of health benefits**



Health Benefits Attributable to the CAA

- **NOx Budget Program reduced deaths and medical expenditures**
 - The NBP reduced deaths by 2,500 each year in the 19 states in which the program operated
 - It reduced defensive medical expenditures by \$800 million (2015\$) annually
- **TSP reductions under the 1970 CAA increased human capital and earnings**
 - Children born in NA counties after the 1970 CAA had higher lifetime earnings of \$6.5 billion (2008\$) than children born in NA counties before the CAA
- **A 1 $\mu\text{g}/\text{m}^3$ fall in PM_{2.5} exposure under the 1990 CAAA reduced diagnoses of dementia by 180,000**



Impact of the CAA on Property Values

- Capitalization of air quality into property values reflects improvements in visibility and health, as perceived by consumers
- 1970 – 1980: Reductions in TSP in Non-attainment counties raised property values by \$45 billion (1982\$) relative to attainment counties
- 1990 – 2000: Reductions in PM10 in Non-attainment counties raised property values by \$44 billion (2000\$)
- Studies suggest that increases in property values are not fully passed on to renters – so renters as well as homeowners enjoy these benefits



What Have We Learned About Costs?

- **Ex ante estimates of compliance costs focus on engineering cost estimates – How do ex post estimates compare?**
 - **Fowlie (2010) and Linn (2008) examine how firms complied with the NBP**
 - **Chan et al. (2018) examine compliance with the Acid Rain Program**
 - **These studies suggest firms don't always cost minimize**
 - **Shapiro and Walker (2020) use offset trades to estimate compliance costs**
- **Large literature on the adjustment costs (e.g., on employment, plant location) of imposing stricter standards in non-attainment areas**
- **Studies of the market impacts of ARP and reformulated gas rules**



Costs of Spatially Differentiated Standards

- **Evidence that NA Status for O₃ shifted plant births from NA to A counties**
 - NA status in 1977-87 reduced plant births by 45% (organic chemicals) and 26-29% (plastics, metal containers, wood furniture) over the 1967 – 1992 period
 - New plants larger in NA counties, suggesting more up front investment
- **592,000 manufacturing jobs lost, 1972 – 1987 in NA counties**
 - Impact is relative to A counties; largest impacts are NA for CO, O₃
 - No significant impacts on value of shipments or capital stocks
- **Earnings losses under 1990 CAAA for workers in regulated firms**
 - Workers who change firms lose earnings equal (in PDV) to 120% of pre-regulation annual earnings; no losses for workers who stay with same firm



Market Impacts of the CAA

- **Variation in reformulated gasoline standards across states segmented the gasoline market**
 - Increased market power of refiners in some regional markets
 - Raised fuel prices and increased gasoline price volatility
- **Evidence that environmental regulations may have acted as a barrier to entry in the cement industry**
- **During Phase I of the SO₂ Allowance Program, railroads raised price of low-S coal to plants in the program (v. plants regulated under CAC)**



What We Don't Know about the CAA

- **Impact of most CAA regulations on ambient air quality**
 - Literature on NA status measures impacts relative attainment counties, not absolute improvements in air quality (i.e., relative to no CAA)
 - Few quasi-experimental studies of impact of tailpipe emissions standards, New Source Performance Standards, New Source Review
 - If we knew air quality impacts, given expanding causal literature on health effects of air pollution, could calculate health benefits ex post
- **Compliance costs of CAA regulations**
 - Few quasi-experimental, ex post cost studies of regulations
 - Also few studies of welfare impacts: requires structural models, although these are being developed



What We Don't Know about the CAA

- **Whether the benefits of spatially differentiated standards exceed the costs**
 - Is spatial variation in regulatory stringency (fuel content regulations and differential emission standards in Non-Attainment counties) justified on benefit-cost grounds?
- **Magnitude of Net Benefits from the CAA**
 - Ex post studies usually focus on specific regulations; more difficult to develop a causal estimate of the net benefits of the CAA comparable to EPA's 812 studies
- **Distributional Consequences of the CAA**

