Example 20.2
Does the Clean Air Act Pass a Cost-Benefit Test?

The 1970 Clean Air Act (CAA) was the first attempt by the federal government to reduce industrial emissions at their source. It targeted four pollutants – carbon monoxide (CO), tropospheric ozone (O_3), sulfur dioxide (SO_2), and total suspended particulates (TSP), and established a set of regulations on the principal emitters of these pollutants. It also set up effective mechanisms for enforcing the regulations.

The regulations led to a rapid improvement in air quality. Emissions of these four pollutants had already decreased substantially by 1980 and have continued to decrease since then. The air over the United States is much cleaner than it was in 1970.

The CAA chose a command-and-control (CAC) approach to reducing emissions. The regulations were in the form of requirements that polluting firms invest in particular emissions-reducing equipment. As discussed in Chapter 7 of the text, the CAC regulatory approach is much more costly than pricing strategies, such as emissions taxes or marketable permits, for achieving a given amount of pollution reduction.[1] So the question naturally arises: Do the CAA regulations of these four pollutants pass a cost–benefit test? Do the benefits of the reduced emissions exceed the costs to the regulated industries of the excessively costly CAC approach?

The truth of the matter is that economists have no idea what the answer is, although their ignorance has not been for lack of research effort. There have been many studies over the past 30 years of both the benefits and the costs of the CAA regulations. The benefit studies are most often hedonic price estimates of housing values that include TSP levels at the housing site as one of the explanatory variables. TSP is the chosen pollutant for these studies because it is the most visible of the four pollutants. It is also the most harmful in terms of its effects on health because of its relatively high

[1] The Environmental Protection Agency, which administers the CAA, did institute a system of marketable permits in 1990 to control the emissions of SO_2 from the electric utilities, but this is the only example of a pricing approach to controlling the four pollutants from industrial sources. And it does not apply to SO_2 emissions by any industry other than the electric utilities. The other industries are still subject to the EPA's regulatory approach to reduce SO_2 and the three other pollutants.

concentrations in the atmosphere compared with the other three pollutants. The cost studies try to determine the effect of the EPA regulations on the inputs (employment and investment) and outputs (sales) of the emitting industries.

The weight of the evidence of all this research by the year 2000 was really quite remarkable: The entire 30-year history of the regulations appeared to be much ado about nothing. On the benefit side, Kerry Smith and Ju-chin Huang reviewed 37 studies of the effect of air quality on housing values. Their conclusion regarding TSP was that a one microgram per cubic meter ($1\mu g/m^3$) reduction in TSP led to a .05% to .10% increase in property values. This implies a negligible elasticity of housing values with respect to the reduction in TSP concentrations of between –.04 and –.07. Either people place no value on cleaner air or the existing hedonic price estimates were unable to uncover the value.

On the cost side, surveys of managers in the emitting industries indicate that the CAA regulations are very costly and threaten their competitiveness in world markets. But the econometric studies do not bear this out. They typically find that the regulations have had virtually no effect on the activity of the emitting industries. Moreover if a study did find an effect it was typically *positive* – the regulations are somehow *beneficial* to the industry! Again, either the regulations are costless or the existing studies are simply unable to uncover the costs.

The strong presumption among economists, and probably anyone else, is that there are substantial benefits and costs to the CAA regulations, so that the existing studies must suffer from design flaws in trying to estimate them. Two recent studies on the benefits and costs of the CAA regulations by Michael Greenstone strongly suggest that this presumption is correct (the benefits study was joint research with Kenneth Chay).[2] Greenstone (and Chay) made two significant advances on the existing literature. They used massive data sets to estimate the benefits and costs that were far more detailed and comprehensive than had been used before, and they exploited a design feature of the CAA regulations to overcome a serious design flaw of the previous studies. Their results show that there are, indeed, substantial benefits and costs associated with the CAA regulations.

The design feature they exploit is that, immediately after the passage of the 1970 CAA, the Environmental Protection Agency (EPA) established a system of monitoring the four pollutants at numerous sites across the United States. The EPA reports the air quality for each of the 3070 counties in the U.S. and each year designates a county as nonattainment or attainment with respect to each pollutant. For example, a county is designated as nonattainment with respect to TSP if either:

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[2] Chay, K., and Greenstone, M. (2005) Does Air Quality Matter? Evidence from the Housing Market, *Journal of Political Economy*, **113**(2); and Greenstone, M. (2002) The Impacts of Environmental Regulations on Industrial Activity: Evidence from the 1970 and 1977 Clean Air Act Amendments and the Census of Manufacturers, *Journal of Political Economy*, **110**(6). The Smith and Huang elasticity estimates are reported in Chay and Greenstone (2005), p. 377. The original reference is Smith, V. K., and Huang, J. (1995) Can Markets Value Air Quality? A Meta-Analysis of Hedonic Property Value Models, *Journal of Political Economy*, **103**(February). The summary of the literature on environmental regulations and industrial activity is reported in Greenstone (2002), p. 1176.

- the annual geometric mean concentration exceeds 75μg/m^3, or
- the second highest daily concentration was above 200μg/m^3.[3]

Counties can, and do, move in and out of nonattainment status year by year.

Emitting industries located in nonattainment counties are subject to more stringent regulations than their counterparts located in attainment counties. In the nonattainment counties, the industries must install equipment for reducing the nonattaining pollutant at each of their manufacturing plants that is the best practice equipment for that industry. In addition, if a firm's investment in a new plant or the expansion of an existing plant leads to new emissions, as it surely will, then the emissions have to be offset by equal reductions in emissions at the firm's existing plants. Finally, all firms must obtain emissions permits that limit their overall emissions of the pollutant. In the attainment counties, in contrast, the required emission-reducing equipment that firms must install is well below best practice, and therefore less costly and less effective. Also, only the larger plants are subject to this regulation; the smaller plants are exempt. And there is no offset provision for new investment. A final point is that the regulations apply in either type of county only to the plants in industries that the EPA identifies as significant emitters of one or more of the four pollutants.

The effects of these county designations and regulations are twofold. First, the reduction in pollutants has been much larger in the nonattainment counties than in the attainment counties. And this was true almost immediately. For example, from 1971–5 the TSP concentrations fell by 10μg/m^3 more in the nonattainment counties than in the attainment counties, a difference of about 12% relative to 1970 average concentrations.[4] Second, the regulations are much more costly to firms in emitting industries whose plants are located in nonattainment counties. Greenstone and Chay exploit these differences in their benefit and cost studies.

Benefits of Reducing Pollutants

Chay and Greenstone employ the hedonic price estimation of housing values using TSP concentrations as their measure of air quality, consistent with most of the literature. But they point out that a major design flaw in the previous studies is that they use actual TSP concentrations as the explanatory variable for air quality in the hedonic price equation. The problem is that TSP concentrations are correlated with many of the other explanatory variables commonly used in these equations. For example, TSP concentrations tend to be higher in areas with higher population densities, per capita incomes, crime rates, and stronger local economies (as the economy improves, industrial production increases and with it TSP concentrations increase). But if TSP concentrations are correlated with explanatory variables that are included in the equation, then they are likely to be correlated with omitted variables that the econometrician does not have access to but that also affect housing prices. The error term in a regression equation picks up the effects of

[3] Chay and Greenstone (2005), p. 383.
[4] Ibid., p. 378.

the omitted variables, which means that TSP concentrations are likely to be correlated with the error term. The econometric issue is that the coefficient estimates of explanatory variables that are correlated with the error term are biased and the direction of the bias may not be predictable, as is the case for TSP concentrations. The solution is to find what econometricians refer to as an instrument variable to substitute for the explanatory variable in the estimating equation, in this case, a variable that is highly correlated with TSP concentrations but not directly correlated with housing values. The EPA's designation of a county as nonattainment or attainment is just such a variable.

Therefore, Chay and Greenstone use data from the 1970 and 1980 censuses to build a huge database of housing values and a set of explanatory control variables within the 3070 counties in the United States. The change in housing values from 1970 to 1980 is the dependent variable, and the 1975 nonattainment/attainment status of the county in which a house is located is the instrumental variable for county TSP concentrations. As noted above, nonattainment counties experienced a much larger reduction in TSP concentrations than did attainment counties by 1975. They find that housing values do respond to nonattainment status and that the estimated response is robust to different combinations of explanatory control variables (a feature that is generally not true of the previous literature). The coefficient estimate on nonattainment status implies that a $1\mu g/m^3$ reduction in TSP concentration leads to a .2% to .4% increase in housing values. This leads to an elasticity of housing values with respect to reductions in TSP concentrations of between –.2 and –.35, an elasticity five to eight times larger than in the previous literature reviewed by Smith and Huang. The mean housing prices in nonattainment countries were $2,400 higher than in attainment counties during the sample period, other things equal. Since there were about 19 million homes in the nonattainment counties, this implies an aggregate willingness to pay off approximately $45 billion for the lower TSP concentrations achieved by the stricter nonattainment regulations. This is the first study to find benefits of cleaner air of this magnitude for which the estimates on the pollution variable are likely to be relatively free of bias.[5]

Costs of Reducing Pollution

The previous studies on the costs of the CAA regulations suffer from the same bias as the benefit studies. Concentrations of the various pollutants are not only related to the level of activity in the polluting industries, but they are also related to factors that might be used as explanatory variables in a regression equation, such as the variables on the performance of the overall economy. The ideal solution to this problem would be if regulations were randomly assigned to plants, in which case the regulations could not be related to any omitted variables, and therefore not to the error term in a regression equation. The use of location in a nonattainment or attainment county to proxy the effects of the regulations is not quite as clean as random assignment, but it is far better in avoiding estimation bias than using concentrations of pollutants as an explanatory variable.

[5] The results are summarized in ibid., pp. 418–9.

In addition, the previous studies are often too aggregated. They use data on industries or firms, whereas the regulations are applied to individual plants. Greenstone solved this problem by collecting data on approximately 1.75 million plants over four 5-year Census of Manufacturers survey periods, 1967–72 (pre-regulations), 1972–77, 1977–82, and 1982–87. He tags industries as emitting industries if they are responsible for at least 7% of the emissions of each of the four pollutants, either individually or together.[6] The plants in the other industries are assumed not to be subject to the CAA regulations. This was by far the largest data set on CAA regulations and industrial activity ever assembled.

The results are worth the effort. Greenstone finds that location in a nonattainment county relative to an attainment county led to losses of 590,000 jobs, $37 billion of capital, and $75 billion of sales (in 1987 dollars) in the emitting industries during the first 15 years that the CAA regulations were in effect.[7] These losses do not directly translate into the costs of the CAA regulations because some or all of the released labor found employment elsewhere, and firms reallocated investment to non-regulated industries or attainment counties, leading to offsetting increased sales elsewhere in the economy. Rather, the costs are in the nature of adjustment costs, such as the lower wages received in alternative jobs and the costs of adjusting capital stocks, which are often considerable. In addition, Greenstone is unable to estimate the effect of the regulations in the attainment counties. But the point is that he is able to demonstrate for the first time that the CAA regulations have had a substantial effect on industrial activity in the emitting industries, which is certainly plausible.

In summary, the use of county-level data and exploiting the differences between attainment and nonattainment counties would seem to be viable strategy for conducting a cost–benefit analysis of the CAA regulations. At this point though, such a study remains a topic for future research. The question of whether the Clear Air Act passes a cost–benefit test remains an open question.

[6] Some industries emit significant amounts of more than one of the four pollutants, such as pulp and paper and iron and steel, which emit significant amounts of all four pollutants. Greenstone (2002), p. 1181. The EPA does not make available its list of significant polluters subject to the regulations, which is why Greenstone uses an arbitrary 7% standard.
[7] Ibid., p. 1213.