

## DISCUSSION

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I find Mr. Kohn's paper of considerable interest. It is a substantial step away from the partial equilibrium analysis that has been all too prevalent in studies of environmental quality issues. Lack of recognition of the effects of control of the flow of pollutants to one resource on the production of pollutants released to another source can (and has) lead to unsatisfactory results. For example, a few years ago stringent controls were placed on water pollution on the Wisconsin River. These controls stimulated some paper manufacturers to change processes from one which polluted the water to one which polluted the air. The result is obvious to anyone who has passed within a few miles of one of those plants.

As with any initial break with traditional methods, the author leaves several questions unanswered or incompletely answered. There are three areas I wish to emphasize: factors affecting Mr. Kohn's estimates of the cost of control, the trade-off between air pollution and other forms of pollution, and the desired level of air quality.

### I. Cost of Control

The first point I would like to stress is the apparent lack of inclusion of possible major process shifts by the manufacturing sources. Mr. Kohn has included such minor process shifts as changes in energy source within the existing plant but has not as far as I can tell included alternatives which would require substantial change-over costs or completely new construction. This is especially relevant in the context of an analysis in 1970 of how to meet the air quality standards in 1975. The planning period allows sufficient time for such process changes. If, for example, the power industry were contemplating the construction of new or expanded facilities in 1971, these facilities could be designed to meet the standards. Inclusion of air pollution control in the design process is likely to be cheaper than the exclusive use of add-on devices envisioned here. To the extent that these possibilities are not included the cost estimates presented represent an upper bound.

The assumptions of the model allow for the use of one or another control method on a source or possibly no control at all but they do not allow for the complete elimination of all or part of a source. That is, there is not a set of control levels ( $b_{pj}$ ) and corresponding costs ( $c_j$ ) which allow for 100 percent control via closing down one or more plants. The problem of estimating the  $c_j$ 's would be complex and this set of alternatives may not be economically or politically viable but the matter deserves some attention. These alternatives may be more efficient than controls on existing sources. This fact provides another argument for the cost estimates being over estimated.

An additional cost not included in Mr. Kohn's estimates is the cost of inspecting and enforcing control efforts. Enforcement is often costly and measurement of compliance may be difficult or impossible. Furthermore, these measurement problems and enforcement costs vary with the type of source being controlled. Recognition of this problem would cause an upward adjustment in the  $c_j$ 's and to the extent enforcement is not perfect some decrease in the  $b_{pj}$ 's.<sup>1/</sup>

It is likely that the controls instituted will increase costs of production and hence, through prices, the output and level of pollution production of the industries. This effect is not included. Estimating the extent of this type of feedback effect would be difficult and time consuming and may not be worth the effort but it ought to be given some consideration.

A version of the model might be developed which introduces institutional and political constraints. Such constraints might be in terms of maximum expenditures for one or another source or unequal air quality standards in different political jurisdictions. The effect of such constraints on the cost of control and the sources controlled might provide useful information to policy makers and to the public. An example of such a constraint in California is the legal requirement that retrofit control devices for used cars cost less than \$60.00 to purchase and install. This requirement restricts mobile source control alternatives sharply and is probably increasing the cost of control substantially.<sup>2/</sup>

Finally, there is no account taken of the timing and location of pollutant release. The damages of air pollutants are more a function of the intensity and duration of exposure to a pollutant than its average annual level. Since the presumed goal of control is to reduce these damages, some model building efforts along these lines would be very helpful. To the extent control efforts are to reduce peaks rather than averages, the cost and level of control is likely to be greater than that determined by the model presented here. Taking all the locational, chemical, timing, and meteorological factors into account requires resources and knowledge far beyond that available to an individual researcher. A well funded multidisciplinary effort is required to make substantial progress along these lines. Mr. Kohn can certainly be excused from not taking this task on by himself.

### II. The Desired Level of Air Quality

The air quality standards used in this paper and set by the Missouri Air Conservation Commission are not likely to be set at the most desirable level because they were set in ignorance of the results of this paper. It is my belief that if standards are to be used some recognition of their economic effects and the

cost of reaching the standards should be included in the decision-making process. An expanded version of the model developed by Mr. Kohn would serve this purpose well. Different levels of control (air quality standards) could be imposed on the model and their effects on the cost of control, the level of control by source, and their expected effect on economic activity and employment could be estimated. These effects could then be weighed by the decision-makers against the damages averted (both health and physical) by that level of control.

Also it should be explicitly realized that there is a possible trade-off among air pollutants. The damages caused by a pound of carbon monoxide (CO) is most likely not equal to that nitrogen oxides (NO<sub>x</sub>) or hydrocarbons (HC). Furthermore, NO<sub>x</sub> and HC combine in the presence of sunlight to produce ozone which itself causes damages. The amount of ozone produced depends in a non-linear way upon the proportion of NO<sub>x</sub> to HC present as well as their levels. This fact makes the solution of the linear programming model much more complex. It also makes the setting of standards based on ambient air levels of chemically unstable compounds tenuous. Some recognition of these chemical reactions and the damages resulting from their secondary products will likely yield better standards than we now have and a different solution to Mr. Kohn's model.

### III. The Trade-off Between Air Quality and Other Environmental Quality Parameters.

I would extend this standards setting concept further by adding an analysis of the trade-offs between air pollution and other forms of pollution. Mr. Kohn's work allows us to make such an analysis but he does not do so. Rather, in Models III and IV he uses the criterion that if it costs more to treat and render harmless (100 percent effective treatment?) a secondary pollutant than to stop its production in the air pollution control

process, that control process should not be used. It is possible and may indeed be economically rational to say, for example, that the burning of solid wastes as fuel in an electric power generating station should not be done. This would be true if the dollar value (or subjective value felt by the decision-makers) of the land-pollution-caused damages and the cost of the sanitary land fill operation are less than the cost of using the wastes as fuel plus the cost of the additional air pollution control and the residual air-pollution-caused damages. Perhaps it is this trade-off analysis ability, which is the heart of the Ayres and Kneese argument, that is the major contribution of Mr. Kohn's model.

### IV. Conclusion

In conclusion, I feel that Mr. Kohn's paper is a substantial step in the right direction. That it does not go far enough is perhaps the fault of the complexity of the problem. We certainly cannot expect one economist, or the whole profession for that matter, to provide all the answers. I feel that the solution to the air pollution problem will be found in the combined coordinated efforts of scientists from many disciplines. Past efforts which excluded social scientists have not been successful. Expanded efforts along the lines of Mr. Kohn's paper will hopefully make future efforts at a solution more successful.

### Footnotes:

1/ For an extended discussion of the problems and costs of enforcement under various control schemes see Thomas D. Crocker and A. L. Rogers III, Environmental Economics, (Hinsdale, Ill.: Dryden Press, Inc., Feb., 1971).

2/ Paul B. Downing and Lytton Stoddard, "Benefit-Cost Analysis of Air Pollution Control Devices for Used Cars", University of California, Project Clean Air, Research Reports, Volume 3, September 1, 1970.