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Environmental Policy Instruments: Some Open Questions

Horst Siebert

In the 1970's, environmental laws were enacted in nearly all of the industrialized nations. Experience in implementing these laws has been gathered, and some laws are up for revision (Clean Air Act in the United States in 1981). Taking into account the time-lag of environmental legislation among nations, revisions will be spread over the decade. The 1980's will be the period of evaluating and revising the body of existing environmental laws.

This process of revision takes place in an economic situation where the energy problem requires difficult adjustments, a sizable reallocation of factors of production and shift in sector structure, where an important part of real income of the industrialized nations is transferred to the OPEC countries and where lagging productivity growth, unemployment, inflation and balance-of-payments deficits represent pressing macroeconomic policy problems. Under these conditions, the criterion of economic efficiency of environmental policy instruments receives a greater weight. Environmental policy cannot afford to be inefficient since this implies the risk that the targets of environmental policy will be reduced. Thus, in analyzing how to improve the efficiency of environmental policy instruments, the economist is the environmentalist's friend.

The environmentalist cannot rely on the hypothesis that the energy problem will present a great stimulus to resource conservation and thus to an improvement of environmental quality. This is only correct insofar as incentives to conserve resources will imply that a smaller volume of material will be withdrawn from nature, and consequently, returned to the

environment and that changing relative prices will stimulate recycling, conservation, substitution and innovation and consequently reduce the volume of emissions. In contrast to these positive developments for the environment, there is a conflicting relationship between the energy problem and environmental protection. The pollution-intensive producing sectors of the economy (resource extraction, energy production, the chemical industry, steel, paper) are also energy-intensive. These so-called basic industries which belong to the industrial core of an economy are negatively affected by the energy problem. Energy production is capital-intensive. The increased demand for capital in energy production competes with capital requirements for abatement. Extraction of new resource deposits may involve increased environmental risks (open pit mining, sea bed mining, oil shale). Energy conservation may only be possible at the cost of a larger volume of emissions. The smaller increase in real income (in some countries even a decline) has reduced the acceptance of environmental considerations. Finally, the energy constraint has affected the political position of industrialized nations. Therefore the political acceptance of additional constraints on economic activities, established from inside, is considerably reduced.

1. Transforming Quality Targets into Individual Behavior

In discussing the problem of environmental policy instruments we start from the assumption that the targets of environmental policy are determined in a political process and are given. The problem then is how these targets can best be transformed into discharge and abatement behavior of individual entities. What institutional arrangements and which policy instruments are available so that the target of

environmental protection is reached by the individual decisions of a set of polluters? We may distinguish among the following instruments.

(1) Moral Suasion. The policymaker attempts to influence the targets of private subjects in such a way that the social impact of private decisions is considered more carefully; that is, the political leader tries to change the orientation of households and producers.

(2) Subsidies. The government pays subsidies in order to induce abatement activities or reduce pollution. The subsidies are financed by general taxes.

(3) Regulation. A regulatory approach is followed in which the government specifies the maximum amount of emissions per firm or per equipment (emission norms, permits). When a quality target is violated in an environmental medium, no new permit can be issued.

(4) Emission Taxes. A price per unit of emission is charged (emission tax, effluent charge) with the intent to induce abatement or less pollution-intensive technologies.

(5) Transferable Discharge Permit. By fixing the quality target, the policymaker determines the tolerable total quantity of all emissions, that is, the sum of emission rights for an environmental medium. These emission rights are either auctioned among competing users or are sold and purchased in an artificial market.

(6) Cost-Sharing. Associations for specific environmental media are formed that either determine the quality target themselves or implement the quality target which is specified by the policymaker. The role of these associations is to distribute the costs of achieving a desired environmental quality to the polluters; the attribution of costs should be undertaken in such a way that incentives for abatement are created.

In the following analysis, two instruments are not considered further, namely, moral suasion and subsidies. Moral suasion is an attempt to influence the targets of private economic subjects in such a way that the social consequences of private decisions are considered. It includes a change of ethical norms with respect to nature and ecological problems. This approach may bring about results, but since the economic success of an enterprise is the central element of a free-market system, we cannot rely on firms to consider the social effects of their economic decisions. Rather, it should be the task of the economist to change the frame of reference (the data corona) of private economic decisions in such a way that social costs are internalized.

Subsidies are practical and proposed in a number of forms in environmental policy. Quite a few objections can be raised against subsidies. They have to be financed by general taxes, and in most industrialized countries subsidies already account for a large part of the budget. Also, whereas most subsidies are motivated by social policies such as health care or agriculture, the environmental problem is an allocation question. The main objection to subsidies, however, is that subsidies stimulate the pollution-intensive commodity. They take over a part of the environmental damage. Because of this subsidization, the enterprise does not need to introduce these costs into its price. Therefore, the price of the pollution-intensive commodity is too low in comparison to commodities being produced favorably to the environment. The price structure as an allocation guideline does not change as is desired. In comparison to a desired optimal situation, excessive quantities of pollution-intensive commodities should be limited. The subsidy systematically distorts the economic price mechanism and causes a

false allocation of resources.

In the following considerations, we will briefly review the criteria for evaluating instruments and then focus on the regulatory approach, emission taxes, discharge licenses and institutional arrangements for cost-sharing. The policy instruments have already been described in the literature in great detail (Kneese and Bower 1968; Kneese and Schultze 1975; Mills 1978). In the following discussion, we will address some of the open questions that arise in applying these policy instruments.

2. Direct Regulation

The regulatory approach seeks to reach a given quality target for an environmental system by regulating individual behavior. The typical instruments are pollution norms, that is, allowances to emit a specific quantity of a pollutant into an environmental system. Permits are issued until the quality target has been reached; then no further permits are given.

Regulations can take different forms according to what they specify. The usual permit is a property right to emit a maximum quantity of pollutants. Other types of regulations are obligations to reduce a given amount of pollutants, in absolute or in relative quantities. Still other examples of this approach include regulations which stipulate the state of technology to be applied in abatement or production or which monitor the type of input to be used. Product norms may define the quantity of pollutants which are contained in goods (DDT, for example, in agricultural products) or which emerge through the use of commodities (noise emitted through the use of commodities such as a car). Production quantities may be limited, or production of a specific product may be

lower cost than firm 1 can abate AD. An emission tax OT shows the efficient solution.

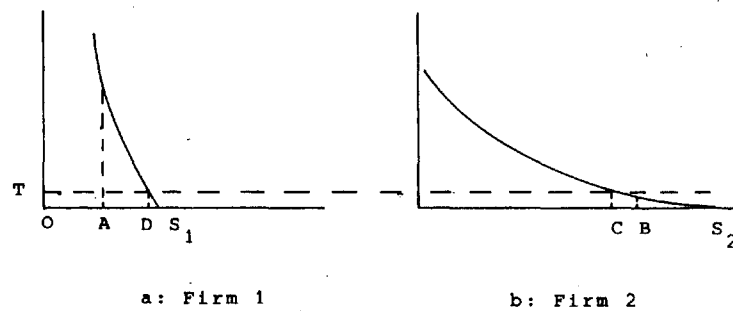


Figure 1

The inefficiency argument implies that resources are wasted. Thus, the opportunity costs of environmental policy are too high. Since the costs of environmental policy will have an effect on the target level, inefficient abatement implies less environmental quality. Therefore, the regulatory approach reduces the chances for an effective environmental policy.

(2) Bureaucracy. Government agencies have to issue permits specifying the allowable quantity of emissions for specific equipment within the firm. For instance, in the North Rhine Westfalia region of West Germany, air quality policy attempts to regulate each stationary source of emission (Dreyhaupt 1979). We may call this approach the "individual stack policy" where the government regulates each individual facility. According to Mills (1978, p. 186), 46,000 permits were issued

in the United States for water pollution as a result of new legislation in the period from 1972 to 1976. We may doubt whether a government agency has all the necessary information to make a proper assessment in such matters. We may also note that such decisions may create an atmosphere in which government interference with individual decisions, even in other fields, becomes a widely accepted practice. Incidentally, in West Germany the time required to obtain pollution permits for facilities averages about three years.

(3) No Scarcity Price. The regulatory approach allocates pollution permits on a first come, first served basis. This is not a very feasible allocation mechanism. Some companies receive permits at a zero price; others are charged at a price of infinity, that is, this factor of production is not available.

(4) Market Entry and Dynamic Firms. The regulatory approach views the economy as being a static entity. As soon as the environmental quality standard for the region is surpassed, no new permits can be issued. Thus, direct regulation protects the existing firms and tends to perpetuate the given structure of firms and sectors in an economy. Dynamic firms cannot expand, new firms cannot enter the market. Competition is impaired. Necessary changes such as sectoral shifts, the expansion of growth industries and the reallocation of factors of production cannot take place.

(5) Spatial Structure and the Regional Labor Market. In preventing the location of new firms, the interregional migration of capital is impaired. Thus, a given spatial structure is likely to become encrusted. This consequence is not only to the disadvantage of business; it also negatively affects labor. New firms may not be able to locate in

a region although they may provide interesting and improved employment opportunities. The existing firms receive a monopsony with respect to the regional labor supply. They do not have to fear competitors in the regional labor market. Consequently, their incentive to compete for labor is reduced.

(6) State of Technology. Permits very often require that the producers use the existing state of technology. For instance, the air quality law in West Germany stipulates such a condition. This condition has a very interesting implication: The government will try to prove that new technologies are possible whereas the entrepreneur will use his talent to show that these new technologies are not feasible or not economical. We have feedback on the economic system. Whereas in a market economy it is the role of firms to find new technologies, given our scenario, firms will relinquish this function to the government.

(7) The Role of Courts. In most countries, government decisions can be made subject to checks by the courts. For instance, in West Germany the residents or the firms affected by a permit may go to the administrative courts on at least two levels. There are examples where a court has withdrawn a permit already granted by a local administration only to have a higher court reverse this decision after a year or two. Regulations give a greater role to the courts in the allocation process. But, excluding exceptional cases, allocation of resources cannot be undertaken by the courts.

3. More Flexible Forms of Regulation

In the command-and-control type of direct regulation, the government identifies the source of emissions and specifies for each source the

permitted volume of emissions. Such an approach is rather strict; it presupposes that the government has all the relevant information to specify which measure has to be taken. In attempts of deregulation, it has been proposed that more flexible approaches of regulation should be used.

(1) Performance Standards. Instead of detailed compliance requirements more general performance requirements are proposed (U.S. Regulatory Council 1980). Such an approach would allow the regulated entity to find the most efficient way of complying. This would introduce an incentive for each firm to reach the given overall restriction with minimum costs. An example is EPA's "controlled trading" approach according to the bubble concept in air quality management (American Petroleum Institute 1980). Consider a firm with multiple emission sources or a group of firms that are confronted with emission limitation requirements as specified in a state implementation plan. Under the bubble concept, firms may violate the requirement for one source if at another source there is excess emission reduction--the important condition being that the overall performance standard for the firm as a whole (or for the group of firms) is not violated. Thus, costs will be reduced.

Some restrictions for using the bubble concept have to be observed, relating to hazardous material, new source performance standards, meeting existing air quality standards, proof of the equivalence of the proposal to the state implementation plan, etc.

Performance standards have the advantage to reduce the costs of compliance. Though making the direct regulation more flexible, the approach is still embedded in a system of direct regulations such as

state implementation plans and individual stack requirements. Also, costs of abatement are only minimized within a firm or a very limited group of firms. They should, however, be minimized over the whole economy.

(2) Banking and Offsets. According to the 1977 Amendment of the Clean Air Act, new sources entering a region in which the national ambient air quality standards are violated must offset the emissions they will create by purchasing reductions in emissions from existing sources. This provision gives the right to pollute to the existing firms but it allows the location of new firms in an area. There is an incentive for the newcomer to buy emission rights at the most reasonable price from existing polluters. Consequently, costs of abatement are reduced. Offsets may also be "banked" so that they can be used in future trades or in bubble cases.

The advantage of this approach consists in releasing the restriction for newcomers in non-attainment regions and thus abolishing one of the handicaps of the more direct regulation. The problem lies in the definition of some standard of emissions, from which offsets are defined. If this frame of reference could be taken away, the offset approach comes pretty close to the marketable emission license.

Offsets show that firms can abate a larger volume than the agency anticipated. Therefore it may be very tempting for the agency to revise the detailed requirements. If the firms anticipate such a behavior, the long-run incentives for innovation will not be too strong. After all, the system of production norms in Eastern Europe produces exactly the same behavior of managers in state-owned firms.

prohibited. Finally, the location of firms may be forbidden in a specific area.

The regulatory approach has been widely used in environmental policy. Thus, water and air quality management in the United States is based on a permit system (Mills 1978). In Western Europe and Japan, permits are used in air quality policy.

The advantage of the regulatory approach is seen in its ecological incidence. If the quality target is properly set and if private emitters do not violate the laws, then the quality target will be reached. This argument makes the regulatory approach very attractive to environmentalists. Unfortunately, the regulatory approach has severe shortcomings.

(1) Inefficiency. The regulatory approach requires a set of emission rules that apply to all emitters of a specific pollutant. The policymaker planes the economic subsystems by using a general approach, and thus he is not able to take into account particular differences. Therefore, the regulatory approach is inefficient. As an example, consider an obligation to reduce a given amount of pollutants by x percent. We neglect the announcement effect which would clearly indicate that the level of pollutants should not be reduced before the instrument is applied (in fact, more pollution should be produced now so that one will be faced with only a relatively small reduction later on). In Figure 1, the marginal abatement costs of two firms are shown. Firm 1 has relatively unfavorable abatement costs, whereas firm 2 can abate at lower costs. If both firms have to reduce their emissions by one third, firm 1 will abate S_1A with relatively high abatement costs, and firm 2 will abate S_2B with relatively low abatement costs. Abatement is inefficient in the sense that firm 2 can abate BC of the pollutants at a

4. Emission Taxes

Allocation theory suggests that a zero price of environmental use implies a discrepancy of private and social costs, a distortion in favor of the pollution-intensive producing sector, a misallocation of resources and an overusage of the environment as a receptacle of wastes. Emission taxes or effluent fees attempt to introduce a price for environmental use. This proposal has been described extensively in the literature (Kneese and Bower 1968; Mills 1978; Siebert 1976; Tietenberg 1973). The following problems require discussion if emission taxes are to be used in practical environmental policy.

(1) Reaction of Firms. Emission taxes introduce an incentive to prevent emissions if the costs of prevention are lower than the emission tax. A firm has a set of potential adaptations at its disposal. One of the crucial effects of an emission tax is the inducement to introduce improved abatement technologies. Figure 2 summarizes the chain of reactions to an emission tax. The decisive reactions have to take place within the individual firm. Only after these adaptations have occurred, will relative prices of the economy change and will demand adjust accordingly.

The position that shifting the emission tax to the consumer will destroy the incentive is in error. As long as firms minimize costs, an emission tax will present the correct incentives. This even holds in monopoly (Siebert 1976).

(2) Tax Base. The correct tax base for an emission tax or an effluent charge is the quantity of emissions, measured in pounds or tons. In practical policy, we can expect that information problems will arise and that alternative tax bases need to be used. Figure 3 shows some tax bases.

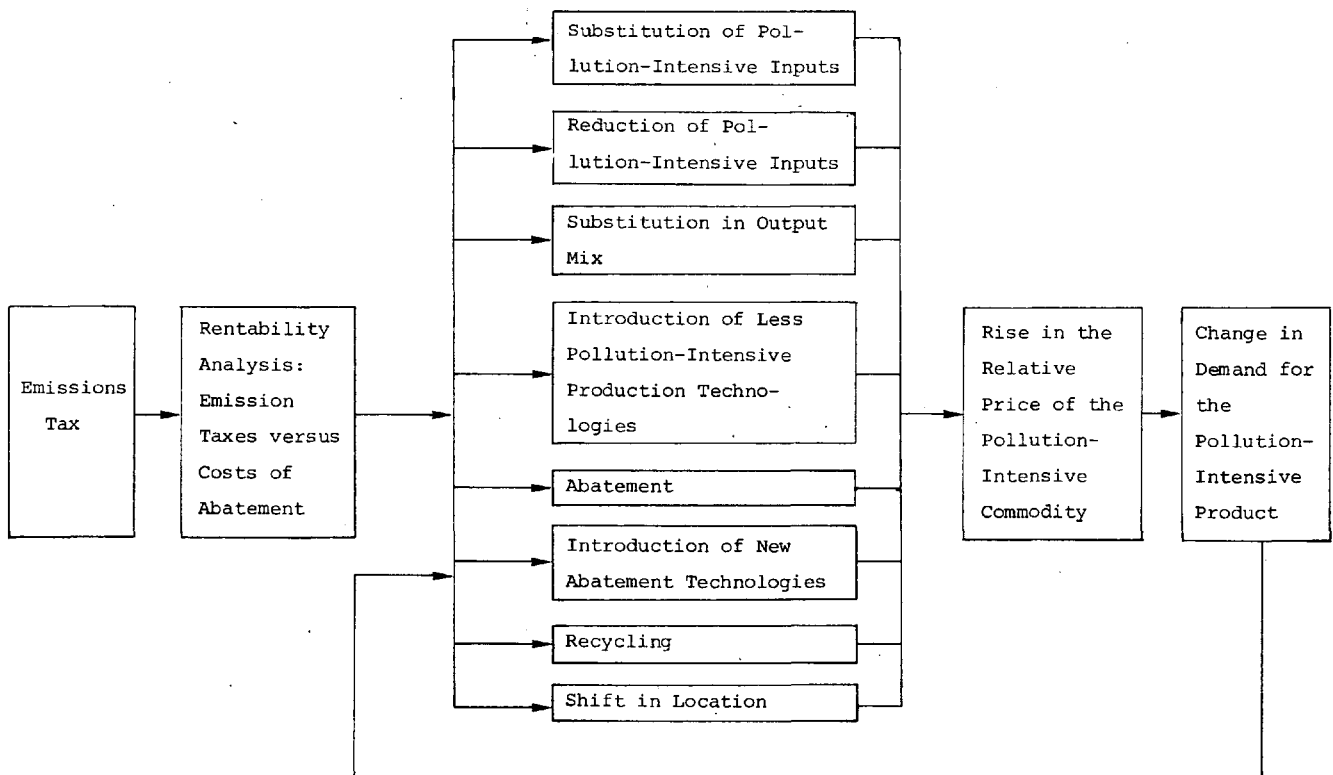


Figure 2

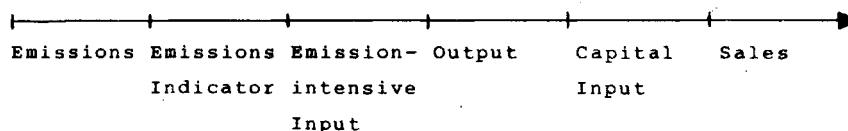


Figure 3

Assume that the quantities of emissions are not known and that we have to use proxies for emissions. Then we will not obtain the desired reactions. Let an emissions indicator such as SO_2 be considered representative of all air pollutants such as CO , NO_2 , and particulates. Then, by taxing the indicator, we stimulate abatement of SO_2 but not of the other pollutants. It is quite possible that in the process of abating SO_2 , other emissions will be increased. A similar indicator problem arises in water quality management if emissions are calculated in units equivalent to the wastes per inhabitant. In all these cases, the indicator should be constantly revised.

If pollution-intensive inputs are taxed, we introduce an incentive to economize on these inputs; however, this target may be reached with more emissions. In this context, the problem of the second-best solution arises. Assume that we want to differentiate the tax according to a reasonable criterion such as levying a high tax rate on emissions in winter than in summer.¹ If the tax base is the SO_2 content of heating

1) OECD, Instruments for Controlling Sulfur Dioxide Emissions from Fuel Combustion in Stationary Sources: A Case Study of Norwegian Measures, prepared by F.F. Forsund and S. Strom (Paris, 1973), p. 23.

oil, firms will not pollute less in winter but will buy more oil in summer and store it. Or assume that you want to use a higher tax in a metropolitan center than in the countryside. Then we will have interregional trade, and in order to maintain the tax differential, we will have to create an artificial monopoly for the oil supplier in town.²

If the tax is based on pollution-intensive outputs rather than emissions, we obtain a change in relative price and in demand. There is no response originating in the abatement and production activities. Tax bases such as capital input or sales will distort reactions even further.

(3) Measuring Emissions. It is an important question of environmental policy whether emissions can be measured within reasonable cost parameters. Note that this question also arises for the regulatory approach because, with permits, quantities of emissions are specified. Examples of measuring experience for water management can be found in Kühner (1979). Another survey of measuring technologies is given by Anderson (1977). In West Germany, the cost of measuring CO, SO₂, NO, HC, and particulates amounts to 40,000 German marks (\$20,000) per stack and per year.³ Self-reporting is the usual practice in monitoring emissions in the case of permits. Self-reporting, backed up by occasional checks and by measurement of the ambient environmental quality, seems to be a practical approach to the measurement problem.

(4) Interaction of Pollutants. When pollutants are diffused or when interactions such as synergisms occur, the link between emissions and quality variables seems to be destroyed. This problem, however, relates not only to emission taxes but also to regulation. We must require that the political process which establishes the ambient quality target also

²) Ibid., p. 24.

³) Information from West German industry.

determine the total quantity of tolerable emissions.

The point is that the quality targets are given as a result of the political process and that appropriate taxes must be found so that these targets will be reached. In setting these taxes, one must consider that an emission tax for pollutant A may lead to more pollutants of another type B. For instance, the tax for emission A may induce a new production technology with more emissions of type B. Or an emission tax may reduce emissions into the environmental medium α , but increase emissions into medium β . Therefore, a correct vector for emission taxes has to be found so that the appropriate relative prices for different types of emissions are set.

(5) Emission Tax as a Political Price. Who will set the emission tax? One procedure is for the legislature to specify a nationally uniform tax rate. This approach has been followed in West Germany's effluent charge for water wastes. This law defines a unit of emission based on an emission indicator. Prior to 1986, 12 German marks will be charged per unit of emission; in 1986 the rate will increase to 40 German marks per unit. The law was passed in 1978 with the established tax rates being valid until 1986. Allowing for the time required to prepare and enact such laws, prices have to be fixed which will apply for a period of ten years or more.

Another procedure would be for the legislature to define the quality targets for different environmental media with respect to the most important pollutants and to transfer the right to determine emission taxes to an independent government agency. The agency would be limited by the quality targets; its role would be to set prices and adjust them in such a way that the targets would be reached.

Such an institutional setting would be consistent with nationally uniform environmental policy instruments; it could also be applied to a regionalization of environmental policy.

5. Transferable Discharge Permits

In the case of transferable discharge permits, the total quantity of tolerable emissions for an environmental medium is limited in a political process. Then these emission rights are sold to those wanting to use the environment as a waste receptor. The limited quantity of emission rights is allocated through an artificial market where polluters represent demand and the government determines supply.

Discharge rights must be transferable. If a firm learns that it can abate emissions at lower costs, it must be able to sell its discharge rights to another polluter. Or if a firm wants to locate in a different area, it must be able to acquire pollution rights by inducing abatement in an existing firm. The transferability of discharge permits brings about flexibility in the allocation of the limited quantity of tolerable emissions.

This approach is beneficial because it combines the advantages of the regulatory approach with the advantages of emission taxes. By specifying the total quantity of tolerable emissions, environmental quality is clearly determined; there is no uncertainty with respect to the total quantity of emissions. In addition, a price is charged for using the environment as a waste receptor. Another advantage compared to emission taxes is that the government does not have to worry about the correct price relationship among different types of pollutants. The government only has to set the quality targets for different environmental systems. Once these quality targets are specified, the market will find the

correct relative prices. Substitution will take place until a set of "equilibrium prices" for pollution rights is found such that demand equals supply of pollution rights.

Pollution rights may be easily used in the case of regionalized environmental policy. Assume that environmental policy sets different quality targets for regional media, for instance, in order to protect a specific area of natural beauty. Then fewer pollution rights would be supplied for this area. The price for a pollution right would be higher; consequently, either more abatement would take place, or fewer pollution-intensive sectors would locate in that region.

The following problems are connected with pollution rights (American Petroleum Institute 1980; Tietenberg 1980).

(1) Definition of Rights. Discharge permits must be defined in terms of emissions. The target variable, however, is the ambient quality of an environmental medium. The question therefore arises whether the discharge right should take into account ambient quality at the location of potential receptors. This would be the case with an "Ambient Discharge System" where each source would have to purchase receptor-specific permits. The diffusion process would have to be explicitly incorporated into the system by diffusion coefficients or other modeling approaches. This requirement, though solving the problem of interregional diffusion, is rather impractical. Consequently, as in regulation and emission taxes, the total quantity of tolerable emissions has to be specified in a political process.

The discharge right will normally be linked to a facility or a group of facilities at a location. Another proposal, emission density zoning, relates the right to the land or the landowner. After the quality target for a region has been transformed into a tolerable quantity of emissions,

these are partitioned into quantities for zones. Then emission limitations are defined per unit of land, for instance in pounds per acre per year. The discharge right is transferable within each zone.⁴

(2) Delineation of Regions. Whereas emission taxes may be used nationwide, discharge permits presuppose regional delineation of environmental media since the total quantity of rights must be defined for a specific area. Pollution rights are easier to implement for a river system than for an air system. Interregional diffusion is an important issue in this context. If we have two regions, each with different environmental scarcity, it may be profitable to locate firms in those places of the less polluted area that are very close to the polluted region (economics of agglomeration). Thus, pollution rights may induce a spatial structure that is not desired. It may be necessary to introduce zoning in this case. Zoning may also be required if we have concentrations of pollution within an environmental region ("hot spot"). However, zoning implies that pollution rights may have to be differentiated according to zones within an environmental region. This could restrict transferability and thus would take away some of the advantages of this proposal.

(3) Complementarity in Demand. A given facility requires a set of pollution rights where pollutants normally are in a constant relation to one another. If such technical conditions are given, the transferability of pollution rights may be reduced. It is interesting to note, however, that some substitution already takes place within a firm if a firm has more than one facility.

4) In emission density zoning, the "bubble" may be too small. It may also be difficult to integrate the approach into the existing practice of issuing permits.

(4) Auctioneering the Discharge Permits. One procedure for allocating pollution rights is to auction them. For instance, all pollution rights would be sold each year on a specific date in public bidding. An argument against this procedure is that firms are confronted with the risk of not receiving a discharge permit, an event which could endanger their existence. From an allocation point of view, the auction merely serves to sell and buy a factor of production. Although firms may get used to this procedure, we have to recognize that a firm usually has some certainty on the availability of factors of production such as capital, land, and labor. If the market process withdraws factors of production from a firm, it normally does so over a period of time. However, in the case of an auction for pollution rights, we may have abrupt changes. This discontinuity in the availability of a factor of production makes auctions an impractical instrument for environmental policy.

(5) Discharge Permits According to Initial Pollution. The problem of uncertainty may be prevented by giving pollution rights to the existing polluters. In this case, one could ask them to reduce pollution by a given percentage over a number of years and grant them the right to emit the residual amount. Newcomers to the region could buy a pollution right from existing firms. Although the incentive to reduce pollution would exist once this policy were implemented, there would be undesired announcement effects between the time that the measure were proposed and made effective. That is, firms would have an incentive to produce many pollutants upon learning of this policy consideration in order to receive a larger quantity of pollution rights later. Since it would take a long time to enact and possibly clarify (through the courts) such an institutional arrangement, the announcement effect may be important.

(6) Transferability. The announcement effect can be avoided if the idea of pollution rights is combined with the regulatory approach. In the first phase, emission norms for facilities may be specified which implicitly grant a right to pollute up to a specified volume. Then these implicitly defined rights may be made transferable. In the long run, a price for pollution rights would be established, and emission rights would be allocated via the price mechanism.

(7) Duration of Rights. Pollution rights may be defined on a temporary basis or without a time limit. If they are defined temporarily, it may be for a year or according to the life span of the facility. The allocation effects and the practicability of pollution rights may vary with these temporal definitions.

(8) Integration into Existing Laws. All environmental policy instruments have to be integrated into the existing legal framework. Very often economists make proposals that are ideal from their point of view but which do not take into consideration existing legal restrictions. In many countries, permits are used as an instrument of environmental policy. These permits specify the maximum amount of emissions allowed by a specific facility or firm per year. Very often they are granted on a temporary basis which is related to the life span of a facility. Furthermore, the permits are frequently granted at virtually a zero price. If these permits were combined with a price tag, a feasible allocation mechanism could be introduced.

(9) Monopolies. Assume that a sector of the economy happens to be located in an environmentally sensitive region. Also assume that this sector is monopolistic or has a dominant oligopolist. Then the large firm may use pollution rights to restrict the output of its competitors

if the competitors cannot substitute emissions easily in their production. The large firm has an incentive to buy more pollution rights than it needs for production since pollution rights will not be available to its competitors. Consequently, in this case, pollution rights may strengthen the position of a dominant firm.

A similar argument is valid with respect to the labor market in a region. The large firm is induced to buy pollution rights since this may reduce the output of other firms and, concomitantly, reduce the competing demand for labor. Thus, the large firm can increase its labor supply in a region by buying pollution rights. This argument, however, is only valid if the small firms are characterized by low elasticities of substitution with respect to emissions as a factor of production (Siebert 1981).

6. Institutional Arrangements for Cost-Sharing

Besides regulation, emission taxes, transferable discharge rights, a quality target can be transformed into individual behavior through a mechanism which shares the costs of reaching the targets and simultaneously develops an incentive system that guarantees efficiency. The water associations of the Ruhr area in Germany represent such an approach (Kneese and Bower 1968; Klevorick and Kramer 1973).

(1) Transforming Quality Targets. The water associations of the Ruhr area (Ruhr, Emscher, Lippe, Wupper, Niers, Erft, Left Lower Rhine, and Ruhr Water Dam Association) represent organizations in which membership is mandatory for every polluter. The general assembly of the association determines the water quality to be attained. When the required environmental quality level is known, the association can determine the

amount of capital equipment, investment, and operating costs that it must spend to attain these standards. Thus, the total costs of abatement are specified. The problem then consists of allocating these costs to the individual polluter. Costs are attributed in such a way that the costs to the individual polluter are related to its quantity (and quality) of pollution. This creates an incentive to abate pollutants.

(2) Attributing Costs. For instance, the "Emschergenossenschaft" has developed an index that defines the quantity of unpolluted water necessary to dilute polluted water to the level where damage to a test fish is prevented. By this method, a quality target can be fixed; at the same time, different types of pollutants can be expressed in a homogeneous dimension. The formula is (Kneese and Bower 1968, p. 250; Johnson and Brown 1976, p. 123):

$$V = \frac{S}{S^Z} + \frac{1}{Z} \frac{B}{B^Z} + \frac{K - 3D}{2K^Z} - F$$

where V is the dilution factor, S the materials subject to sedimentation in centimeters per liter, S^Z the permitted S , B the biochemical oxygen demand BOD_5 in milligrams per liter after sedimentation, B^Z the permitted BOD_5 , K the potassium permanganate oxygen ($KMNO_4$) used, K^Z the permitted K in milligrams per liter, and F a coefficient of fish toxicity. Let V_i be the dilution factor for polluter i , and let E_i be the quantity of wastewater. Then the cost share π_i is given by

$$\pi_i = \frac{V_i E_i}{\sum_1^n V_i E_i} \quad \text{with} \quad \sum_1^n \pi_i = 1$$

If total costs are denoted by C , then the cost share for the individual

producer is given by $C_i = \pi_i C$. The polluter can influence C_i by reducing π_i , that is, by reducing V_i and E_i . Thus, there is an incentive to reduce pollution.

The Ruhr Association uses population equivalents (PEs) as a measure of pollution (Kneese and Bower 1972, p. 60). Dividing the total costs of abatement by the sum of all population equivalents PE, the price p per population equivalent is obtained: $p = C / \sum PE$. The cost share for the individual polluter is given by $C_i = p PE_i$.

For industrial polluters, the quantity of population equivalents is determined as follows. First, a coefficient of 0.5 PE is used per employee. Second, wastewater is evaluated with 0.01 PE/m³. Third, special coefficients are used for specific sectors. For instance, 0.85 PE/ton of paper is the coefficient used in paper sulfide production; other examples of coefficients include 31 PE/ton of sulfuric acid used in metal finishing or 0.35 PE/ton of raw cabbage used in the production of sauerkraut. The coefficients vary for the firms within an industry, depending on the production and abatement technology used. For instance, for metal finishing, the coefficient varies between 31 and 6 PE/ton of sulfuric acid used (Kühner 1979). Thus, an incentive is introduced to abate pollutants.

(3) Institutional Constraints. There are some interesting institutional features of the water associations. Voting rights vary with the volume of effluent charges paid and consequently with the volume of pollution produced; thus, the largest polluter has the greatest number of votes. In spite of this rule, analysis shows that the decisions of the associations seem to have been reasonable. Klevorick and Kramer (1973) have researched this problem and have shown that most

environmental concerns have been taken care of by the associations. One reason for this success is that institutional safeguards have been introduced. For instance, in the Niers Association, the downstream polluters receive 75 votes before the remaining 225 votes are distributed according to the paid effluent charges. In the Lippe Association, coal mines cannot have more than 40 percent of the votes.

(4) Cost Sharing in Air Quality Management. It is tempting to ask the question whether institutional mechanisms are conceivable for cost sharing in air quality management. Performance standards for a firm with multiple emission sources or a group of firms are a step in this direction. Applying the "bubble concept", controlled trading could be organized by a voluntary association of firms or even by an "offset exchange" where firms would offer and purchase offsets.

One could even conceive of an air quality authority being made up of the polluters of a region and being confronted with an ambient air standard set by the political process. Similarly as the water associations, the air quality association would have to find a mechanism by which the costs for achieving a quality target would be minimized for the region as a whole.

The analogy between a water association and an air quality association is not perfect since in water management, pollutants are abated after having entered an environmental medium. Thus, total costs of abatement are known and have to be portioned to the polluters. In air quality management, one would have to find another mechanism by which costs would be minimized since pollutants must be prevented before entering the medium. Also the following problems have to be solved: air regions of a nation have to be defined consistently. There is the

tendency of regional authorities to neglect interregional diffusion. Consequently, some procedure must be found to prevent a "high stack policy" (interregional diffusion norms). The three main sources of air pollution, stationary sources of households, industry and mobile sources of traffic are rather heterogeneous. How can they be incorporated into such an institutional setting? There will be a built-in tendency for such an organization to ask for subsidies. Finally, since the polluters have an influence in specifying the measurement technology and costs attributions, there may be a tendency to define parameters in such a way that entry barriers for newcomers are erected so that the regional labor market is reserved for existing firms and closed to newcomers.

7. Taxonomy of the Environmental Problem and Policy Instruments

In this paper we have discussed four approaches which transmit environmental quality targets into the pollution behavior of industrial polluters: regulation, emission taxes, transferable discharge permits and cost sharing. We should point out that the policy instruments used vary with the problem at hand. Our discussion mainly applies to the problem where pollutants arise as a joint output of production. If other problems prevail, different policy instruments from the ones discussed may be necessary (Siebert 1981). For instance, if pollutants are contained in products, such as DDT in agricultural goods, we may have to use product norms. A similar problem arises with respect to pharmacological products. If pollutants are introduced into the environment via new products, such as occurs in the chemical industry, emission taxes may not be effective or practical.

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