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USING MARKET INCENTIVES TO CURE ACID RAIN

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INTRODUCTION

Proposals to control acid rain by reducing sulfur dioxide emissions by coal-fired power plants have been much in the news recently. For economists, the issue suggests a textbook prescription: rely on market incentives (prices or permits) rather than traditional regulatory devices (performance standards or mandated technologies). In practice, the government's environmental program almost always utilizes the latter, and most current acid rain control proposals have taken the traditional route as well. Market incentives should be considered as an option, however, and it is the purpose of this paper to discuss that possibility.

As general background, the first section presents issues affecting the basic abatement decision, historical perspectives, and current policy developments. The market option is contrasted with traditional approaches in the second section. Included are cost estimates for alternative emission reduction plans. Assuming a decision to use an incentive policy, general considerations on selection of a permit or tax system are summarized in the third section. Assuming selection of a tax approach over permits, the last section presents some advantages and disadvantages of alternative strategies.

1. BACKGROUND

The Acid Rain Phenomenon

Acid rain stems from emissions of sulfur dioxide and nitrogen oxides. These are converted by not well-known atmospheric chemical processes into what are essentially solutions of sulfuric and nitric acids. Wet deposition may fall as rain, snow, fog or other precipitation. Dry deposition includes gases and solid particles which settle to earth, go into solution upon contact with surface moisture, and behave like acid rainfall(2).

Acid rain falls on lakes and ponds, streams and rivers, forests, crops and buildings, primarily in eastern parts of the United States and Canada. The centers in the United States focus principally on surface water acidification such as lakes in the Adirondacks and its impact on fishing and forestry.

Because of the possibility of long-distance transport of emissions limited to acid rain, there is also an international aspect. For example, the Canadian government has called for reductions in U.S. sulfur emissions, arguing that its lakes and forests are being irreparably damaged.

The primary cause of acid rain in Eastern North America is allegedly the sulfur dioxide emissions from coal-fired utilities, especially those in the Midwest. Collectively, U.S. coal-fired utilities exhaust about 10.6 million tons of sulfur dioxide (SO2) per year, or about 48 percent of 24 million tons emitted annually from all man-made sources. Coal-fired power plants are also the source of about 25 percent of the nitrogen oxides (NOx) from all sources (most come from auto and truck emissions). While NOx emissions may also cause acid rain, the primary public policy focus is first SO2 emissions, the suspected cause of Eastern North America's acid rain, and then on the Midwest's electric utility plants which emit most of it.

### Source-Receptor and Linearity Problem

One technical issue is the link between emissions from specific plants in one area and the deposition in another area. Known as source-receptor relationships, a second issue is linearity: would a given quantity of emissions reductions produce a proportional reduction in acid deposition? Good information on these problems is needed for design of control plans. At this point the true nature of these relationships is uncertain, however.

On June 28, 1983 a White House panel of nine nationally known scientists advising the Office of Science and Technology Policy (OSTP) issued a report[4]. The panel noted that the "...existing models (of atmospheric emissions) do not agree with one another and cannot be verified by comparison with observation because of the scarcity of good field data." They concluded that there is no "...acceptable method for the determination of source/receptor relationships on a scale much smaller than 'Eastern North America'."

At the same time, the National Academy of Sciences (NAS) issued a study which concluded that existing evidence does not support non-linearity[5]. This has been interpreted as meaning that it supports linearity. However, a consensus of scientists from four national laboratories (Argonne, Brookhaven, Oakridge, and Pacific Northwest) disagreed with the NAS linearity finding and the methods used to reach the conclusion, in particular the weight given to allegedly weak field data[6]. The NAS study was also reportedly unable to differentiate between the effect of local and long-distance sources of sulfur dioxide on acid rain deposition[7].

### Trends in Acid Deposition

Design of control plans will also be affected by estimates of trends in acid deposition. A U.S. Biological Survey (USGS) study released in September 1983 concludes that acid rain deposition in the Northeast (the area of public policy concern) has actually been decreasing over the last 15 years, while increasing somewhat in the West[8].

The analysis was based upon 15 years of USGS data on water quality measurements taken at headwater streams across the country. The report also concludes that acid rain deposition is consistent with an examination of trends in substantial declines in SO2 emissions from 1968 to 1980. The report does not directly address the source-receptor issue, but inspection of the state by state emissions and acidity data[9] suggests that the source-receptor relationships may be local (the state level), not long distance.

### Historical Perspective

Concern about effects of sulfur emissions, and consideration of alternative control strategies is not a new issue. The recent focus on acid rain has only reawakened interest in an old problem.

During the early 1970's, Senator Edmund Muskie, the leader in development of the Clean Air Act, was unsympathetic towards the market incentive approach, believing that direct regulation had not been given a fair trial in earlier years(10). However, responding to a number of studies urging the adoption of a tax, the Nixon administration sent to Congress legislation for the "Pure Air Tax Act of 1972(11). The proposal would have introduced a tax on sulfur emissions. With the level of the tax related to a region's air quality in the previous year. The tax varied from 25 cents per pound of sulfur emissions in regions where primary standards had been violated to zero where no violations occurred.

The proposal fell through, in part due to general reluctance about using a market incentive, and specifically because of the varying regional impacts of the proposed legislation. While such differentials make sense from an economic viewpoint, they put industries with lesser air quality at a competitive disadvantage, and establish an incentive for heavy polluters to move to clean areas. These possible effects were unacceptable politically.

Later, during the process of amending the Clean Air Act in 1977, the creation of alternative control strategies again over regulation of new sources of SO2. In the end, Congress chose to mandate stack gas scrubbers for new sources, even though less cost-effective than performance standards. Support for the mandated technology came from three groups: Eastern high-sulfur coal producers, who had lost sales if utilities were allowed to switch to low-sulfur western coal; environmental groups, who prefer mandating technology and representatives of Northern and urban areas, who have a stake in making economic growth in Western and Southern areas more expensive[12].

More generally with respect to overall air pollution regulation, the Environmental Protection Agency (EPA) began in 1979 to introduce aspects of the incentive approach which allow specific firms additional flexibility in meeting prescribable emission limits with the knowledge and the offsets policies. As implemented so far, these represent an improvement, though not the substantial shift to reliance on incentives contemplated by many economists[13].

### Current Follow-up Development

Last year the Justice Department labeled two Canadian firms on acid rain as political propaganda. This had the effect of drawing a great deal of media attention to the issue, and many acid rain bills have been introduced. Some call for more research, others for reductions in sulfur dioxide emissions in the 31 states bordering on or east of the Mississippi River, and still others for reduction of both sulfur and nitrogen dioxide in all 48 states.

A plan introduced by Representative Waxman (HR 3468) is receiving much attention. The Waxman bill would set quantitative emission reduction targets and require cleanup using stack gas scrubbers. This requirement would prevent utilities from switching free high-sulfur Eastern coal to low-sulfur Western coal, and...
would have the effect of preserving Eastern coal jobs. The Waxman Bill would also tax electricity users nationwide to pay for the cleanup to avoid increases in electricity rates in the Midwest.

The electric utility industry is split. The American Public Power Association (APPA) has decided to push for acid rain control solutions while the leadership of the Edison Electric Institute (EEI), which represents privately-owned utilities, remains publicly committed to a research-only position. Environmental organizations generally favor an approach mandating technologies, such as the Waxman bill, though often with higher total reduction targets. The Administration has decided on an enhanced acid rain research program, but declined to adopt any control proposals due to the current scientific uncertainty and its own unfavorable evaluation of the cost-benefit picture.

As yet there is very little policy consensus in the Congress. The regional conflicts between Northeast, Midwest and West, over who benefits and who pays under the various plans are exceptionally severe[15]. In the face of the scientific and political uncertainties, it is unlikely that there will be any final action by the government on an acid rain control program this year.

II. THE MARKET INCENTIVE OPTION

Three Control Approaches

Assuming a decision to reduce sulfur emissions, and an abatement target, there are three possible control strategies.

The first is to mandate technologies for installation at emission sources. In the acid rain case, the proposed technology is stack gas scrubbers. Flue gas from power plants is sprayed with a slurry of water and lime or limestone. It is an established method for high SO2 removal (up to 90%) but it is usually the least cost-effective in terms of cost per ton of SO2 removed and is capital intensive. Requiring stack gas scrubbers permits continued use of high-sulfur coal; thus avoiding loss of coal miner jobs. (See the Appendix for a summary of current and future cleaning technologies.)

The second approach is to set source-specific performance standards. All plants meet the same emissions standards, but are free to choose how this is done. For example, a firm could choose to switching to high sulfur coal.

The third choice is to use market incentives. In order to give the producer of the pollutant an economic incentive to curb its emission[16]. There are two market incentive policies usually put forward.

The most common proposal is to set a tax (sometimes called a fee or charge) on emissions, sufficiently high to induce the abatement reduction objective. In the acid rain case, this could be a tax on the emissions of sulfur outside from the power plant stacks, or a tax on the sulfur content of the fuel shipped.

A second approach would establish permits giving the owner of the permit the right to emit a certain number of units of pollution. The total emissions allowed under all permits would equal total current emissions less the abatement target.

Permits might be allocated to each polluter initially, or they might be auctioned off by the government periodically. Permits would be transferable and traded. Trading establishes a market price for the emission, creating an incentive to find more efficient ways to reduce emissions.

For most economists, a market incentive policy (either taxes or permits) is preferable to either mandated technologies or standards. Since it can achieve the desired pollution abatement objectives at the lowest social cost. Facing a fixed charge for each unit of pollution emitted, firms will find it profitable to continue to abate emissions until the point where their marginal abatement cost equals the charge. By obtaining the targeted reductions from those sources where marginal abatement costs are lowest, net social costs of the control program are reduced.

The Ideal and Reality

Ideally, each pollutant should have its own tax, and each tax should be set at the value equaling the marginal damages and abatement costs of each pollutant. Abatement levels from all sources are then optimized. Since producers are given the correct price signals to induce the appropriate amount of abatement, the costs of pollution abatement are reduced.

Market incentive options actually represent a second-best substitute when compared to the ideal[17]. While they may obtain a given level of reduction for less social cost, there is no inherent reason that they will reach the optimal level of reduction. There is hardly any data on either the total or marginal damages done by a given quantity of pollutants.

In practice, society seems to follow roughly, but not necessarily in sequence, a three-stage policy development process. First, some degree of agreement is reached on the science of a problem. Second, the government chooses an abatement target, based on more or less explicit cost-benefit analysis (usually less). Third, regulations are then issued specifying detailed standards, or mandating the use of specific technologies. Debate then centers on the cost-effectiveness of the regulatory implementing techniques. It is at this latter point that market incentives tend to compete for attention with the traditional techniques.

Cost-Effectiveness of Alternative Approaches

Two caveats are in order. First, the least-cost solutions cited by most models are engineering least costs. Generally, they do not represent calculations of net social cost, after secondary effects, such as employment shifts are included. Second, using a model's least-cost solution as evidence supporting a market incentive approach implicitly includes this assumption that the market incentive policy selected would be implemented in a fashion that the least-cost solution is actually elicited. In practice many things could go wrong.

Keeping these qualifications in mind, the present and past modeling work supports the view that market incentives are more cost-effective than performance standards, and even more so when matched against mandated technologies.
For example, the Office of Technology Assessment (OTA) has modeled the costs of typical control options, summarized at Table 1[18]. The results reveal the hierarchy of cost effectiveness expected by theory. The model used, created by E. H. Pechan, selects incrementally (and plant by plant) the lowest cost control strategy allowable under a given plan. Using a least-cost solution is 26 percent less expensive than the next most expensive option, which requires flue gas scrubbers at fifty specific utilities and performance standards at the rest.

The Congressional Budget Office recently issued a Staff Working Paper on acid rain[19], which also used the Pechan model. It analyzed a plan for allocating costs under an abatement program which would mandate scrubbers to protect employment in the Midwestern coal industry. In one part of the analysis the base case program was modified to allow emissions reduction trading within a state (but still not allowing any fuel switching to low-sulfur fuels). Costs were reduced by 26 percent. Any partial use of market incentive options helps reduce costs.

Ten years ago, the Research Triangle Institute estimated the costs of direct controls (source-specific performance standards) versus emission charges in reducing sulfur emissions in St. Louis and Cleveland[20]. Using emission charges to obtain the same total reduction as direct controls was less expensive by 61 percent in St. Louis and by 29 percent in Cleveland. The source of the cost savings, as theory suggests, was found in the large differences in abatement costs among various polluters.

Using its own model, ICF Incorporated prepared a cost estimate for the Alliance for Clean Energy, which was analyzed by Portney[21]. The ICF analysis was consistent with the IEA report for EPA. ICF found that source-specific performance standards would save $1 billion annually over forced scrubbing, even after allowing for an anticipated increase in the price of low-sulfur coal stemming from the probable increase in demand. This result is comparable to the first-year savings indicated by the OTA results. The ICF analysis did not look at a solution which could serve as a proxy for a generic market incentives option.

The Electric Power Research Institute has cost out currently popular proposals, using an approach similar to OTA, but based upon its own cost estimates for the several cleanup alternatives, which are higher than most generally used[22]. Their total first-year cost for a 10 million ton reduction program would be over $12 billion (more than twice OTA's estimate). A more flexible approach would save 12.8 percent (4.5 billion per year). The reason for this low estimate of possible savings is EPRI's view that above a certain quantity target (roughly 5 - 6 million tons per year) utilities would be forced to choose flue gas scrubbers, since the other currently available options -- coal blending and coal cleaning -- have definite technical maximum limits for pulling out sulfur from coal.

One particular secondary effect of control plans has received special public attention: consequences on high-sulfur coal mine worker jobs. ONR has reportedly estimated 10,000 to 20,000 mine worker jobs lost depending on the plan[23]. The ICF analysis by Portney projected that under performance standards two states, Ohio and Illinois, would lose 17,400 jobs by 1990, but that low sulfur mine worker jobs would be created, as well as jobs in coal transportation, for a net gain of 5,400 positions[24]. On the other hand, the United Mine Workers have forecast a loss of up to 50,000 jobs[25].

Table 1

| ILLUSTRATIVE COSTS OF ALTERNATIVE ACID RAIN CONTROL PROGRAMS 17/ (1982 $, Billions) |
|-----------------------------------------------|----------------|
| Using Plant-Specific Performance Standards | Using A Least-Cost Approach |
| And Assuming Mandated Steady One Scrubbers for 50 Midwest Power Plants | 5.3 | 4.5 |
| And Assuming No Mandated Technologies | 4.0 | 2.9 |

Sources: Office of Technology Assessment (February 1984)
The engineering cost differences in the various approaches are substantial. This suggests that the social cost of possible miner worker unemployment could be met by some other means than selecting a high-cost central plan. For example, the difference between the high mandated technologies and low least-cost estimates in the first year is $22.6 billion under OTA's analysis of a 10 million ton reduction in emissions. Even the SPR estimates for similar abatement targets, which show much higher total costs, also suggest savings of $1.5 billion per year under more flexible approaches.

III. PERMITS VS. TAXES

Assume for discussion purposes that a decision has been taken to seek further abatement using an incentive plan. Should it be permits or taxes?

In principle, taxes or permits lead to the same outcome, and share many of the same advantages. The most important being that the abatement objective is advertised at the least cost. The arguments for permits versus taxes do not seem to offer any overriding reason for choosing one over the other, though they may favor taxes slightly. Baumol and Oates[21] suggest some of the advantages and disadvantages of each, summarized below.

Flat rate taxes face two general problems not faced by permits. Unless increased periodically, they are vulnerable to erosion from economic growth. Marketable permits (whether auctioned or traded) are inapplicable to inflation. Since the quantity is fixed at the allowable overall total quantity of pollution, the price would rise automatically in an inflationary period and in the face of economic growth. The latter point could be a serious economic problem if the quantity of pollution is not allowed to grow at all.

Both taxes and permits would be equally difficult to vary geographically, since it is always politically difficult to treat the states other than uniformly.

With taxes there is the basic problem of predicting the abatement responses to a given tax rate, and this problem is particularly important when the tax is being used to achieve a specific abatement objective. Conversely, with issuance of a fixed number of permits, there is always the problem of predicting the cost to society of the permit level chosen.

For most types of pollutants, both taxes and permits require that the monitoring be done effectively for proper administration. Emissions need to be monitored to calculate the tax owed, or in the case of permits they need to be monitored to make sure that total emissions are within permit maximums. The monitoring requirement is so crucial that if it cannot be reliably met, then a traditional regulatory technique is preferable.

IV. TAX STRATEGIES

On the other hand, a tax can be levied on the sulfur content of coal at the minehead or on the sulfur dioxide emissions as they come out of the stack.

A tax could be levied on the sulfur at either end of the fuel stream: on the sulfur content of coal at the minehead or on the sulfur dioxide emissions as they come out of the stack. In a frictionless world, assuming inexpensive and reliable monitoring devices, a tax on sulfur dioxide emissions would be preferable. A tax at this point gives the firm the maximum incentive and flexibility to search for cost-effective ways to reduce emissions at earlier points in the fuel stream, and to the sulfur content of coal efficiently encourages switches to lower sulfur coals, but can also be used to satisfy existing pollution standards from using downstream technologies to clean the stack or reduce emissions. One remedy for this difficulty would be to offer rebates to users based on the quantities of sulfur extracted by the downstream technologies. This remedy would be more administratively complex, however, than the inexpensive and reliable monitoring devices already assumed.

In practice, with expensive and less reliable monitoring devices, there will be a cost and reliability tradeoff between monitoring and other means to ensure sufficient tax compliance. For example, a scheme to relate a marketable permit or tax to the actual monitoring of the physical quantities emitted avoids the problem of ensuring the emission rate from the stack while preserving the incentive for the user to find cost-effective ways to decrease sulfur content. However, it introduces
a second layer of administrative costs. In addition to the original levy at the
mine mouth, and it will have its own measurement problems as well (e.g., assessing
the waste from coal cleaning, furnace ash, etc.).

On the other hand, the monitoring and reliability problems of stack metering may be mitigated by placing a sufficiently high penalty on the user if the metering
device is not operating within certain tolerance or performance levels. This
penalty would be similar to compliance regimes for truck weights, bucket scales
or service station gasoline pumps.

Because monitoring problems are real, most current acid rain control plans have focused on emissions from the largest sources, the utilities. An advantage of a
fuel tax and quantity rebate scheme is that it increases coverage to the forty
percent of emissions emitted by other than utilities.

In practice there is no a priori basis for knowing what alternative would be
desirable taking into account all the tradeoffs. More investigation is needed.

Setting the tax level is the second basic decision needed. Assuming the abate-ment objective, the ideal rate would be that which produced exactly the abatement
objective desired. In order to calculate that rate, exact knowledge would be
needed for all users at all stages of the fuel stream: current emissions, tech-nical abatement options, and marginal costs of each option. In the absence of
such information, one could pick an initial rate, observe the abatement effects,
and adjust accordingly. This has the disadvantage of lacking uncertainty and
possible extra costs on sources. In practice some information is available on
technical options and marginal costs by source (at least for utilities), and this
data could be used to establish a tax rate for a specified abatement objective.
Again, more work is needed.

In addition to the two general considerations, a special problem exists for all
tax schemes. Industry will be led by self interest to oppose tax approaches if
the alternative is the current regulatory regime, since under taxes costs will
generally be higher. Under current direct regulation a given quantity of pollu-tant is allowed to be emitted, up to the emissions standard. In effect this quan-ity is taxed at zero, and amounts to a property right which would be lost with a
tax, thus making the polluter worse off under such a regime. All the emissions would be taxed.

The problem can be mitigated by placing the tax on emissions (or the sulfur-content of coal) only on that portion above the level equal to the current emis-sions standard. This compassing device reduces the efficiency of the tax how-ever, since some sources with low marginal costs will have less incentive to abate
than under a flat tax on all emissions.

Table 2 shows estimates by EPRI/PSI of a fuel tax on the sulfur content of coal
and estimates of the total abatement which could be obtained, taking into account
technical limits of each technology, for illustrative purposes. As an industry
association, EPRI’s estimates of technology costs, and thus tax rates can be ex-pected to serve as an upper bound. One other point bears noting. The abatement
cost schedule is not smooth. There is a sharp break at about 5 million tons (for the
utility universe). Above that level only scrubbers have the technical efficiency to pull out enough sulfur, according to EPRI.
ALTERTIVE SULFUR EMISSIONS CONTROL APPROACHES

CURRENT TECHNOLOGIES

Coal Cleaning

Removing coal can reduce sulfur content of high-sulfur coal by 30% or more. Has collateral benefits such as reduced ash content and increased Btu content. Chemical cleaning can remove far more but is expensive and not commercially ready for use. One half of high-sulfur utility coal is cleaned to some degree already, usually by the supplier.

Coal Switching

Switch to lower-sulfur and high-sulfur coals. Is broadly applicable and attractive. Can cut emissions 30-8%. But technical attractiveness is hampered by impact on high-sulfur coal producers in northern Appalachia and the Midwest. Low-sulfur coals carry about a 20% price premium ($10-$20/ton).

Flue Gas Desulfurization

Flue gas is sprayed with a slurry of water and lime or limestone. An established technology for high-temperature efficiency in SO2 removal up to 90%; but is usually the least cost-effective in terms of cost per ton of SO2 removed, especially in retrofit of existing plant.

FUTURE TECHNOLOGIES

Furnace Scrap Vent Injection

Capture SO2 by injecting limestone directly into the furnace itself. May be capable of 60-65% SO2 capture, about one-half of a scrubber, with operating costs about one-half of scrubbers. Government and industry laboratory R&D projects are underway.

Fluidized-bed Combustion

Diluting air suspends burning coal among limestone particles. Up to 90% SO2 capture. Technology is not yet commercially ready for large utilities, but demonstration projects are underway. Cost is currently roughly comparable to scrubbers, but actual costs will vary considerably depending on plant-specific characteristics.

ENDNOTES

1. The views given in this paper are the author’s alone, and do not necessarily reflect the opinions of the Office of Business Analysis or the U.S. Department of Commerce.


[10] Inside EPA, February 18, 1984, p. 10. This Journal is a weekly newsletter published in Washington, D.C., and provides excellent coverage of developments at EPA.


[17] Smith. On SIDA. See Figure 2 on page 5.


[26] Information in this table was provided by Don Friedman, Office of Technology Assessment, (February 1984). Based on the “Air Test/Air Cost” model created by S. N. Fehan. The analysis covers the costs of alternative regulatory approaches for achieving a nationwide sulfur emissions reduction of 10 billion tons/year by controlling emissions from electric utilities. It assumes a 40-state control program and a sulfur emissions standard of 1.2 lbs. per
EASTERN ECONOMIC JOURNAL

THE EFFECT OF PUBLIC POLICY ON GENDER DIFFERENCES IN THE DEMAND FOR HIGHER EDUCATION

Susan B. Carter and Elizabeth Savacu

I. Introduction

Despite the overwhelming importance of education for gender differences in economic life, gender differences in school attendance have received little systematic analysis from economists. In this paper we present an overview of what is known about gender differences in the economic determinants of the demand for higher education together with some preliminary estimates of these differences. We undertake this project as the first step in eventually discovering how government educational policies influence male and female college enrollment patterns. For while it is well known that government educational expenditures have influenced the rate of college attendance overall, one that these expenditures have a differential impact on enrollments by parental income, gender differences in educational attainment may also be attributable to and change by government involvement.

II. Gender Differences in the Demand for Higher Education

In the human capital tradition the demand for higher education is largely a function of the direct costs of education. The additional earnings expected as a result of additional schooling, and forgone earnings. Government policy may affect this demand through its effects on any of these variables.

Although price elasticities of demand for higher education have been estimated for students from different family income categories and different ability groups, only a few studies have investigated gender differences in responsiveness to changes in tuition. In a cross-sectional study of state-wide enrollments, the Massachusetts Metropolitan Area Planning Council found that the negative impact of tuition on enrollment is greater for males than for females. Using similar data, more variables and a somewhat different functional form, Eayen and Kearns obtain similar results. In a regression which explains how various institutional characteristics influence the college choices of freshmen, Rosenberg and Kearns also found men's choices to be more responsive to tuition costs.

For several reasons we question these findings. The studies which use the states as the unit of analysis rely on data which lacks sufficient detail to measure those men and women who have chosen to attend college. Moreover, they ignore the impact of important factors such as family income and forgone earnings.

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