NATURAL RESOURCES JOURNAL

Volume 12
Issue 1 *Winter 1972*

Winter 1972

Pollution Control - Uses of Corrective Taxes Reconsidered

John T. Wenders

POLLUTION CONTROL—USES OF CORRECTIVE TAXES RECONSIDERED

JOHN T. WENDERS†

In a recent article in this Journal,[1] Professor Colin Wright investigates the use of corrective taxes to control pollution. One of his conclusions is that in certain circumstances the equiproportionate abatement rule is superior to a single tax as a pollution control device. I shall argue in this brief note that in the situation analyzed by Wright a single pollution tax is always superior to the equiproportionate abatement rule. In addition, I shall argue that corrective taxes are superior to other methods of pollution control since they provide an efficient source of revenue for the pollution control board and produce a higher rate of change in pollution abatement technology.

The essence of Wright's argument is that differing sufferer damage functions for each polluter require that different tax rates be levied on each polluter. Since multiple tax rates are probably politically impossible to administer, the best the Pollution Control Board (PCB) can do is impose a single tax on pollutants. This is necessarily non-optimal, and Wright correctly demonstrates that under certain circumstances the equiproportionate abatement rule may be superior to a single tax.

The flaw in this internally correct line of reasoning is that under the assumptions employed by Wright, damages caused by individual polluters are *logically* impossible to estimate. This means that a single corrective tax can be optimal, and therefore the equiproportionate abatement rule is rendered always inferior. The two conditions which make sufferer damage functions for each polluter non-separable are: (1) a mixing or dispersement of pollutants from several sources so that the observed level of pollution cannot be attributed to any single source; and (2) a total damage function for the community which is non-linear, *i.e.*, which rises faster than the level of pollution.[2]

Both of these conditions must prevail for the sufferer damage function for any single polluter to be indeterminant. If the first condition does not prevail then any pollution damage can be traced

---

† Associate Professor of Economics, University of Arizona, Tucson.

1. Wright, *Some Aspects of the Use of Corrective Taxes for Controlling Air Pollution Emissions*, 9 Natural Resources J. 63 (1969).

2. Note the discussion in T. Crocker and A. Rogers, *Environmental Economics* 127-30 (1971).

to its source and sufferer damage functions for each polluter thereby constructed. It would make no difference whether these functions were linear or not. If the second does not hold, *i.e.*, the total damage function is linear, then any given increment of pollution, no matter what the source, would have the same damaging effect, and a damage function for each polluter could be constructed from a knowledge of its emission level. On the other hand, when damages rise faster than the level of pollution, each succeeding increment to the pollution total has a greater damaging effect but the responsible party cannot be identified due to the presence of condition one. The damaging effect of one polluter's emissions is dependent on the level of emissions of other polluters, and therefore sufferer damage functions for each polluter cannot be constructed.

It is clear that Wright's analysis explicitly assumes both of these conditions.

> After pollutants are emitted from their source they are dispersed in a manner determined by meteorological conditions, and configurations of the surrounding terrain, and the pollutants themselves, such that a given emission will affect various people in different locations and at different intensities.[3]
>
> Throughout this paper I shall assume that . . . the increment to total damages (marginal damages) is positive but increasing.[4]
>
> It is most likely the case, . . . that the damage function is not linear and, in fact, rises quite sharply for increasing pollution levels.[5]

Under the conditions assumed by Wright, the result is that sufferer damage functions for each polluter cannot be determined, and therefore conclusions which are based on them are irrelevant. However, it should be emphasized that the *total* damage function can be determined. This may not be cheap, but at least it is logically possible to do so.

Given these conditions, what is the optimal level of pollution? The answer is rather traditional: pollution should be reduced up to the point where the cost of additional abatement exceeds the decrease in damages resulting from that additional abatement.

In order to define this optimum, a composite cost of abatement function for all emitters must be constructed. This function must be derived from the individual cost of abatement functions in a special way if it is going to represent the minimum cost locus for each level

3. Wright, *supra* note 1, at 67.
4. Wright, *supra* note 1, at 64.
5. Wright, *supra* note 1, at 71. Wright refers to the sufferer damage functions of individual polluters. But if these damage functions are non-linear so is the total damage function.

of total abatement. As abatement is increased from the zero level, efficiency requires that abatement begin with the lowest cost source of abatement and proceed to the highest. Thus, if polluters have different cost of abatement schedules, efficiency requires that the marginal cost of abatement be the same for each polluter at each successive level of total abatement. This implies that the levels of abatement for different polluters will differ according to their respective cost of abatement functions.

The imposition of a constant per unit tax on pollutants emitted insures that pollution will be abated according to this marginal rule. Each polluter will automatically equate the tax with his marginal cost of abatement. If the tax rate is set properly, the optimal level of pollution can be achieved by a single tax. Thus, unlike Wright's incorrect analysis, a single tax can be an optimal tax.

It is not difficult to show that in this situation a corrective tax is always superior to the equiproportionate abatement rule.[6] Let us suppose we have an air shed containing two firms, A and B, which produce air pollution. These firms are assumed to be of equal size and emit the same kind of pollutant. They are assumed to have cost of abatement (C) schedules[7] described by

$$C_A = 2\alpha\, aqx^2 \qquad C_B = \alpha\, aqx^2$$

where x is the percent of pollution abated, q is the level of output for the firm, a is the amount of pollutant per unit of output before abatement, and α is a constant which depends only on the level of technology in pollution abatement. Since these firms are assumed to be of equal size, the product aq is the same for each, and I make the additional simplifying assumption that the firms do not change their size throughout the analysis. The only difference between these two firms is that the technology of pollution abatement for firm A is twice as costly (2α vs. α) as for firm B.

Now suppose a unit tax is levied on the amount of pollutant not abated by each firm. The amount of tax collected from each is given by

$$T = taq(1 - x/100)$$

6. This conclusion is certainly not novel. *See* Crocker and Rogers, *supra* note 2, at 121-22.

7. While this particular form for the cost of abatement function has intuitive appeal, it has some basis in fact. *See* A. Kneese and B. Bower, *Managing Water Quality: Economics, Technology, Institutions* 61 (1968), for an example of a cost of abatement function which is similar. The cost of abatement function assumed is consistent with that implied by Wright's MCS curve.

where t is the tax rate per unit of pollution. After the tax the total cost of abatement for the firm is the sum of C and T, or (for firm B, for example)

$$C' = C + T = \alpha aqx^2 - \frac{taq}{100}x + taq$$

and similarly for firm A. The optimum level of abatement (x*), *i.e.*, the minimum of C', and the corresponding direct cost of abatement (C) for each firm is

$$x^*_A = \frac{t}{400\alpha} \qquad x^*_B = \frac{t}{200\alpha}$$

$$C_A = \frac{t^2 aq}{8 \cdot 10^4 \alpha} \qquad C_B = \frac{t^2 aq}{4 \cdot 10^4 \alpha}$$

Thus, assuming that t has been set correctly by the PCB, firm B will engage in twice as much abatement and spend twice as much on abatement as firm A. A check shows the marginal cost of abatement to be the same for each firm at this point. Total expenditure by both firms on $3x^*_A/2$ percent of total pollution abated is

$$C_{A + B} = \frac{3t^2 aq}{8 \cdot 10^4 \alpha}$$

Now suppose the PCB tries to abate the same percent of pollution ($3x^*_A/2$) by forcing each firm to reduce its pollution by this percent. This is the equiproportionate abatement rule. In this case

$$C_A = \frac{18t^2 aq}{64 \cdot 10^4 \alpha} \qquad C_B = \frac{9t^2 aq}{64 \cdot 10^4 \alpha}$$

and the total cost of the same amount of abatement would be

$$C_{A + B} = \frac{27t^2 aq}{64 \cdot 10^4 \alpha}$$

Thus, the equiproportionate abatement rule is about 12.5% more expensive than a corrective tax which achieves the same amount of abatement. In addition, the corrective tax will raise

$$T_{A + B} = taq\left(2 - \frac{3t}{4 \cdot 10^4 \alpha}\right)$$

dollars of tax revenue.

In the last two sections of his paper, Wright correctly argues that the choice among pollution control methods may depend on the relative administrative costs of regulation. No one would argue with this conclusion.

My own sympathy still lies with the corrective tax approach, since my hunch is that administrative costs will not vary much among alternative methods. At a minimum, no matter which method of control is used, the optimal level of pollution still is going to have to be estimated (taking into account the costs of estimation), and the level of pollution will still have to be monitored in some manner.

In discussing the problems of implementing an optimal program, one point is frequently overlooked: there is no reason why all problems have to be solved *ex ante.* It is clearly myopic to demand perfect knowledge, and certainty, before we embark on a pollution abatement program. I would argue that we should pick the approach which in the end seems to have the best hope of working out effectively, and then proceed to grope our way along, learning as we go. Since the idea of corrective taxes has such a strong place in welfare economics, I would argue that this is the way we ought to proceed.

At the very least, Wright has not convinced me that corrective taxes are more costly to administer than other methods of control. He argues that some of the obvious inefficiencies of input standards may be more than offset by the low administrative cost of checking on their compliance. However, if it is indeed cheaper to police pollution abatement by checking on the inputs used, then I would argue that this administrative device should be employed even if a corrective tax were the method of ultimate control. We should not confuse metering devices with controls.

Among the many arguments for corrective taxes,[8] I would like to emphasize two which are infrequently heard: (a) corrective taxes provide an efficient source of revenue for the pollution control board which might not be available through normal revenue channels; and (b) it is easily shown that the expected rate of improvement in pollution abatement technology is higher when corrective taxes are used.

One of the routine conclusions of standard welfare theory is that most taxes impose welfare losses on the economy by distorting the efficient allocation of resources. The same cannot be said for corrective pollution taxes. To the extent that such taxes replace other taxes, the dead-weight loss due to these other taxes will be lessened.[9] In addition, it is my casual impression (and I recognize it as such)

8. *Id.* at ch. 9, for a summary of the advantages of the corrective tax approach.
9. *Id.* at 173-74.

that one of the real bottlenecks preventing the implementation and operation of efficient pollution abatement programs is the shortage of revenue appropriations. Of course, it could be argued that the political mechanism is working efficiently; my impression is that it is not. Pollution abatement programs which are self-funding have, I believe, a better chance of being implemented quickly and efficiently.

One of the reasons why our level of technology in pollution abatement is rather low is because there has been too low a rate of investment in abatement research and development; and this, in turn, has been because there has been little private economic incentive to undertake such investment. I would argue that one of the primary criteria for choosing among abatement methods should be how much economic incentive is given for improvements in abatement technology.

Few, including Wright, would argue that input standards rank high on this score. The firm under input standards is locked into a technological straight jacket and has little economic incentive to employ either the most efficient methods available or to search for new, more efficient, methods of abatement.

Emission standards, like the equiproporationate abatement rule, are better since they allow the firm to employ the most efficient abatement methods available. In addition, if the firm can develop more efficient methods of abatement it will reap the rewards (lower costs) of doing so; some economic incentive is provided for investment in research and development of abatement technology.

However, it is clear that the economic incentive to invest in technological improvements is even greater if corrective taxes are the method of control. Consider the case of firm B in the previous example. If this firm is operating under emission standards and has abated pollution by $x = \frac{t}{200\alpha}$ percent, then its total costs of abatement are described by the right hand equation in (1). If this firm develops a method of abatement which halves the cost of abatement (from α to ½ α) then its cost reduction will be

$$\Delta C_B = \frac{t^2 aq}{8 \cdot 10^4 \alpha}$$

if the firm stayed at the same level of abatement after the innovation (it would have no reason to increase its abatement unless the PCB changed the emission standards).

On the other hand, this same firm with a corrective tax on its emissions would evaluate the benefits of a technological improvement on the basis of equation (3). In this case, when the innovation halves the cost of abatement, the firm will automatically increase its level of abatement (from $\frac{t}{200\alpha}$ to $\frac{t}{100\alpha}$) and experience a reduction in costs equal to

$$\Delta C'_B = \frac{t^2 aq}{4 \cdot 10^4 \alpha}$$

which is twice as large as the cost reduction to the firm under emission standards. In addition, it is relatively easy to show that if the PCB reacts to the improvements in abatement technology, it will raise the emission standards in the former case and lower the tax rate in the latter; this will raise the cost reduction to the firm operating under emission standards compared to the figures in the two above equations. This tends to increase the incentive advantage of the corrective tax.[10]

The reason the rewards for innovation are higher where corrective taxes are used is that the innovating firm will experience a reduction in both its tax liability and in its direct cost of abatement. Under the emission standards only the latter will be reduced. This, of course, amounts to a subsidy to the innovating firm under a corrective tax since other taxes will have to be raised to offset the loss in pollution tax collections. This could be economically inefficient. However, my feeling is that an improvement in abatement technology would yield substantial external *economies*, and therefore it would be economically efficient to subsidize such activity.

Thus, to the extent that the rate of change of abatement technology is dependent on the economic rewards to research and development it will improve faster under a corrective tax than under emission standards.

In my view, the result of all this is that corrective taxes can play an effective and efficient role in controlling pollution. At the very least, they could be used with other kinds of control such as emission standards. Of course, I would not argue that corrective taxes are the best way to control all forms of pollution.[11] But clearly they could play a much greater role than they do presently.

10. For a more detailed analysis, *see* J. Wenders, Analytics of a Corrective Pollution Tax, paper presented to the Western Econ. Ass'n, Econ. of Pollution Section (1971) (mimeograph copies available from author).

11. For instance, noise pollution might be particularly hard to handle by corrective taxes. Although I can see no reason why motor vehicle taxes, especially for trucks and motorcycles, could not be levied in proportion to their exhaust *and* noise pollution capabilities.