The Silver Lining of Industrial Decline: Rust Belt Manufacturing's Impact on Particulates

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Abstract

Reduced industrial activity leads to improved local air quality. Using plant level micro data from the Census of Manufacturers, I explore how county particulate levels vary for counties that feature different manufacturing activity levels and that differ with respect to manufacturing's capital vintage, plant size and SIC industry classification. These estimates are used to simulate the benefits of reduced manufacturing activity. The magnitude of the social benefits of increased local public goods is compared to the aggregate private costs suffered by workers displaced to the low wage service sector.

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I. Introduction

The displaced worker literature has stressed the costs of lost "good manufacturing" jobs (Jacobson, Lalonde and Sullivan 1993). Between 1972 and 1987, Illinois experienced a 55% decline in employment in primary metals plants (SIC 33). If a 5000 person manufacturing plant closes and each of the workers suffers a $10 an hour wage loss as they join the service sector, society has not suffered a net $50,000 an hour loss. The "silver lining" of manufacturing industry decline is improved air quality.[1] If older plants significantly add to local air pollution levels, then the death and the shrinkage of such plants offers an external benefit to those located in a proximity around the plants.

To calculate the environmental benefit of reduced manufacturing activity, one would have to estimate how this activity affects air quality and map this decrease in pollution to health outcomes and finally translate these health improvements into dollar values.[2] There is an epidemiology literature to map pollution inputs into health outcomes. There are hedonic value of life estimates and contingent valuation studies to map health damage into dollar values.[3]

The missing step in calculating the "silver lining" of industrial decline are estimates of how actual plant activity impacts local air quality.[4] This study proxies for local air quality using a county's mean annual particulate level. To quantify the pollution content of different manufacturing plants, I use micro plant level data from the Census of Manufacturing. I aggregate this data by county to create county level

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[1]Industrial processes account for 37.3% of particulates.

[2]Since air pollution is a local public bad, the population density and the income distribution of people around the polluting site are also relevant in determining total damage caused by the pollution. The formal definition of damage would be the sum of each individual's willingness to pay to face less air pollution.

[3]Both hedonic studies (Blomquist et. al. 1988, Smith and Hwang 1995) and epidemiological studies (Ostro 1987, Portney and Mullahy 1990, Ranson and Pope 1995) indicate that people value lower particulate levels.

[4]In previous work, I have used a national county panel data set of particulates and aggregate county manufacturing activity to document manufacturing's impact on particulates (Kahn 1995). This paper adds to my previous research by exploring for a given level of manufacturing jobs within a county how the distribution of activity across industry, capital vintage, and individual plant size affects air quality.

manufacturing cells in 1982 and 1987 and focus on the impact of primary metals plants that were active before the enaction of the Clean Air Act. Primary metals plants are known to be high particulate emitters and pre-Clean Air Act plants are regulated under a less stringent regulatory code (Portney 1990). I quantify their pollution externality by regressing particulates on county manufacturing. Differential capital vintage and industry effects are identified because there is sufficient variation in manufacturing's composition varies across counties.

This paper's findings are relevant for "green accounting". In the last section of the paper, I use my particulate impact estimates to quantify the social benefits of the decline of older steel plants. Decreased manufacturing increases local air quality levels. Such increases are a local public good. Thus, local benefits are an increasing function of county population size. The benefits estimates are large and suggest that the environmental gains mitigate the social costs of industrial decline. This paper is organized as follows. Section Two presents my data sources. Section Three presents the levels and differenced multivariate particulate regressions. Section Four uses my estimates to simulate the environmental benefits of reduced industrial activity. Section Five concludes.

II. Data

Micro data on manufacturing activity is available because the Census Bureau has developed the Longitudinal Research Database (LRD) which is a time series of economic variables collected from manufacturing establishments in the Census of Manufacturers and Annual Survey of Manufacturers programs. The LRD file contains establishment level identifying information on the factors of production and the products produced (LRD Technical Documentation Manual 1992). The data file includes geographical information identifying each plant's state, and county. I use a special micro data extract from the Longitudinal Research Database of Rust Belt plants.[5] This data set of 215,650 plants includes information on the plant's total employment in 1967, 1972, 1977, 1982 and 1987, the plant's SIC code and its state and county location. I use this micro data set to create my own county aggregate measures. I use my LRD sample to create county level employment cells. These measures are used as exogenous regressors to explain county particulate levels. The cells' coefficients can be interpreted as the marginal

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[5]I define the Rust Belt as; Illinois, Indiana, Michigan, New Jersey, New York, Ohio, Pennsylvania, West Virginia.

impact of each type of manufacturing activity on pollution. This methodology identifies the pollution content of manufacturing by plant vintage, size and industry. As I document below, economic activity concentrated in pre-Clean Air Act vintage primary metals (SIC33) is an important variable for explaining cross-sectional and time series variation in particulate levels across the United States. Table One reports trends in manufacturing employment in SIC 33 between 1972 and 1987. Note that average county employment in Primary Metals (SIC 33) plants that were operation before the Clean Air Act of 1970 decreased from 3,100 in 1982 to 1,900 in 1987. These industries have severely declined. Pennsylvania experienced a destruction of 64% of these jobs between 1972 and 1987.[6]

In addition to constructing proxies for county manufacturing activity, I am also interested in proxying for industrial concentration of activity to test whether counties which have manufacturing concentrated in a few large plants have higher or lower particulate levels than counties with more dispersed employment patterns. For each county in each year, I use the LRD to generate a regressor that indicates the percentage of plants in the county with over 100 employees. I generate a second regressor that indicates the percentage of plants with between 50 and 100 employees.

The Environmental Protection Agency is the source of my particulate data. The EPA chooses monitoring locations to identify which areas are not in attainment of the Clean Air Act standards so that it can impose more stringent regulation to bring these areas into compliance. EPA monitoring intensity varies across states.[7] Monitoring generates a large data base that can be used to study pollution trends. The data source for particulates is the EPA's Aeromatic Information Retrieval System (AIRS) data base. The unit of analysis is the monitoring station. Some counties have many monitoring stations. In the empirical analysis, a data point represents a single monitoring station. Table Two reports state median particulate patterns for the years 1981 to 1989. Note the large reduction in particulates for all states, with the exception of New York, between 1981 and 1982. Between 1982 and 1989, states experienced different particulate trends. In New Jersey, particulates increased during the 1980s while in West Virginia particulates continued to fall. After 1982, particulates were roughly constant in Illinois, Indiana, Ohio, Pennsylvania, New York and Michigan

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[6]Davis, Haltiwanger and Schuh (1996) present additional documentation of the decline of the steel industry from the 1970s-1980s (p112).

[7]In California in 1981, there was one particulate monitoring station for every 161,000 people while in Ohio there was one particulate monitoring station for every 32,000 people. My sample includes data from 35% of all counties.

To proxy for particulate regulation's intensity, I use the 1979 Federal Registar 40 CFR part 81 to assign all counties into two groups; those in attainment and those not in attainment with the Clean Air Act's particulate standard. Counties not in attainment face stricter regulation to bring them into compliance.[8] Non-attainment counties face more stringent regulation of new and existing polluting sources. The Clean Air Act's New Source Performance Standards affect the technology built into all stationary sources regardless if they are located in high polluted area or not. New sources located in counties not in attainment with the Clean Air Act standards were forced to adopt "lowest achievable emissions rates" (LAER) technology (Portney 1981). In addition, states had to design state implementation plans (SIPS) to demonstrate how existing plants would be regulated so that the area would come into compliance with the Clean Air Act's goals. Nationwide 384 counties were assigned to non-attainment status.[9]

Table Three reports the summary statistics for the 1982 and 1987 samples. The final data set includes measures of county air quality, manufacturing activity, industrial structure, and regulatory severity.

III. Empirical Framework

My goal is to quantify the impact of older vintage "smoke stack" manufacturing activity on air pollution. Manufacturing' impact may depend on its industrial organization. Concentration of activity within a single large plant might lead to more pollution if that plant had bargaining power with state officials who feared that increased regulatory costs might translate into a plant shut down (Deily and Gray 1991). Conversely, concentration of activity might lead to lower pollution if each plant has private information about its polluting activity and the regulator must pay a fixed cost to visit a plant and "get to know" its workings. In this case, counties with more activity concentrated at a few large plants should have lower particulate levels than counties which have a large number of small plants. LRD micro level data allows a simple test of this hypothesis. Particulates are an outcome measure that can used to study

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[8]Before 1987, the Clean Air Act standard for particulates was a yearly geometric average of 75 milligrams per cubic meter and a daily maximum of 265 not to be exceeded more than once a year (US EPA 1990 p31).

[9]Henderson (1995) uses county ozone attainment status as a proxy for regulatory severity in studying the impact of ozone regulation on ambient ozone levels.

whether regulation has a uniform impact across all types of firms. If total particulates from one 1000 employee firm equaled the total particulates from ten 100 employee firms then this would be evidence against the claim that small firms tend to face less stringent regulation than larger firms (Brown, Hamilton and Medoff 1990 p82).

I chose to focus on primary metals plants because they represent a relatively large share of Rust Belt activity and it is known to be a highly polluting industry.[10] To confirm this, I present in Table Four, 18 separate regressions. Each row of this table reports a separate regression where the dependent variable is the log of a monitoring station's yearly mean reading. This air quality measure is regressed on county manufacturing employment in a given two digit SIC industry in 1982 and on the aggregate manufacturing employment in all other industries. the remaining SIC industries. This table reports the coefficient from the particulate regression and its statistical significance. The third column reports the two digit SIC mean county employment measured in 100,000 workers. The right column reports the correlation between each counties's two digit sic manufacturing employment and all other manufacturing employment in the county. The key point to note is that only SIC 32 (Stone, Clay, glass), 33 (Primary metals), and 37 (Transportation Equipment) have a statistically significant impact on particulates after I control for all other manufacturing activity. Surprisingly, Table Four indicates many negative coefficients for the pollution impact of certain industries such as SIC 26 (Paper) and 36 (electronics). This is clearly due to the high correlation with all other manufacturing employment. This is suggestive though that plant closings in these industries will not lead to the same "green benefits" as a plant closing in SIC 32 or 33.

Given the findings in Table Four, I have chosen to aggregate manufacturing employment into the following cells; total county employment at plants that were operating in 1967 and that are in SIC 33 (primary metals), total county employment in SIC 32 at pre-1970 plants and all other manufacturing plants' employment. Total all other manufacturing activity is highly correlated with county employment levels, thus it is a proxy for county economic activity.

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[10]Ranson and Pope (1995) present an interesting case study that indicates the polluting content of steel production. They study daily Utah hospital admissions from 1985-1991 for breathing problems caused by small particulate matter caused by the local steel mill. They have a "natural experiment" because this steel mill is the only major producer of particulates in the area and because for one year the mill shut down due to a labor dispute. When the steel mill was open, the area averaged 12.6 violations of the 24 hour particulate standard while when the mill was closed the particulate standard was never violated.

Levels and Growth Rate Regressions

I assume that ambient particulate levels at a given monitoring station in a county is solely a function of manufacturing activity within that county that year. The levels estimation equation is presented in Equation (1). The dependent variable is the log of a monitoring station's annual mean particulate level. The independent variables include the three manufacturing employment cells (county total: pre-1972 vintage SIC 33, pre-1972 vintage SIC 32 employment, and all other manufacturing employment), the proxies for large and middle sized plants in the county, and state fixed effects.[11] I estimate equation (1) separately for counties assigned to and not assigned to non-attainment status in 1977.

$$\log(Tsp_{it}) = \phi + B\,X_{it} + \sum_j \alpha_j * cell_{jit} + U_{it} \qquad \textbf{(1)}$$

Note that equation (1) assumes that in a given year county manufacturing levels are not caused by local air pollution. As documented in Barnett and Crandall (1986), and Barnett and Shorsch (1983), declines in the integrated steel industry were caused by the rise of minimills, increased foreign competition and a slowing of demand growth. Equation (1) is estimated separately for attainment and non-attainment counties where attainment status was based on 1977 county particulate levels. . I estimate the model separately to study whether a plant employment contraction would have a larger impact in more or less regulated counties.[12]

Table Five presents four separate estimates of equation (1). Each column of Table Five reports a different set of estimates. The left two are for the 1982 sample and the right two columns present the 1987 results. In 1982, a 1000 person increase in primary metals (SIC 33) at pre-1970 plants would increase attainment county particulate levels by 1.7% and would increase non-attainment county particulate levels by 1.1%. Both of these estimates are statistically significant. This finding is consistent with the hypothesis that particulate regulation is lowering pollution per unit of economic activity. Interestingly, the impact of SIC 33 on particulates increases from 1982 to 1987 in both the attainment and

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[11]I estimate the levels regressions using a group effects specification, (the huber command in stata) that allows for monitoring stations within the same county to have correlated disturbance terms.

[12]Clearly, there is a selection issue that initial attainment status is not randomly assigned but I am not attempting to estimate the counter-factual of what the marginal pollution content in non-attainment areas would have been in the absence of regulation.

non-attainment counties. The top row of the right two columns of Table Six indicates that a 1000 person increase in SIC 33 at pre-1970 plants would increase attainment county particulate levels by 3.1% and would increase non-attainment county particulate levels by 2.4%. Deily and Gray's (1991) work offers one potential explanation. For the steel industry, Deily and Gray find that plants that had a higher probability of closing faced less stringent regulation. During the 1980s, as more steel plants closed, local environmental regulators might have eased off on their inspections. More convincing evidence for this theory would be if pollution per unit of steel plant activity increased by more in non-attainment than attainment counties between 1982 and 1987. Table Five does indicate that pollution per unit of steel activity did increase more in non-attainment than attainment counties. Table Five indicates that the impact of SIC 32 activity has a large positive but imprecisely measured impact on particulates. Surprisingly, I find that the SIC 32 coefficient shrinks markedly between 1982 and 1987 in non-attainment counties. This may be evidence of regulatory success for this particular industry.

The third row of Table Five presents the impact of all other manufacturing, besides for pre-1970 SIC 33, activity on particulates. For attainment counties, I find a statistically significant effect in 1982 and 1987 that a 1000 person increase in county "other manufacturing" increases particulates by only .2%. Interestingly, for non-attainment counties the coefficient is negative and statistically insignificant in both 1982 and 1987.

To test whether an industry's organization matters for conducting a green accounting, I use the results in Table Six. Table Six indicates that counties with more activity concentrated in a few small plants do not have a statistically insignificant for attainment counties but for non-attainment counties it is negative and statistically significant in both 1982 and 1987. This suggests that counties with more concentrated manufacturing employment enjoy lower particulate levels. This is consistent with a fixed cost monitoring hypothesis. Note that the variable "percent of plants that employ between 50 and 100" is statistically insignificant in all four specifications.

Table Six repeats the exercise in Table Five but the four specifications do not include state fixed effects or the SIC 32 employment variables. I include this specification to indicate that the steel plant pollution coefficient estimates are robust across alternative specifications. In 1982 in attainment counties, a 1000 person increase in pre-70 SIC 33 increases particulates by 2.4% in this specification (as compared to 1.7%) in Table Five.

Table Seven reports estimates of equation (1) where I have imposed the pollution per unit of manufacturing is equal. Note that manufacturing does increase pollution but the coefficient is much smaller than the primary metal's coefficient reported in Tables Five or Six. An extra 10,000 manufacturing jobs in an attainment county raise particulate levels by 2.8% while this would raise particulates by .5% in non-attainment counties.

Growth Regressions

Manufacturing employment change can occur at the intensive or extensive margin. Plants can shut down or can shrink in size. These two different events may have different impacts on local air quality. If environmental abatement investment has a variable cost component and firms know that during recessions they are less likely to be monitored, then firms have an incentive to lower their pollution abatement expenditures during downturns. A testable hypothesis based on this theory is that reductions in manufacturing activity at the intensive margin should have less of an effect on air quality than changes in activity at the extensive margin. I use the panel nature of my data to test whether plant shutdowns have a greater impact on air quality than plant employment reductions.

To study how changes in manufacturing activity at the intensive and extensive margin affect county particulate levels, I re-estimate a first differenced version of equation (1) but break out the cells by whether change occurs at the intensive or extensive margin. I define the intensive margin as changes in employment for firms that stay in business. I define the extensive margin as employment changes for plants that enter or shut down. For example, if in county j in 1982 two plants each employ 100 workers and in 1983 one plant goes out of business and the other employees 110 workers, then intensive growth has been 10 and extensive growth has been -100. In the regression, there are now four manufacturing variables and a constant that represents the time trend. Two of the manufacturing activity proxies are; total county growth in primary metals employment at pre-1970 vintage plants at the intensive margin and the extensive margin. I aggregate all other manufacturing industries into two categories; county job growth at the intensive and extensive margin. As I discussed above, I use my growth rate regressions to study whether reduced activity at the extensive margin has a greater impact on air quality than changes in employment at the intensive margin.

Table Eight presents the results.[13] For both attainment and non-attainment counties, employment

[13]As would be expected, I do not obtain a very impressive fit in a differenced regression. The R2 for the attainment counties is .06 and is .04 for the non-attainment counties

growth at the intensive margin for pre-1970 primary metals plants increases local particulate levels. At the 5% significance level, I cannot reject the hypothesis that the marginal pollution impact across attainment and non-attainment counties are equal. It is interesting to note that the intensive margin coefficient estimates are roughly similar to the estimates from the levels regressions. For all other manufacturing growth at the intensive margin, I find that it does have a statistically significant positive impact on particulates in attainment counties but that its impact is 1/3 the impact of primary metals activity. The extensive margin estimates are more puzzling. Interestingly, for the attainment counties, primary metals has a much larger extensive margin impact than at the intensive margin. This suggests that there are large air quality gains enjoyed when primary metals plants shut down. In attainment counties, if a 1000 person plant closes particulates fall by 8.1%! For non-attainment counties, I find no evidence that employment changes at the extensive margin have a larger impact than at the intensive margin.

IV. Benefit Simulations

I now have all the ingredients to conduct a "Green Accounting" calculation. My goal is to simulate the county aggregate environmental benefits when a manufacturing plant closes and its workers are displaced to the low paid, low pollution service sector. I use my pollution production estimates to predict the local improvement in air quality from a reduction in manufacturing activity. This marginal increase in air quality is then mapped through a heath production function to estimate the social benefits of the plant's decline. This exercise yields an estimate of the "silver lining" of declining plant production. To conduct this simulation, I borrow from Portney's (1981) study. His work offers a methodology for combining estimates from the value of life and the epidemiology literatures to predict the dollar value of reduced particulate levels.[14] Table Nine reports willingness to pay for reduced particulate levels under different assumptions on one's value of life and the mortality impact of particulates. Taking the mortality rate of an increase in particulates as given, I estimate how much a risk neutral individual would be willing to pay under different scenarios on his value of life.[15] For example, if one valued one's life at a million

[14]Portney takes an EPA's mortality study's estimate that a 18 cubic milligram reduction in tsp will lower the annual risk of death for a middle aged man by .00009. This implicitly is assuming that mortality is a linear function of particulate exposure.

[15]Multiplying the value of life times the probability of death yields the upper bound of what a risk neutral fully informed agent would be willing to pay to avoid exposure.

dollars and a reduction in particulate would lower the chance of dying by .001, then a risk neutral person would be willing to pay a maximum of $1000 for this air quality improvement. Interestingly, the values presented in Table Nine are roughly in line with recent hedonic estimates. For example, the elderly would be willing to pay a maximum of $26 to reduce particulates by one unit. This estimate is at the median of Smith an Hwang's (1995) meta-analysis.

To simulate, I use the estimates from Table Six that 1000 pre-1970 primary metal jobs in an attainment county increase particulates by 2.4% and in a non-attainment county increase particulates by 1.3%. Let 5000 manufacturing jobs in a county with 500,000 people be destroyed. Let initial air quality be the mean in 1982 of 52. If the county were a non-attainment county the 5000 job loss would reduce particulates down to 47.3. This would be a reduction of 4.7 units of particulates. Following Table Nine, I assume that a risk neutral person's willingness to pay is $40 per unit of particulates.[16] Thus, each person is willing to pay $188 for this air quality improvement. Since this air quality improvement is a local public good, I multiply individual willingness to pay times the number of people in the county, 500,000. This equals 94 million dollars.

This air quality improvement has been achieved but 5000 "good jobs" have been lost. Let the wage loss each worker suffers by being displaced to the service sector be called D. Assuming that each person works 2000 hours a year, then if 2,000*D*5,000 is greater than 94 million dollars the losers have lost more than the rest of society has gained by the improvement in air quality. In this simulation, this displaced wage threshold is $9.4 dollars an hour.[17] This is the reservation wage loss such that society could "compensate the losers" and still have a pareto optimum of shutting down the plant. If the displacement loss is less than $9.4 an hour then it is Hicksian pareto improvement that the steel activity decreased. Clearly this simulation has ignored the regional multiplier effects of having a steel plant operating and it has ignored the economic profits lost by the owners of the firm but the simulation does show that the gains to the rest of the county are roughly comparable to the expected losses to the

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[16]Note that the inputs in this table are an epidemiology estimate of the impact of particulates on health and an assumed value of life. An alternative methodology would be to estimate hedonic wage and rental regressions and to use the implicit price of particulates to proxy for willingness to pay (see Blomquist et. al. 1988).

[17]Jacobson, Lalonde and Sullivan (1993) using administrative data from Pennsylvania in the early 1980s find that for workers in the primary metals industry who were displaced have suffered between $10,500 and $12,000 yearly loss after being displaced five years before. At 2,000 hours this would translate into a $5 to $6 an hour loss.

displaced workers. Recent labor research on the costs of displacement suggest that $10 an hour is roughly the displacement cost for experienced workers. Thus, the air pollution gains are surprisingly large relative to the private costs.[18]

V. Conclusion

By spatially merging air quality data and manufacturing data, this paper presented new estimates of the pollution externality created by different types of manufacturing plants. This regression framework extends the recent case study by Ransom and Pope (1995) which directly studied the health benefits of a single plant shutdown in Utah. Given the high population density of the "Rust Belt" states it is important to quantify how their air quality co-moves with economic activity. I demonstrated the importance of disaggregating manufacturing activity by SIC industry type and by plant vintage when measuring the pollution externality from manufacturing activity.

Combining the estimates of manufacturing's pollution externality with estimates of the value of particulate reduction, I conducted a green accounting exercise to estimate the net change in a local economy's welfare when a plant closes. The decline in primary metals production in Rust Belt states has lowered local particulate levels. Although manufacturing workers have been displaced and are likely to take lower paying jobs in the service sector, on net the social benefits for large counties are comparable to the displaced workers' private costs.

This paper's findings have consequences for Grossman and Krueger's (1995) empirical finding of a U relation between environmental quality and national income. Selden and Song (1995) argue that the U is achieved because of a regulatory J curve. This theory argues that as income rises, individual demand for regulation increases and that regulation causes the environmental improvement. This paper's empirical work suggests an alternative route. The change in the mix of a nation's industrial composition away from manufacturing and toward services. There are gains from becoming a "service" economy. Such benefits should be reflected in national income accounting.

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[18]Clearly the benefits estimates would be smaller if the county had a smaller population, or if there were diminishing marginal returns to reduced particulates, or if the value of life is lower than a million dollars per person.

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Table One

Employment Trends in SIC 33 (Primary Metals)

State	1972	1977	1982	1987	1972 to 1987 % change
Illinois	98	89	60.7	43.2	-55.9
Indiana	103	102	86.2	60.3	-41.4
New Jersey	31	21	21.6	18.3	-41.0
New York	58	53	38.2	22	-62.1
Ohio	142	134.2	97.6	65.6	-55.9
Penn	186	172	118.7	67.3	-63.8
Employment Expressed in 1000s					

Table Two

Rust Belt Median Particulates 1981-1989

State	1981	1982	1983	1984	1985	1986	1987	1988	1989
IL	66	56	65	54	56	53	57	61	75
IN	64	52	54	52	53	51	55	58	46
OH	64	54	55	54	51	50	52	58	57
PA	63	53	51	52	48	50	49	53	54
WV	66	59	57	54	48	49	48	51	46
NY	49	45	39	46	45	45	49	49	47
MI	54	48	48	49	50	45	51	47	47
NJ	51	44	50	55	55	53	59	63	-
Yearly State Medians - units are micrograms per cubic meter									

Table Three

Summary Statistics

Variable	1982 mean (SD)	1987 mean (SD)
mean particulates	52.0 (15.5)	52.7 (15.6)
dummy for non-attainment county	.64 (.48)	.67 (.47)
SIC 33 Pre-1970	.031 (.056)	.019 (.03)
All Other Manufacturing employment	.34 (.64)	.28 (.53)
% of plants that employ greater than 100	.10 (.06)	.10 (.08)
Aggregate manufacturing employment	.38 (.68)	.31 (.56)
observations	1315	967

employment measured in 100,000s, the unit of analysis is a monitoring station in a county. Thus, counties with multiple monitoring stations are more heavily represented. In 1982, mean particulates in attainment counties was 47 while in non-attainment counties it was 54.7.

Table Four

Particulate Pollution by Two Digit SIC

SIC name and number	Pollution content for Two digit SIC	Pollution content for all other Manufacturing employment	Mean Employment for that Two Digit SIC	correlation of all other Manufacturing employment and employment in that SIC
22 (Textile Mill)	-.31	.000000109**	.003	.31
23 (Apparel and Other Textiles)	.088	.000000104**	.02	.53
24 (Lumber and Wood)	-21.4**	.000000287**	.003	.91
25 (Furniture and Fixtures)	-3.33*	.000000173**	.006	.85
26 (Paper)	-2.81*	.000000205**	.012	.90
27 (Printing and Publishing)	-1.15	.000000257**	.037	.95
28 (Chemicals)	.37	.0000000957**	.018	.78
30 (Rubber and Plastics)	-2.76*	.000000219*	.013	.92
31 (Leather)	-4.59	.000000128**	.002	.59
32 (Stone, Clay, glass)	8.82**	.0000000367	.006	.67
33 (Primary Metals)	1.79**	.0000000159	.031	.62
34 (Fabricated Metals)	-.30	.000000152*	.045	.96
35 (Industrial Machinery)	-.15	.000000129	.056	.96
36 (Electronics)	-1.41**	.000000252**	.032	.92
37 (Transportation Equipment)	.58**	.0000000735**	.036	.58
38 (Instruments)	-.46**	.000000129**	.019	.48
39 (Misc.)	-4.00*	.000000226**	.008	.92

Each row of this table reports a separate regression where the dependent variable is the log of a monitoring station's yearly mean reading. This air quality measure is regressed on county manufacturing employment in a given two digit SIC indusry in 1982 and in the remaining SIC industries. Thus for each regression, I aggregate up all other industries employment to form aggregate manufacturing. This table reports the coefficient from the particulate regression and its statistical significance. ** indicates 1% level, and * indicates 5% level. The third column reports the Two digit SIC mean county employment measured in 100,000 workers. The right column reports the correlation between each counties's two digit sic manufacturing employment and all other manufacturing employment in the county. N=1315.

Table Five

Rust Belt County Particulate Levels Regressions

Dependent Variable is the log of a monitoring station's yearly average particulates				
Independent variable Variable	1982		1987	
	Attainment County	Non-Attainment County	Attainment County	Non-Attainment County
county manufacturing in SIC 33 in Pre-1970 Plants	1.66 (.22)	1.08 (.39)	3.06 (.71)	2.44 (1.33)
county manufacturing in SIC 32 in Pre-1970 Plants	8.11 (2.99)	4.24 (2.50)	7.34 (4.62)	1.09 (2.42)
total county manufacturing at all other plants	.21 (.04)	-.05 (.04)	.21 (.09)	-.06 (.07)
% of plants that employ greater than 100	.19 (.15)	-.20 (.14)	.11 (.15)	-.31 (.17)
% of plants that employ between 50 and 100	-.29 (.24)	.24 (.41)	.07 (.50)	-.10 (.63)
R2	.36	.21	.21	.17
observations	464	851	294	646
(SIC 32 is Stone, Clay, Glass), SIC 33 is primary metals. standard errors in parentheses. Employment measured in 100,000s.				

Table Six

Rust Belt County Particulate Levels Regressions

Dependent Variable is the log of a monitoring station's yearly average particulates				
Independent variable Variable	1982		1987	
	Attainment County	Non-Attainment County	Attainment County	Non-Attainment County
county manufacturing in SIC 33 in Pre-1970 Plants	2.36 (.22)	1.34 (.51)	3.59 (.41)	2.64 (1.30)
total county manufacturing at all other plants	.21 (.075)	.005 (.03)	.19 (.095)	-.02 (.06)
% of plants that employ greater than 100	.40 (.14)	-.13 (.31)	.17 (.11)	-.33 (.12)
constant	3.67 (.04)	3.92 (.04)	3.79 (.04)	3.93 (.02)
R2	.21	.25	.14	.12
observations	464	851	294	646

SIC 33 is primary metals. standard errors in parentheses. Employment measured in 100,000s.

Table Seven

Aggregate Particulate Levels Regressions

Dependent Variable is the log of a monitoring station's yearly average particulates				
Independent variable Variable	1982		1987	
	Attainment County	Non-Attainment County	Attainment County	Non-Attainment County
Aggregate County Manufacturing Employment	.28 (.09)	.07 (.018)	.23 (.10)	.09 (.02)
% of plants that employ greater than 100	.41 (.15)	-.18 (.31)	.10 (.13)	-.38 (.12)
constant	3.71 (.04)	3.94 (.03)	3.82 (.04)	3.94 (.023)
R2	.07	.06	.02	.08
observations	464	851	294	646
Standard errors are in parentheses. Employment measured in 100,000s.				

Table Eight

Rust Belt County Particulate Growth Rate Regression

The dependent variable is the growth rate between 1982 and 1987 in yearly average particulates at a given monitoring station.		
Independent variable Variable		
	Attainment County	Non-Attainment County
change in county manufacturing in SIC 33 in Pre-1970 Plants at the intensive margin	1.69 (.64)	1.97 (.68)
change in county manufacturing in SIC 33 in Pre-1970 Plants at the extensive margin	-8.12 (5.17)	-.67 (.24)
change in all other county manufacturing at the intensive margin	.58 (.24)	.51 (.35)
change in all other county manufacturing at the extensive margin	.15 (.19)	-.11 (.07)
constant	-.03 (.014)	-.06 (.014)
R2	.04	.03
observations	246	560
Standard errors in parentheses. Manufacturing measured in 100,000s of jobs.		

Table Nine

Willingess To Pay for Reduce Particulate Levels

thought experiment	value of life	change in mortality rate for demographic group	Risk Neutral WTP
particulates decline by 10	1,000,000	.0004 (men aged 45-64)	400
particulates decline by 10	1,000,000	.00005 (men aged 45)	50
particulates decline by 10	250,000	.001 men aged 65+	258
Mortality rates for a given reduction in particulates are taken from Portney (1981). Risk Neutral willingness to pay (WTP) is calculated by multiplying the value of life by the change in the mortality rate.			

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