

A Review of *Markets for Clean Air: The U.S. Acid Rain Program*¹ by A. Denny Ellerman, Paul L. Joskow, Richard Schmalensee, Juan-Pablo Montero, and Elizabeth M. Bailey

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THE BOOK BEGINS with a quote from J. H. Dales' *Pollution, Property, and Prices*, "If it is feasible to establish a market to implement a policy, no policymaker can afford to do without one." This book provides important evidence in support of Dales' statement by thoroughly examining the first several years of the U.S. acid rain program. This innovative program uses a cap-and-trade approach, rather than the traditional command-and-control approach, to reduce sulfur dioxide (SO₂) emissions. The book offers substantial evidence of the program's success.

The analysis is of both practical and scientific importance. From a practical viewpoint, the acid rain program is an ambitious effort to reduce a major pollutant. It is important for us to understand whether the program is successful and how it might be improved. From a scientific viewpoint, the authors' analy-

sis provides a framework and methodology for evaluating similar programs. There is much we can learn about effective regulation from the analysis.

Background. Title IV of the 1990 Clean Air Act Amendments created an SO₂ emissions trading program. SO₂ is one of the main pollutants responsible for acid rain, which harms aquatic life and trees, especially in the northeast U.S. and southeast Canada. In 1985, electric utilities accounted for about 70 percent of the SO₂ emissions, with nearly all coming from coal-fired units. Title IV imposes a national cap on SO₂ emissions from electric utilities. Each utility is given allowances; each allowance (or permit) entitles the holder to emit one ton of SO₂ in the vintage year or any later year. On an annual basis, the utility must have sufficient allowances in its account, managed by the Environmental Protection Agency (EPA), to cover its emissions. Title IV encourages trading of the allowances in both private markets and in an annual EPA auction.

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Before Title IV, air pollution in the U.S. was governed through command-and-control regulation. Specific rates of emission would be set for a particular pollution source, or specific control technologies would be required. Instead, Title IV sets a cap on national emissions of SO₂. The cap was set to reduce SO₂ emissions by 10 million tons per year from 1980 levels by the year 2000. In Phase I (1995–99), the program applied to the 263 dirtiest large generating units. In Phase II (2000 and beyond), the program applies to nearly all fossil-fueled generating units.

By January 31 of each year, each utility must turn over to the EPA sufficient allowances to cover its emissions for the year. Failure to do so results in substantial fines and further emission reductions. The utility receives an initial endowment of allowances based largely on historical heat input. Typically, the initial endowment is insufficient to maintain the status quo. The utility must either purchase additional allowances (from those with a surplus) or reduce its emission levels. Abatement can be accomplished in a number of ways: (1) shifting generation from dirtier units to cleaner units, (2) changing fuel type from dirtier fuel to cleaner fuel, and (3) installing scrubbers that remove SO₂ from the flue gas. In addition, since excess allowances can be banked for use in later years, a utility can satisfy future needs by over-complying in earlier years.

The primary advantage of a cap-and-trade program is that it provides incentives for least-cost attainment of the environmental goal, in this case the mandated reduction in SO₂ emissions. Efficient abatement is achieved in theory, since the utility has the flexibility to employ the least-cost abatement techniques, or to purchase additional allowances if others can reduce emis-

sions more cheaply. All that is required for efficient abatement are cost-minimizing utilities and an efficient market for allowances.

Since 1993, the EPA has conducted an annual auction. About 2.8 percent of the allowances are held back from the utilities and sold in a revenue-neutral auction. Any party can buy or sell allowances in this auction. The auction was intended to stimulate private markets by providing some early price signals. It also reduced fears that entry would be impeded by utilities hoarding allowances.

A key element of the cap-and-trade program is accurate measurement of emissions. Title IV requires each utility to install continuous emission monitoring equipment, and imposes stiff penalties if the equipment is not accurate. The EPA also maintains a database to track each unit's allowances over time. Private trades of allowances are reported to the EPA and recorded in the database.

Outline. The book's coverage of the acid rain program is comprehensive. It begins by looking at the political economy of the steps leading to the adoption of Title IV. This helps us understand the political constraints that led to its ultimate design. Next the book analyses the effects of Title IV on SO₂ emissions, the compliance strategy of firms, the performance of allowance markets, and the cost of compliance. The cost savings under Title IV versus traditional command-and-control are estimated. The book concludes with lessons learned from the Title IV experience. My remarks will follow this outline.

Politics. In understanding the politics of Title IV, there are two main questions. Why was a cap-and-trade program adopted, rather than command-and-control? And how should the allowances be allocated? There is little in the book on the first question.

Economists have long advocated cap-and-trade programs. Certainly, George Bush's election was important in both supporting the acid rain program generally, and a market-based approach in particular. A second factor was the relative simplicity of implementation. Most of the SO₂ pollution was coming from a known set of utilities. Accurate and cost-effective measurement of emissions was possible.

The second question—how should the allowances be allocated?—is a thorny distributive matter. Not surprisingly, much of the debate focused on this question, as each special interest sought to shift the allocation in its favor. The program potentially provides an excellent opportunity to test theories of distributive politics, given the clear outcome (a specific allocation) and the high stakes (undiscounted estimates of the value of allowances over the first ten years of Phase II ranged between \$45 and \$63 billion). The book performs such an analysis. However, because of the difficulties in measuring the inputs to the distributive bargain, it is hard to conclude too much from the outcome. The regression results do not support any one theory of distributive politics. The authors conclude that the results appear too complex to be captured by a simple regression analysis.

Interestingly, the distributive analysis takes as given that the allowances will be predominantly “grandfathered” based on historical heat input. Apparently, the option of awarding the allowances to the public was never seriously considered, even though such an approach has some economic merit. For example, the publicly-owned allowances could be auctioned with revenues going to the Treasury, providing a distortion-free revenue stream to offset distortionary taxation. That the diffuse interests of the taxpayers were ignored in favor

of the focused interests of the utility industry supports a Stigler-Peltzman theory of distributive politics.

Performance. The first step in understanding the performance of Title IV is creating a counterfactual estimate of what would happen to SO₂ emissions without Title IV. To this end, the authors study the pre-1995 trend in SO₂ emissions. From 1985, despite increasing generation, SO₂ emissions fell. Pre-1994, the decline in emissions is attributable to rail-rate deregulation, which made it economical for some substitution of high-sulfur coal for low-sulfur coal. The subsequent analysis uses this counterfactual benchmark in evaluating the impact and cost of Title IV.

A visible success measure of any program is compliance. Here Title IV shines. In the first three years, compliance was perfect. Indeed, there was substantial overcompliance, with most utilities banking surplus allowances for use in later years. Still, it is important to understand how the utilities complied. Roughly 37 percent of the abatement came from scrubbers, with the remaining coming from fuel switching. Fuel switching was aided by the substantial drop in rail rates.

One of the potential flaws in the acid rain program is its national structure. SO₂ is a regional pollutant. Its effects may be felt hundreds of miles from the source, but not thousands. Hence, there was a possibility that the abatement would occur in the wrong spots. The alternative was to set regional caps that would prevent hot spots, but reduce trading flexibility. Thus far, hot spots have not developed. The greatest abatement occurred in regions causing the biggest problems. I would contend that there is some amount of good fortune in this result. The economics simply made it attractive for the most problematic polluters to abate. The authors raise an

alternative hypothesis that there was a tendency for each utility to perform its own abatement, rather than rely on trade. Indeed, only one utility relied significantly on the purchase of allowances. This would suggest that the economic gains from inter-utility trading may have been only partially realized.

Most utilities satisfied Title IV through internal trading of allowances; that is, trading allowances between units owned by a single utility, rather than trading between different utilities. The utility would have some units with surplus, and would apply this surplus to meet shortages on other units. About 75 percent of current allowance demand was met through internal trade. The remaining 25 percent was met with either external purchase or withdrawals from banked allowances. Despite this evidence of the importance of internal trading, the external trading market was important. It is the external trading market that provides a market price for allowances. This price information is essential for efficient utility decision making. In any program like this, it is natural for the internal trading opportunities to be exploited first, but this does not mean that external trading is any less important in promoting long-run efficiency.

Title IV includes a voluntary compliance program, which allows the owners of the 263 units under mandatory compliance to satisfy their reductions from other units. The owners voluntarily select the units they want to "opt in" to the program. These units are credited with an allowance allocation. If the allowance allocation is equal to the counterfactual emissions (the emissions of the unit had it not opted in), then this added flexibility is desirable. Only units with low abatement costs would have an incentive to opt in. In practice, the allowance allocation does not equal coun-

terfactual emissions; sometimes it is high and sometimes it is low. This creates an adverse selection problem, since those units with low counterfactual emissions, relative to the allowance allocation, have an incentive to opt in. Hence, the voluntary program has the benefit of more efficient abatement, but at a cost of creating excess allowances due to the adverse selection problem. The authors' analysis reveals that the adverse selection was a problem. The voluntary program appears to have raised SO₂ emissions by between 1 to 2 million tons, without having a significant impact in reducing allowance prices.

External Allowance Market. Next the authors tackle the essential question of whether an efficient allowance market formed. An efficient allowance market is necessary for least-cost abatement. Otherwise some gains from trading allowances will not be found.

One remarkable feature of the SO₂ allowance market is the absence of trade restrictions. There are no restrictions on who can trade allowances or on the mechanism for trading. Allowances can be traded nationally, and may be banked for use in later years. This flexibility is key to the success of the allowance market.

Title IV recognized the importance of the development of private markets, but established an annual EPA auction to promote early price discovery and reduce fears of allowance hoarding by utilities. The two-sided auction works as follows. Sellers submit offers to sell and buyers submit bids to buy. A supply curve is formed by sorting the offers from lowest to highest, and a demand curve is formed by sorting the bids from highest to lowest. Then the bids and offers are matched, beginning with the highest buyer bid and the lowest seller offer, with trade occurring between the seller and buyer *at the buyer's bid*. The

matching stops when the highest remaining bid is less than the lowest remaining offer.

This would be a standard pay-your-bid auction, like Treasury auctions before November 1998, but for the fact that there are many sellers. With many sellers, this auction creates strange incentives. Each seller wants to be matched with the highest bid, and this is accomplished with the lowest offer. Hence, seller offers are biased downward. Bidding in such an auction involves a lot of guesswork by both buyer and seller. Buyers must guess what the clearing price is likely to be and bid as close to that as desirable. The sellers' guesswork is even more difficult. For example, if a seller thinks that the price is likely to be above its marginal cost of abatement, then the seller has an incentive to make the smallest possible offer. The problem is that bids and offers are only loosely tied to the marginal cost of abatement, which frustrates price discovery and efficiency in the EPA auction.

To assure that some quantity is available at the EPA auction, about 2.8 percent of the allowances are withheld from the utilities and offered at the auction at a price of 0. Most of these allowances are current vintage (so they can be used in any future year), but some allowances with vintages seven years in advance are also sold. The auction is held in March of each year, which is peculiar given that the annual allowance settlement occurs on January 31.

One might think that this flawed auction design would undermine the efficiency of the allowance market. However, the authors argue convincingly that the EPA auction is irrelevant. Private markets began in the very first year of trading (1993). By the second year, still one year before allowances were required, more allowances were traded

in the private market than in the auction. By 1997, the private market totally dominated the auction, with about 98 percent of the allowance trades occurring in the private market. In the first two years, the auction exhibited a modest amount of price dispersion, reflecting the early price uncertainty. But in the next four years, the price dispersion all but vanished. Almost all quantity was bid within a few percent of the prevailing price in the private market. Hence, rather than the private market being informed by the EPA auction, the EPA auction was informed by the private market. The downward bias on seller offers in the EPA auction did not matter, since price was set by the buyer bids at the current private market price. The irrelevance of the EPA auction is further seen by the fact that almost no quantity is offered voluntarily in the EPA auction, and of the small quantity that is offered less than 1 percent sells.

The private markets that developed appeared competitive by the time allowances were actually required in 1995. Success of the private markets should not be a surprise. The private market makers have every incentive to satisfy the needs of the sellers and buyers of allowances. The task is not too difficult given the large number of sellers and buyers, trading a homogeneous good on a national basis. Plus, banking of allowances means that there are good substitution possibilities across years.

Although the ineffective EPA auction did not undermine the market for allowances, it would be wrong to conclude that there would be little value from good auction design. One of the difficulties is that Congress was too specific in its language mandating the auction. As a general rule, Congress should simply provide agencies with authority to conduct auctions, specify the goal of the auction, and then let the agency

develop a design to meet the goal. The innovative FCC spectrum auctions are a good example. If the EPA developed its auction to promote price discovery, I suspect that they would have come up with a different auction. The rules, the timing, and the packaging likely would be different.

Cost Savings. An important question is whether the cap-and-trade program resulted in cost savings relative to a command-and-control program. The authors find abundant evidence that the utilities took advantage of the flexible trading under Title IV to reduce compliance costs. The command-and-control alternative assumes a unit-level constraint on emissions equal to the unit's allowances. This is a bit of a straw man, but it does capture the gains from flexible trading under Title IV. The estimate of savings includes both trading across units and trading across time (banking). On a present-value basis, the cost savings over the 13-year horizon is estimated at \$20 billion, compared with \$16 billion spent on emission reductions. The estimated cost savings of 55 percent is clearly economically significant. The authors take care in checking the sensitivity of their estimate, and compare it with other estimates. The conclusion is that emission trading cut compliance costs by about one-half.

Interestingly, the estimated savings from banking of \$1.4 billion is relatively modest, but this understates the importance of banking in the success of the program. Banking too has important benefits. It improves the ability of the utilities to deal with the fixed constraint in an uncertain world. Second, it improves liquidity, since allowances of different vintages become close substitutes.

The market prices of allowances do not follow the price path one would expect in a certain world. Prices started out at about \$140 in 1993, then fell to a

low of about \$65 in 1996, and then gradually increased to about \$200 in 1998. In a certain world, we would expect prices to increase gradually with the rate of interest. The authors argue that the price path is not a result of flaws in the program, but rather the inherent uncertainty in factors that govern the supply and demand of allowances. The early decline in price appears to be the result of overcompliance in response to the falling rail costs. As a result of long-term contracts it took years for this overcompliance to correct itself, pushing prices up in the later years. The volatility of allowance prices does not appear to be out of line with what we would expect from a competitive market in an uncertain world.

Lessons Learned. The main message of the book is that cap-and-trade programs can work, and that Title IV is a vivid example of a successful program. The authors provide an objective and convincing case for its success. However, they are careful to emphasize that the cap-and-trade approach is not the ultimate solution to all environmental problems. Rather there are special features of SO₂ emissions that make them well suited to the cap-and-trade approach, especially the low-cost accurate measurement of emissions and the ability to conduct a national program.

In terms of politics, the lesson is that the efficiency of the program was not undermined by rent seeking over allowance allocations. This is especially welcome news, but perhaps is not a general result. Intuition for the result is that once a cap is set, it is in the joint interest of the utilities to meet the cap at least cost. In this case, the distributive issue—allowance allotments—was separate from the main efficiency issues—the absence of trade restrictions, banking, and a national program. However, one

can imagine that in other programs the separation may not be so clear. For example, there might be a tendency to use a national cap, when regional caps are required for efficient mitigation. Also there might be excessive reliance on voluntary “opt in” features in the face of severe adverse selection.

We also learned that effective private markets can develop in favorable circumstances. Here the definition of allowances, the absence of trading restrictions, and the banking of allowances for use in later years were important.

Another general lesson is that a market-based regulatory program is apt to respond better to the uncertainties of a changing world. The participants respond to market price signals. If the prices are right, then efficiency is achieved. Inflexible command-and-control programs react much more slowly and less efficiently to new information.

The authors recognize the difficulties of constructing a successful cap-and-trade program. They warn against its indiscriminate use. This is sensible. However, I would have liked to have seen more on how one might apply cap-and-trade in other areas. Carbon dioxide (CO₂) emissions are mentioned, but only to point out that these emissions

come from many more sources than SO₂, and so a cap-and-trade program might not be feasible, due to difficulties in measurement and enforcement. More could be done here. One can imagine an upstream CO₂ program, which focuses on the producers of fossil fuels (refiners, coal mines, etc.). Emissions could be estimated from fuel type, rather than directly measured. Greater discussion of a CO₂ program would help clarify how the ideas presented here can be applied elsewhere.

Markets for Clean Air is the definitive text on the U.S. acid rain program. The authors’ analysis is careful and convincing. The reader is rewarded with significant insights about a major environmental program. One learns how Title IV came to be and what were the consequences of rent seeking in its formation. One learns that the program was successful in cutting the costs of SO₂ emission reductions by about half, saving tens of billions of dollars over the life of the program. And one learns a sound methodology for evaluating the success of an innovative market-based program. Both scholars and policy-makers will have a better sense of the virtues and pitfalls of market-based regulation after reading this book.