almost certainly not be worth the risk of acting with highly imperfect, inconclusive information.

In some cases, notably in the field of public utility regulation, some economists have criticized the employment of acceptability standards on both these grounds; they have asserted that the social costs of monopolistic misallocation of resources are probably not very high (that is, the relevant portion of the social welfare curve in Figure 11.1 is not steep), and that the regulation can itself introduce inefficiencies into the operations of the regulated industries.

Advocacy of environmental pricing and standards procedures for the control of externalities must therefore rest on the belief that, in this area, we do have a clear notion of the general shape of the social welfare curve. This will presumably hold true where the evidence indicates, first, that a particular externality really does have a substantial and unambiguous effect on the quality of life (if, for example, it makes existence very unpleasant for everyone or constitutes a serious hazard to health); and, second, that reductions in the levels of these activities do not themselves entail huge resource costs. On the first point, there is growing evidence that various types of pollutants do in fact have such unfortunate consequences, particularly in areas where they are highly concentrated. Second, what experience we have had with, for example, the reduction of waste discharges into waterways suggests that processes involving the recycling and reuse of waste materials can frequently be achieved at surprisingly modest cost. In such cases, the rationale for the imposition of environmental standards is clear, and it seems to us that the rejection of such crude measures on the grounds that they will probably violate the requirements of optimality may well be considered a kind of perverse perfectionism.

CHAPTER 12

Marketable emission permits for protection of the environment

In the preceding chapter, we examined the case for a system of effluent fees for the attainment of a set of predetermined environmental standards. We found, in particular, that such a fee system has the capacity to achieve the standards at the least cost to society. There is, however, an interesting, and in certain circumstances, an appealing alternative to fees that also possesses the least-cost property: a system of marketable emission permits.

While economists were making the case for effluent fees in the 1960s, a political scientist at the University of Toronto, J. H. Dales, published a small volume in which he proposed, as an alternative to fees, a system of tradable property rights for the management of environmental quality.[1] Basically, Dales proposed that property rights be defined for environmental resources and then offered for sale to the highest bidder. For example, the environmental authority might create a limited number of permits for the discharge of a specified air or water pollutant; these permits would then be sold through some kind of auction.

It is easy to see that such a system can be used to achieve a specified environmental target and can do so, like fees, at minimum cost. In brief, the environmental authority can directly limit waste discharges to their target level by restricting the quantity of permits. As a market for these permits develops, a market-clearing price would emerge that (like a fee) will indicate to polluters the opportunity cost of waste emissions. Since all sources would face the same price for a permit, cost-minimizing behavior would result because marginal abatement cost would be equalized among these sources. This, as we have seen, is the first-order condition for the least-cost allocation of "pollution quotas" among sources.

In this chapter, we shall first discuss some of the attractive characteristics of the permit approach in a policy setting. We then turn to the issues of the design and operation of such a system.

[1] J. H. Dales, *Pollution, Property and Prices* (Toronto: University of Toronto Press, 1968).

1 Marketable permits versus fees in a policy setting

Although both effluent fees and systems of marketable permits have the capacity to achieve a set of environmental standards at least cost, they are by no means equivalent policy instruments from the viewpoint of an environmental agency. We shall consider first the grounds on which the environmental authority might prefer such permits to fees and shall then turn to the case for fees.

The first, and a major, advantage of marketable permits over fees is that permits promise to reduce the uncertainty and adjustment costs involved in attaining legally required levels of environmental quality. The environmental authority cannot be completely sure of the response of polluters to a particular magnitude of an effluent charge; in particular, if the authority inadvertently sets the fee too low, environmental standards will not be met. As we discussed in the preceding chapter, the fee may have to be raised and then altered again to generate an iterative path converging toward the target level of emissions. This means costly adjustments and readjustments by polluters in their levels of waste discharges and the associated abatement technology. The need for repeated changes in the fee is also an unattractive prospect for administrators of the program. In contrast, under a permit scheme, the environmental agency directly sets the total quantity of emissions at the allowable standard; there is, in principle, no problem in achieving the target.

Second, and closely related to the issue just discussed, are the complications that result from economic growth and price inflation. Continuing inflation will erode the real value of a fee; similarly, expanding production of both old and new firms will increase the demand for waste emissions. Both of these will require the fee to be raised periodically if environmental standards are to be maintained. The burden of initiating such corrective action under a system of fees falls necessarily upon environmental officials; they are forced to choose between unpopular fee increases or nonattainment of standards. Under a system of permits, market forces automatically accommodate themselves to inflation and growth with no increase in pollution. The rise in demand for permits, real and nominal, simply translates itself directly into a higher price.

Third, the introduction of a system of effluent fees may involve enormous increases in costs to polluters *relative* to alternative regulatory policies. This point may seem somewhat paradoxical in light of the widespread recognition that systems of pricing incentives promise large savings in aggregate abatement costs. But the two are not inconsistent. Although a system of effluent charges will reduce total abatement costs, it will impose a new financial burden, the tax bill itself, on polluting firms. Although

these taxes represent a transfer payment from the viewpoint of society, they are a cost of operation for the firm. Some recent evidence on this issue suggests that the figures can be rather staggering. One such study of the use of pricing incentives to restrict emissions of certain halocarbons into the atmosphere estimates that aggregate abatement costs under a realistic program of direct controls would total about $230 million; a system of fees or of marketable permits would reduce these costs to an estimated $110 million (a saving of roughly 50 percent).[2] However, the cost of the fees or permits to polluters would total about $1,400 million so that, in spite of the substantial savings in abatement costs, a program of pricing incentives would, in this instance, increase the total cost to polluters by a factor of *six* relative to a program of direct controls! Some studies of other pollutants also suggest that fees can be a major source of new costs.[3] It is true that a system of marketable permits *making use of an auction for the initial acquisition of these rights* is subject to the same problem, because sources face high prices for permits. However, there is an alternative that gets around the problem: A permit system can be initiated through a *free* initial distribution of the permits among current polluters. This version of the permit scheme effectively eliminates the added costs for existing firms without any necessarily adverse consequences for the efficiency properties of the program and with some obvious and major advantages for its political acceptability. It is interesting in this regard that existing systems of marketable permits in the United States embody a kind of "grandfathering" scheme involving an initial distribution of emission permits or "rights" among polluters based on historical levels of emissions.

Fourth, as we noted in the preceding chapter, there may be instances where geographical distinctions among polluters are important. In fact, for several important air and water pollutants, various studies indicate that it is imperative for the environmental authority to differentiate among polluters according to their location if environmental standards are to be realized in a cost-effective way.[4] Sources at a highly polluted location within an air shed cannot be allowed to increase their emissions on a one-to-one basis in exchange for emissions reductions by other sources at a less-polluted point. As we have indicated, it can be administratively quite

[2] A. Palmer, et al., *Economic Implications of Regulating Chlorofluorocarbon Emissions from Nonaerosol Applications* (Santa Monica, Calif.: The Rand Corporation, 1980).

[3] See, for example, E. Seskin, R. Anderson, Jr., and R. Reid, "An Empirical Analysis of Economic Strategies for Controlling Air Pollution," *Journal of Environmental Economics and Management* X (June, 1983), 112–24.

[4] See, for example, Seskin, et al., "An Empirical Analysis of Economic Strategies for Controlling Air Pollution."

cumbersome to deal with the spatial problem under a system of effluent charges, for it will typically require the environmental agency to determine a separate effluent fee for each source, depending upon its location in the air shed or river basin (or alternatively, it will be necessary to introduce a system of zones with different charges). Such discrimination among sources in fee levels may either be explicitly illegal or politically infeasible. In contrast, a system of marketable permits (as will become clear in the next section) can address these spatial dimensions of the pollution problem in a manner that is less objectionable.

Fifth, marketable permits may well be the more feasible approach on grounds of familiarity. The introduction of a system of effluent fees requires the adoption of a wholly new method of controlling pollution, new both to regulators and polluters. Such sharp departures from established practice are hard to sell; moreover, some real questions have been raised about the legality of charging for pollution. In contrast, permits already exist, and it may be a less-radical step to make these permits effectively marketable.

There is thus a strong case on administrative grounds for favoring marketable permits over effluent fees. But the case is far from ironclad. Where charges are feasible, they represent a most attractive source of revenues for the public sector. Most taxes in the economy have undesired side effects: they distort economic choices in various ways. Income taxes, for example, can induce individuals to choose untaxed leisure activities rather than work; excise taxes shift peoples' purchases away from the taxed goods; and so on. Such taxes generate an "excess burden" on the economy – a cost in addition to the reduced disposable income directly attributable to the revenues. Effluent fees, in contrast, have a beneficial side effect: They tend to correct distortions in the economy while at the same time generating public revenues. Such fees can be said to impose a "negative excess burden." Fees, then, to the extent they are feasible, are a very desirable source of public revenues in terms of economic efficiency.

One can also make an equity argument on behalf of fees. The Organization for Economic Cooperation and Development has done just this in terms of what they call the "Polluter-Pays-Principle."[5] Under this approach, society's environmental resources, including clean air and water, are taken to belong to the public at large. Those who "use" these resources must then compensate the "owners" (i.e., the public) for any environmental degradation that occurs. The equity issue is, however, a complicated one. In certain instances, for example, a firm may have adopted measures that minimize the damage from discharges, only to find some

[5] *OECD and the Environment* (Paris, 1979), p. 26.

years later that the recent arrival of residents and other firms now makes these discharges objectionable. Just who *should* bear the cleanup costs in such cases is not wholly clear on equity grounds. Moreover, as a practical matter, most polluters have already been required to institute extensive control measures to reduce their waste discharges. Grandfathering would thus involve a free distribution of permits for only the remaining, or residual, discharges. This may perhaps represent a reasonable compromise on equity grounds.

There is yet another argument favoring effluent fees – one that involves savings in certain transactions costs. A system of marketable emission permits requires an initial distribution of the permits. However, if this initial distribution is based on the grandfathering principle or some other mechanism that does not reflect the relative marginal abatement costs of the different sources, a series of transfers (purchases and sales) of permits will be required if the least-cost allocation is to be attained. The incentives for such transfers exist: Buyers who can reduce emissions only at a higher real cost will be willing to pay more than the reservation price of sellers. But there may well be significant search costs and elements of strategic behavior that impede the transfers of emissions entitlements that are necessary to achieve the least-cost outcome. In contrast, under a system of fees, no such transfers of permits are needed – each source simply responds directly to the incentive provided by the fee. It may thus prove easier in certain circumstances to attain the least-cost allocation of waste emissions under a set of fees than under a system of marketable permits.

2 The design of a system of marketable emission permits

Although the case, in principle, for marketable emission permits is impressive, it is a long way from a general decision on policy strategy to the design of an actual system of marketable permits. We turn in this section to an exploration of some alternative forms of a permit market and their properties.[6]

It will facilitate the discussion to provide here a more specific and formal statement of the control problem in which we shall incorporate explicitly the geographical dimension of polluting activities. Let us consider a particular region consisting either of an air shed or system of waterways in which there are m sources of pollution, each of which is fixed in location. Environmental (air or water) quality is defined in terms of pollutant concentrations at each of n "receptor points" in the region;

[6] This section draws heavily on A. Krupnick, W. Oates, and E. Van De Verg, "On Marketable Air Pollution Permits: The Case for a System of Pollution Offsets," *Journal of Environmental Economics and Management* X (September, 1980), 233–47.

this implies that we can describe environmental quality by a vector $Q = (q_1, \dots, q_n)$ whose elements indicate the concentration of the pollutant at each of the receptors. The dispersion of waste emissions from the m sources is described by an $m \times n$ matrix of unit diffusion (or transfer) coefficients:

$$D = \begin{bmatrix} & \vdots & \\ \dots & d_{ij} & \dots \\ & \vdots & \end{bmatrix}.$$

In this matrix, the element d_{ij} indicates the contribution that one unit of emissions from source i makes to the pollutant concentration at point j.

The environmental objective is to attain some predetermined level(s) of pollutant concentrations within the region; we denote these standards as $Q^* = (q_1^*, \dots, q_n^*)$. Note that the standard need not be the same at each receptor point; the environmental authority can, for example, prescribe lower concentrations as the target in densely populated areas.

The problem thus becomes one of attaining a set of predetermined levels of pollutant concentrations at the minimum aggregate abatement cost. Or, in other words, we are looking for a vector of emissions from our m sources, $E = (e_1, \dots, e_m)$, that will minimize abatement costs subject to the constraint that the prescribed standards are met at each of the n locations in the region. The abatement costs of the ith source are a function of its level of emissions: $c_i(e_i)$. So our problem, in formal terms, is to

$$\begin{aligned} \text{Minimize} \quad & \sum_i c_i(e_i) \\ \text{s.t.} \quad & ED \leq Q^* \\ & E \geq 0. \end{aligned}$$

There are two basic approaches to the design of a marketable permit system that deals with this control problem. First, the environmental authority can simply issue q_j^* permits at each receptor point, with these permits defined in terms of an allowed contribution to the pollutant concentration at j. This would effectively create a separate market corresponding to each receptor point, and a source, to justify its emissions, would have to procure a "portfolio" of permits from the various receptor points at which its emissions contribute to pollution levels. More specifically, source i would have to obtain $e_i d_{ij}$ permits from the jth receptor market. This form of permit market is an ambient-permit system (APS) in which the permits refer, not to a source's emissions, but to the effects of these emissions on levels of pollution at a particular point. Note that this implies that emissions entitlements will not, in general, exchange for one another on a one-for-one basis; a source whose emissions per unit are more damaging to a particular receptor will have to purchase commensurately more emissions entitlements from another source whose discharges contribute less per unit to pollutant concentrations at that receptor point.

Alternatively, the environmental agency can introduce an emissions-permit system (EPS). Here the agency would divide the region into zones, and within each zone sources would trade emissions entitlements on a one-for-one basis. The EPS system has some obvious attractions in terms of simplifying transactions among sources.

We turn next to the properties of the two permit systems. For the APS scheme, Montgomery, in a seminal paper, has shown that, if the sources of pollution are cost-minimizing agents, the emissions vector and shadow prices that emerge from the preceding minimization calculation satisfy the same set of conditions as do the vectors of emissions and permit prices for a competitive equilibrium in the permits market.[7] In short, if the environmental authority were simply to issue q_j^* permits (defined in terms of pollutant concentrations) for each of the n receptor points, competitive bidding for these permits would generate an equilibrium solution that satisfies the conditions for the minimization of total abatement costs.

The APS system can thus, in principle, achieve the least-cost outcome. Two properties of this form of permit market are noteworthy. The first is the utter simplicity of the system from the viewpoint of the environmental agency. In particular, officials need have no information whatsoever regarding abatement costs; they simply issue the prescribed number of permits at each receptor point, and competitive bidding takes care of matters from there. Alternatively, the environmental authority could make an initial allocation of these permits among current polluters. In a competitive setting, subsequent transactions will then lead automatically to the cost-minimizing solution. As Montgomery proves formally, the least-cost outcome is independent of the initial allocation of the permits. Second, in contrast to the modest burden it places on administrators, this system can be extremely cumbersome for polluters. Note that a firm emitting wastes must assemble a "portfolio" of permits from *each* of the receptor points that is affected by its emissions: A source at point i will have to acquire permits from each receptor point j in the amount $d_{ij} e_i$. There will, therefore, exist n different markets for permits, one for each receptor point, and each polluter will participate in the subset of these markets corresponding to the receptor points affected by his or her emissions. Transactions costs for polluters may be high.

[7] W. E. Montgomery, "Markets in Licenses and Efficient Pollution Control Programs," *Journal of Economic Theory* V (December, 1972), 395–418.

The APS system suffers from a second deficiency that is potentially quite troublesome. The analysis here has run in terms of a given and fixed set of receptor points at which the attainment of predetermined levels of air quality are required. However, the Clean Air Act in the United States requires that the National Ambient Air Quality Standards (NAAQS) be met at *all* locations. But for pollutants with more localized effects (and this includes most of the major air and water pollutants), it is possible for changing location patterns of emissions to generate "hot spots" that do not coincide with designated receptor points. To prevent the occurrence of localized hot spots for such pollutants, a relatively fine mesh of receptor points will be needed, implying a large number of receptor markets with comparatively high transactions costs. Further, since each receptor is associated with an individual permit market, receptor points would tend to become "institutionalized." The moving of a receptor point to adapt it to a new pattern of pollution would create dislocations: It would alter the structure of permit markets and would probably give rise to difficult administrative and legal problems. And it would not preclude the need for future readjustments. The APS form of the permit market is not without serious problems.

As noted earlier, the EPS can greatly simplify life for polluters. Instead of assembling the requisite portfolio of permits from different receptor markets, each source would find itself assigned to a single zone within which emissions entitlements would exchange one-for-one. However, the EPS system cannot, in general, achieve the least-cost solution, and it makes enormous demands on an administering agency that tries to approximate this solution. Since polluters with somewhat varying dispersion coefficients are aggregated into the same zone, one-for-one trades of pollution entitlements will ignore the differences in the concentrations contributed by their respective emissions. In short, the price of emissions to each polluter will not correspond accurately to the shadow price of the binding pollution constraint. This objection to EPS need not be serious, if the dispersion characteristics of emissions within each zone are not very different. However, this is often not true. The ambient effects of emissions do not depend solely on the geographical location of the source; for air pollutants, for example, they depend significantly on such things as stack height and diameter and on gas temperature and exit velocity. EPS cannot readily incorporate such elements without losing the basic simplicity of one-for-one transfers of emissions entitlements.

A further difficulty besetting EPS is that, even were there no differences in the dispersion characteristics of emissions within each zone, the environmental authority must still determine how many permits to assign to each zone. And this determination requires *the complete solution* by the administrator of the cost-minimization problem. To reach this solution, the administering agency must have not only an air-quality model (to provide the d_{ij}) and a complete emissions inventory, but source-specific abatement cost functions and the capacity to solve the programming problem. With less-than-perfect information, the agency's assignment of permits may not result in the attainment of the ambient air-quality targets. If pollution were excessive, the authority would have to reenter the market (in at least some of the zones, where the pattern of zonal purchases would again require a fairly sophisticated analysis) and purchase or confiscate permits. Such an iterative procedure is not only cumbersome for the administrator of the system, but may create considerable uncertainty for firms about the future course of permit prices. Note, moreover, that this procedure involves more than just groping once and for all toward an unchanging equilibrium. Altered patterns of emissions resulting from the growth (or contraction) of existing firms, the entry of new firms, and changing abatement technology will generate a continually shifting least-cost pattern of emissions among zones. Under EPS, the environmental authority faces a dynamic problem that will require periodic adjustments to the supplies of permits in each zone.

3 The pollution-offset system

Both the APS and EPS forms of marketable permit systems are, then, subject to some serious problems. However, there is a third alternative, a kind of hybrid system, that may be able to circumvent these problems: the pollution-offset (PO) system.[8] Under this approach, permits are defined in terms of emissions (e.g., the permit allows the discharge of X pounds of the pollutant, say, per week). However, sources are not allowed to trade permits on a one-to-one basis. More specifically, *transfers of permits under the PO scheme are subject to the restriction that the transfer does not result in a violation of the environmental quality standard at any receptor point.* This is the sole constraint on trades of permits.

The key to the working of the PO system is its implication that if a proposed transfer encounters a binding pollution constraint at some receptor point, then emissions must trade at a rate equal to the ratio of the sources' transfer coefficients (the d_{ij}'s), for the ratio of the transfer coefficients indicates the rate at which emissions from one source can substitute for emissions from the other with no change in pollutant concentrations at the binding receptor point. For example, if a unit of emissions from source

[8] See Krupnick et al., "On Marketable Air Pollution Permits: The Case for a System of Pollution Offsets."

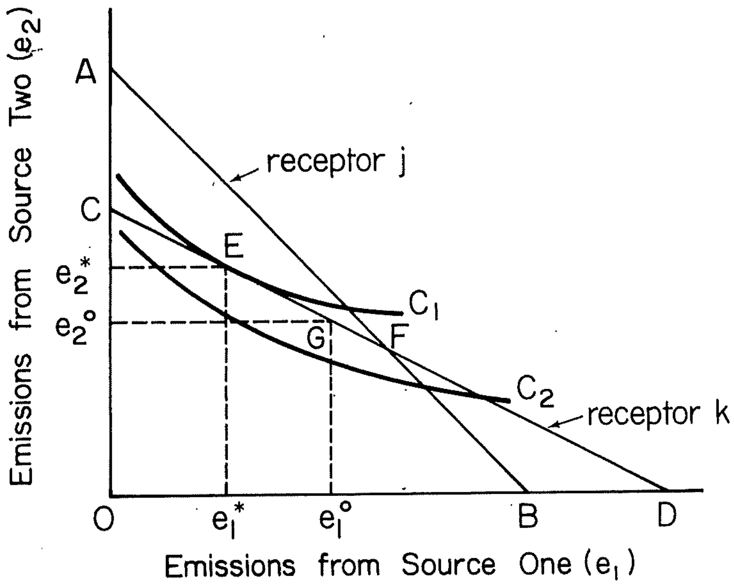

Figure 12.1

A contributes twice as much to pollutant concentrations at binding receptor point *I* as a unit of source *B*'s emissions, then *A* will be required to acquire two of *B*'s unit permits before *A* is allowed to increase its own emissions by one unit. Although permits are defined in terms of emissions, as under EPS, trades are really governed by the effects of emissions on ambient air quality, in the spirit of APS.

The PO system shares with the APS the important property that mutually beneficial trades among sources can lead to the least-cost solution and that this result is independent of the initial allocation of permits. This coincidence of the "trading equilibrium" with the least-cost solution can be seen with the aid of Figure 12.1. In the figure, the horizontal and vertical axes measure, respectively, the levels of emissions of firms 1 and 2 (i.e., e_1 and e_2). The curves C_1 and C_2 are iso-cost curves for pollution abatement costs.[9] Note that higher curves correspond to lower total abatement costs. The line *AB* depicts the pollution constraint associated with receptor *j*. Points on *AB* denote combinations of e_1 and e_2 for which $q_j = q_j^*$; the slope of the line equals the ratio of the transfer coefficients

[9] A sufficient (but not necessary) condition for the iso-cost curves to have the desired curvature in Figure 12.1 is that both firms face a schedule of rising marginal abatement costs.

(i.e., the rate at which emissions from firm 2 can substitute for emissions from firm 1 with no change in pollution concentrations at receptor *j*). Similarly, *CD* depicts the pollution constraint for receptor *k*. The combinations of emissions from firms 1 and 2 that satisfy the pollution constraint at both receptors are thus the set of points *OCFB*. We see immediately that the least-cost solution occurs at *E*, at which point we reach the highest iso-cost curve consistent with the pollution constraint. At this point, the ratio of marginal abatement costs equals the ratio of the transfer coefficients.

Suppose, however, that the environmental authority selected for the initial distribution of permits point *G* instead of the least-cost outcome *E*. (Recall that the authority has no knowledge of sources' abatement cost functions and hence is unable to determine e_1^* and e_2^*.) In this instance, source two would find it profitable to purchase permits from source one. The effective rate of exchange of permits would be the slope of the line *CD*, since receptor *k*'s constraint is, in this case, the one that is binding. At this rate of exchange, the transfer of emissions from source one to source two will result in a decrease in aggregate abatement costs. The gains from trade would be exhausted at *E*, where the ratio of the sources' marginal abatement costs become equal to the rate of exchange of permits. We thus find that the "trading equilibrium" under the PO system coincides with the least-cost solution.[10]

Like APS (and unlike EPS), the PO scheme makes modest information demands on the environmental authority. Officials need to know the dispersion characteristics of emissions within the air shed or waterway (i.e., the *D* matrix), but need have no information on sources' abatement costs. The authority does not have to solve the cost-minimization problem to determine the initial allocation of permits: any allocation will do. This, incidentally, is an important property of the system, because it provides the degrees of freedom that will probably be needed to reach a "fair" and politically acceptable distribution of pollution rights.

Unlike APS, however, the PO system does not require sources to trade in a multitude of separate permit markets. Instead, a firm purchases emissions permits directly from other sources. The PO scheme thus promises substantial savings in transactions costs to sources relative to APS. In addition, it is not subject (as is APS) to the requirement that a fixed and

[10] We refer to this as a "trading" equilibrium rather than a "market" equilibrium, because we have not shown formally that there exists a specific set of prices that will sustain an equilibrium among buyers and sellers corresponding to the efficient allocation of permits among polluters. The discussion suggests that the only allocation of permits for which there exist no potential gains from trade (the definition here of a "trading equilibrium") corresponds to the least-cost allocation of emissions entitlements.

"institutionalized" set of receptor points be established. Receptor points can easily be redefined with respect to each trade to coincide with potential hot spots and thus ensure that there are no violations of the environmental standard at any point in the air shed or waterway. Receptor points, incidentally, need not coincide with monitoring locations where air or water quality is actually measured; receptors serve as reference points where pollutant concentrations may be monitored or alternatively inferred from a knowledge of emissions and a dispersion model of the region.

The PO system thus offers a promising approach to the design of a system of marketable emission permits. There may be cases, however, where a system of zones with one-for-one transfers within each zone promises a reasonably efficient outcome and is preferable because it simplifies trading. The attendant gains and losses under the various forms of permit markets need to be evaluated for different pollutants in different areas.[11]

4 On the choice among policy instruments

In the last two chapters, we have explored two alternative approaches to the use of pricing incentives to attain a predetermined set of environmental standards: effluent fees and marketable emission permits. Each approach, as we have seen, can in principle achieve the desired standards at the least cost to society. We reiterate the importance of this property in the light of recent experience with environmental policies. Study after study of current policies making use of direct controls has found that they incur excessively large costs. These pricing approaches thus offer an opportunity for enormous cost-savings in environmental programs. This is particularly important during times of sluggish overall economic performance, when environmental programs are likely to come under very close scrutiny as a source of increased costs to industry. If we cannot achieve our professed environmental objectives in a reasonably efficient way, it is likely that it will be these objectives, and not industrial performance, that will have to give. Thus, the standards of environmental quality that society is willing to accept may themselves depend upon the efficiency of the policy instruments we adopt to achieve the standards.

The choice between a system of effluent fees and one of marketable emission permits depends, as we have seen, on the pertinent circumstances: the nature of the pollutant and its geographical setting, and on various political and administrative considerations. Each policy instrument has its place. Where it is important to distinguish among individual sources, we are inclined to believe that a permit system is the more promising approach. Under such circumstances, one can introduce a pollution-offset system in which sources are allowed to trade permits subject only to the restriction that their trades do not result in any violations of the standards. Trades under this system automatically incorporate the differential effects of the sources' emissions on environmental quality. The PO system thus offers a very attractive and straightforward design for a permit system, one that has already been embodied, in essence, in some programs for the control of both air and water pollution.[12] Alternatively, where a uniform pricing signal is satisfactory, a single effluent charge, applicable to all sources, becomes more appealing. Each source would then respond directly to the fee, with no need for any permit transactions with other sources. Alternatively, the environmental authority can adopt a permit system with a single zone in which the permits trade one-for-one. Here, various administrative issues may suggest the approach that is to be preferred.

In the next two chapters, we shall examine some other policy instruments for the protection of the environment. As we shall see, it is important to understand the particular advantages and disadvantages of the different policy tools, for an effective overall program for the management of environmental quality will be one that embodies the appropriate *mix* of these tools.

[11] There are two recent "experiments" in the United States with systems that allow the transfer of emissions entitlements. The first, emissions trading, provides for the exchange of discharges of air pollutants among sources. The second, the Wisconsin system of transferable discharge permits, involves the transfer of BOD emissions among sources along certain rivers in the state of Wisconsin. Both of these systems, incidentally, are not "pure" systems of marketable emissions permits. They are embedded in a broader set of command-and-control measures that impose certain requirements upon control techniques, etc. It is interesting that both systems are in the spirit of the PO system discussed in this chapter in that they permit transfers of emissions entitlements subject to the absence of violations of the predetermined environmental standards. On emissions trading, see T. Tietenberg, *Emissions Trading: An Exercise in Reforming Pollution Policy* (Washington, D.C.: Resources for the Future, 1985); on the Wisconsin TDP system, see W. O'Neil, M. David, C. Moore, and E. Joeres, "Transferable Discharge Permits and Economic Efficiency: The Fox River," *Journal of Environmental Economics and Management* X (December, 1983), 346–55; for a brief and nontechnical description of both systems, see W. Oates, "Markets for Pollution Control," *Challenge* (May/June, 1984), 11–17.

[12] A straightforward variant of the PO system can, where desired, prevent deterioration in environmental quality in areas where existing pollutant concentrations are less than those allowed by the standard. On this, see A. McGartland and W. Oates, "Marketable Permits for the Prevention of Environmental Deterioration," *Journal of Environmental Economics and Management* XII (September, 1985), 207–228.