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# The Theory of Externalities and Efficiency in Environmental Management

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## Introduction

Today, the government has taken an increasingly active role in ensuring the quality of the environment. Legislation restricting automobile emissions has been passed, and standards for admissible levels of air and water pollution by manufacturers have been established. Stringent regulations for the disposal of toxic chemicals have also been imposed.

Government activity in this area has clearly had some beneficial effect. Still, problems remain: on some days a city is blanketed by smog in spite of stringent regulations on air pollution. Dangerous poisons from chemical dumps have threatened many communities. And the question of whether the government has been lax in enforcing the environmental laws has became a hot political issue. Many claim that still more stringent laws are thus required if we are to ensure the quality of the environment. Others claim that the costs of many of these attempts to control pollution exceed the benefits, and that the present system of government regulations is both unfair and inefficient.

Air and water pollution are examples of a much broader range of phenomena that we refer to as externalities. Whenever an individual or firm undertakes an action that has an effect on another individual or firm for which the latter does not pay or is not paid, we say there is an externality. The objective of this paper is to explain what we mean by externalities especially those externalities that are related to environmental problems, the limits of private market mechanisms to deal with externalities, and therefore, why government action may be required. Finally, we

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ask, given that government action to control externalities may be warranted, what is the best method of dealing with them?

## Externalities : A Classification

Externalities are costs or benefits of market transactions not reflected in prices. The presence of an externality implies that decisions about market exchanges are made on the basis of prices that do not accurately reflect either all the marginal social benefit or all the marginal social cost of traded items.

We can distinguish among several categories of externalities. Some externalities have a beneficial effect on others and are referred to as positive externalities. Others have a detrimental effect and are referred to as negative externalities.

Negative externalities are also called external costs. Negative externalities are costs to third parties, other than the buyers or the sellers of an item, not reflected in the market price. An example of a negative externality is the damage done by industrial pollution to persons and their property. The harmful effects of pollution are impairments to good health and reduction in the value of business and personal property. Another example of a negative externality is the dissatisfaction caused by the noise of low-flying aircraft experienced by residents who are located near an airport. Those bearing pollution damages are third parties to market exchanges between the buyers and the sellers of goods or services. Their interests are not considered by the buyers and the sellers of goods and services when an externality is present.

Positive externalities are benefits to third parties, other than the buyers or the sellers of a good or service, not reflected in prices. Buyers and sellers of goods whose sale results in positive externalities do not consider the fact that each unit produced provides benefits to others. For example, a positive externality is likely to exist for fire prevention, because purchase of smoke alarms and fire-proofing materials is likely to benefit those other than the buyers and sellers by reducing the risk of spread of fire. Buyers and sellers of these goods do not consider the fact that such protection decreases the probability of damage to the property of third parties.

Effects of market exchange on third parties are not externalities when these effects are included in prices. For example, if your hobby is photography, increase in the demand for photographic equipment by others could make you worse off by increasing the price of the equipment that you buy. These higher prices, however, merely reflect the fact that such goods have become scarcer, relative to the demands placed upon them. The higher price serves to transfer income from buyers to sellers and to increase the incentive to produce these goods. Some economists refer to these as pecuniary externalities; that is, the effects of increase (or decrease) in the price of a good on existing consumers as a result of changes in the demand or supply of a good. Pecuniary externalities merely result in changes in real income of buyers or sellers. Real externalities are unpriced costs or benefits. They are effects of market exchanges external to prices.

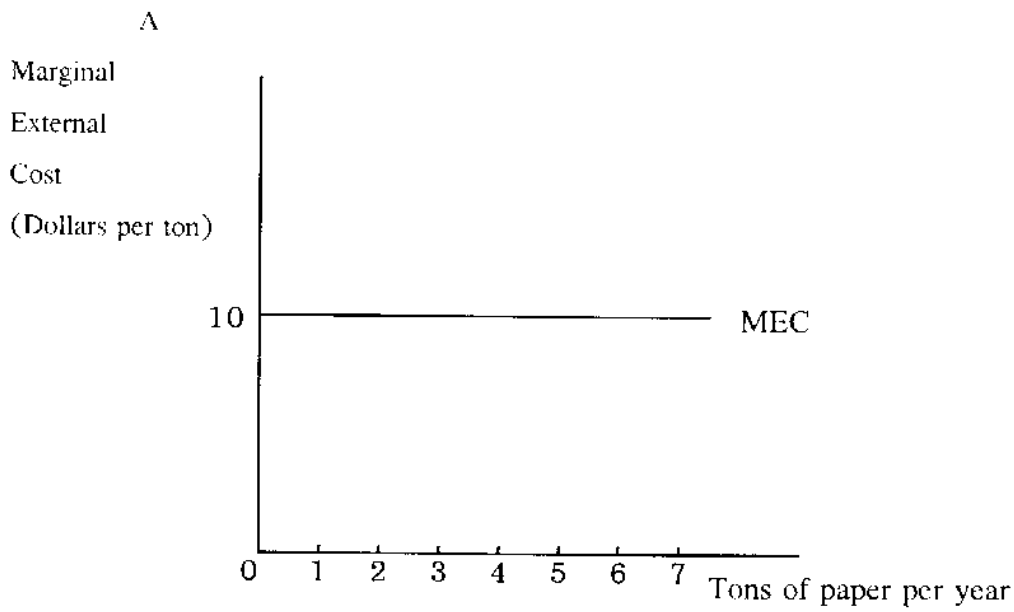
### Externalities and Efficiency

When an externality exists, the marginal benefit or cost on which buyers and sellers base their choices do not accurately reflect marginal social cost or benefit. Externalities prevent markets from achieving efficient output levels.

**Negative Externalities** When negative externalities are present, the price of a good or service does not reflect the full marginal social cost of resources allocated to its production. Suppose, for example, in the production of paper, each unit of output results in a cost to parties other than the buyers or the sellers of the product. This negative externality or external cost might come from the damage done by pollutants emitted into streams and rivers. The pollutants decrease the benefit obtained by other users of streams and rivers, or lakes. For example, industrial pollution from paper production could decrease the catch of commercial fishermen. It could also reduce the benefit that recreational users of lakes and streams can receive from swimming, boating and other activities. However, neither the buyers nor the sellers of the good consider these costs to third parties. The marginal external cost (MEC) is the extra cost to third parties resulting from production of another unit of a good or service. MEC is part of the marginal social cost of making a good available. However, it is not reflected in the price of the good.

In Figure 1A, the marginal external cost is assumed to be a fixed amount per unit of output. The graph of MEC in this case is a horizontal line, implying that the total external cost would increase at a constant rate of $10 per ton of paper. This is shown in Figure 1B. For example, if the total output per year in a certain plant were 40 tons of paper, the marginal external cost would be $10, but the total external cost (TEC) would be $400 dollars. When marginal external cost is a fixed amount per unit of output per year, total external cost of that output will increase at a constant rate per unit output. In the graph, MEC = $10 per ton of paper per year. TEC therefore increases by $10 for each ton of paper produced per year.

**Figure 1** Marginal External Cost and Total External Cost : The Case of Constant MEC



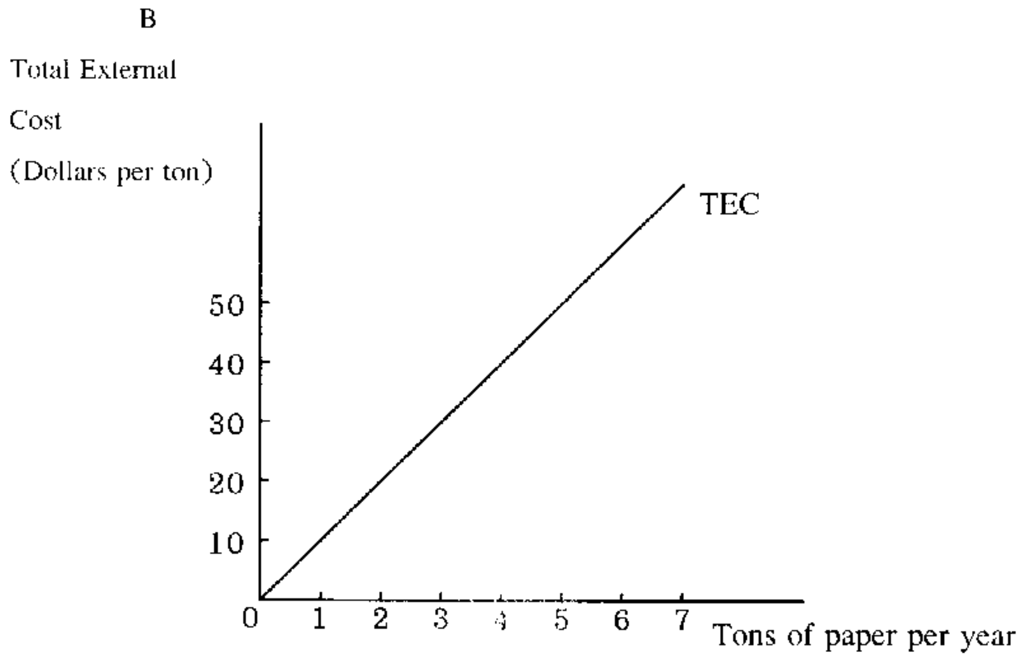
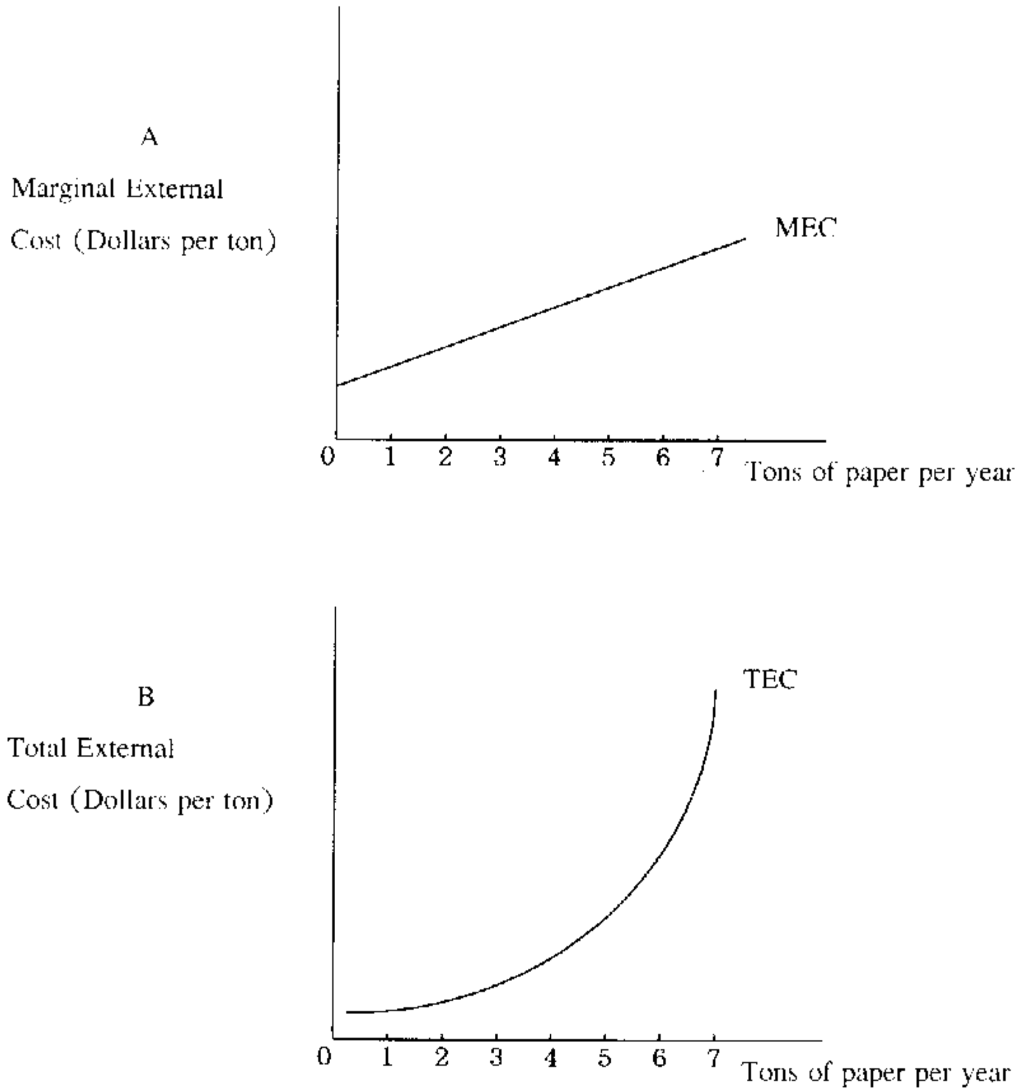



Figure 2 shows the case for which the marginal external cost increases with annual output. Increasing marginal external damage to third parties implies that marginal damage per unit output is greater at higher levels of output per year than at lower levels. This is shown in Figure 2A. The MEC curve is upward sloping in this case. It also implies that the total external damage increases at an increasing rate. The slope of the TEC curve shown in Figure 2B therefore increases as annual output increases. For example, if this were the case, the total external cost imposed on third parties would more than double whenever annual output were to double. This would imply that pollution damage is a more serious social problem at higher levels of paper output than at lower levels.

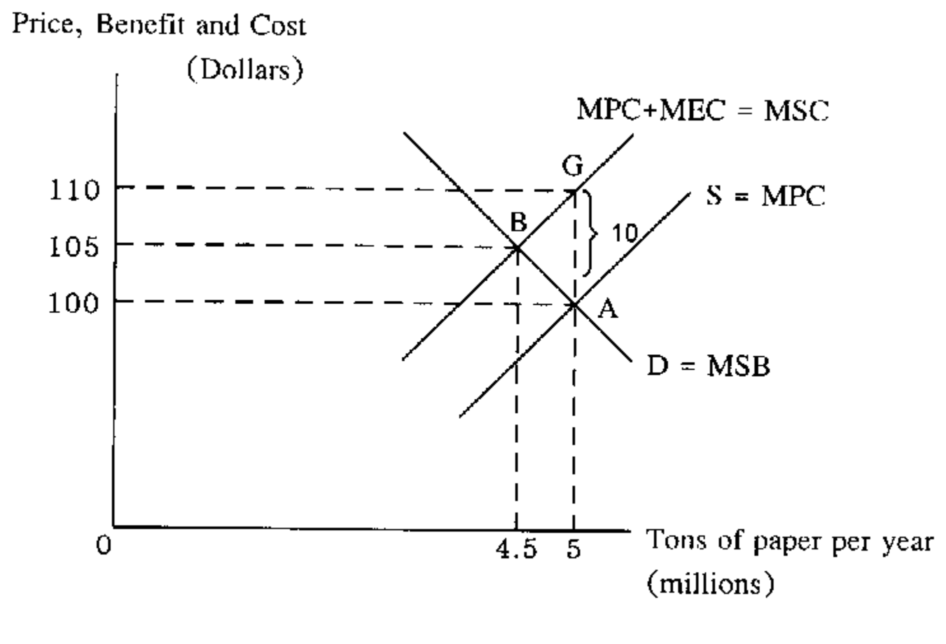
**Figure 2** Increasing Marginal External Cost




**Consequences of Negative Externality.** Whenever there are externalities, resource allocations will not be efficient. In the case of a negative externality, too much output will be produced and sold in a market relative to the efficient amount.

Assume that the paper industry operates under a competitive market, implying that market power is diffused and that no one seller or buyer can influence price. The market equilibrium price and quantity in the competitive market corresponds to point A in Figure 3. The current price of paper is $100 per ton, and the industry produces 5 million tons per year at that price. The demand curve D is based on the marginal benefit that buyers receive from each ton of paper. This is also assumed to be the marginal social benefit of paper. The supply curve is based on the marginal cost actually incurred to produce additional units, such as additional wages and material costs, as firms in the industry produce more. But the marginal cost curve, as seen by producers, does not include all the cost incurred in producing extra units of paper. Suppose that a marginal external cost of $10 is associated with each ton of paper produced. For simplicity, assume that this damage is always $10 per ton of paper produced. Variation of marginal external cost with output is therefore like the pattern shown is Figure 1A.

**Figure 3** Market Equilibrium, Negative Externality and Efficiency



The marginal external cost of $10 per ton is not considered in the producers' choice of output. But external cost is as much a part of the opportunity cost of making paper available as are wages and material cost. If the stream had no other use, then dumping wastes into it would cause no problem inasmuch as the usefulness of the stream to others would not be impaired. The negative externality, in this case, stems from the fact that dumping industrial wastes in the stream decreases its usefulness to other users.

The marginal cost that producers base their decisions on is the marginal private cost of producing paper. To obtain the marginal social cost, the marginal external cost of output (MEC) must be added to the marginal private cost (MPC)

**MPC + MEC = MSC**

When a negative externality exists, the marginal private cost of a good falls short of its marginal social cost of output. To obtain the marginal social cost of paper in Figure 3, MEC must be added to MPC for each possible output. Because MEC = $10 at all output levels, this will shift the MPC curve upward by $10. The distance between the MPC curve and MSC curve in Figure 3 is therefore $10, independent of annual output. If, instead MEC were to increase with annual output, the distance between the MPC curve and the MSC curve would increase as annual output.

The competitive market equilibrium corresponds to point A, at which MPC = MSB. This market equilibrium output of 5 million tons per year is inefficient because MSC > MSB at that output. Efficiency requires that the full marginal social cost of a good be considered in the productive decision. Referring to Figure 3, this means that the efficient equilibrium will be at point B rather than at point A. At point B, the following condition is satisfied:

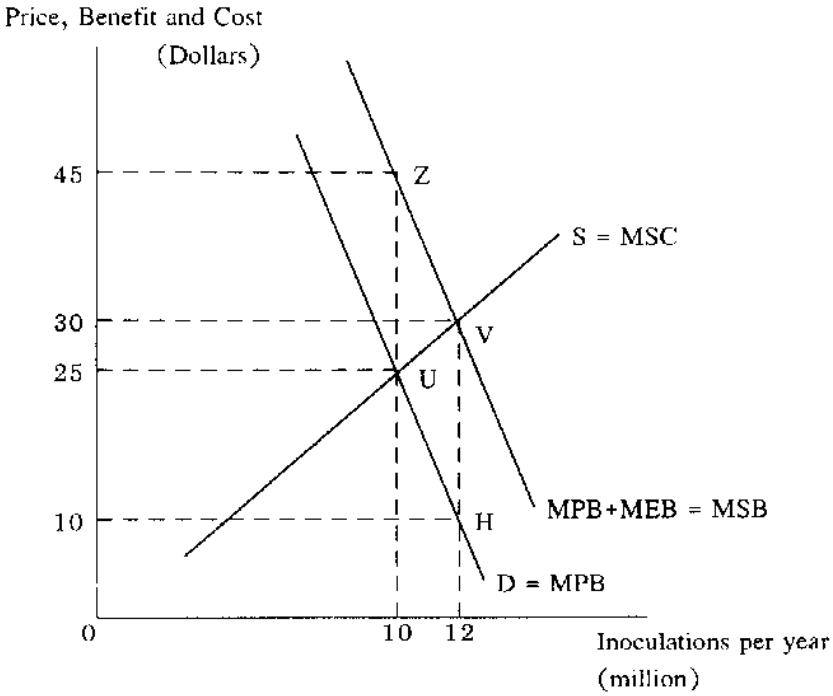
**MSC = MPC + MEC = MSB**

The marginal social cost of the good including the marginal external cost, must be equal to its marginal social benefit to attain efficiency.

The market equilibrium output of 5 million tons per year is inefficient because its marginal social cost equals $110 per ton, at point G, while its marginal social benefit is only $100 per ton at point A. Because the marginal social cost of paper production exceeds its marginal social benefit, too much is being produced and sold in the market relative to the efficient amount.

A gain in net social benefit equal to the triangular area BGA is possible by reducing annual output from 5 million tons to 4.5 million tons. The price of paper would have to increase to $105 per ton to induce consumers to cut back consumption from 5 million tons to 4.5 million tons per year. Therefore, when a negative externality exists, too much output is produced and sold in a market relative to the efficient amount.

**Figure 4** Market Equilibrium, Positive Externality and Efficiency




**Positive Externalities.** When a positive externality is present prices do not fully equal the marginal social benefit of a good or service. For example, suppose inoculation against a disease results in a positive externality. Those who are vaccinated benefit themselves, of course, by reducing the probability that they will contract a contagious disease. But they also provide benefits to those who do not receive inoculations by reducing the number of persons who will become hosts for the disease. This, in turn, reduces the probability of outbreak of the disease for the entire population, including those who are not vaccinated. Eventually, if the disease is eradicated in this way, the entire population will benefit. The external benefit of inoculations is the reduction in the probability that those other than the persons purchasing vaccinations will contract the disease.

It is easy to show the sale of inoculation services in a competitive market will result in less that the efficient annual number if there is a positive externality. This is illustrated in Figure 4. The market equilibrium occurs at point U. At that point, 10 million inoculations are sold per year at a price of $25 per inoculation. Suppose that the marginal external benefit, that is, the benefit of additional output accruing to parties other than buyers or sellers of the good, is $20 for each inoculation. The marginal benefit that consumers base their decisions on is the marginal private benefit. In Figure 4, market equilibrium corresponds to the equality of each person's marginal private benefit, MPB, of an inoculation with the marginal social cost of providing it. At the market equilibrium, point U, the actual marginal social benefit of an inoculation exceeds the $25 price each consumer uses in deciding whether or not to be inoculated. The actual marginal social benefit of an inoculation, when 10 million are purchased per year, is $45. This equals the sum of the marginal private benefit received by consumers and the marginal external benefit (MEB) to others of $20.

**MPB + MEB = MSB**

In general, when a positive externality exists, marginal private benefit will fall short of marginal social benefit at each level of annual output. Less than the efficient output results from market interaction because the marginal social benefit at the market equilibrium exceeds the marginal social cost. The efficient output of inoculations corresponds to point V in Figure 4. At that point, the marginal social benefit of inoculations equals the marginal social cost incurred to produce them. The marginal conditions for efficiency are met at that point because

$$\mathbf{MPB + MEB = MSB = MSC}$$

At V, the marginal social cost of an inoculation would be $30. To get to that point, the price of inoculations to consumers would have to decrease to $10, which corresponds to point H on the market demand curve for inoculations.[1] At that point, the quantity of inoculations demanded by consumers per year would be the efficient number of 12 million. The marginal social benefit of inoculations, MPB + MEB, equals their marginal social cost of production at the efficient output. The increase in net benefits that would be possible by movement to point V is represented by the triangular area UZV in Figure 4.

## Private Solutions to Externalities

One way that the private sector can deal with externalities without the aid of direct government intervention is for the parties involved to get together and set an agreement to reduce externalities.

For example, whenever there are externalities, the parties involved can get together and make some set of arrangements by which the externality can be reduced.[2] This can be shown in the case of smoking. When there are smokers and nonsmokers in the same room, if the loss to the nonsmokers due to the pollution of fresh air exceeds the gains to the smokers, the nonsmokers might get together and "bribe" (or, as economists like to say, "compensate") the smokers not to smoke. If the smokers are in a nonsmoking compartment of a train, and the restriction on smoking (which can be viewed as an externality imposed on the smokers by the nonsmokers) takes away more from their welfare than the nonsmokers gain, the

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[1] The efficient annual output corresponds to point V, at which 12 million inoculations would be consumed per year. The price to consumers would have to fall from $25 to $10 per inoculation to move to that point.

[2] This idea is referred to as the Coase theorem. See R.H. Coase "The Problem of Social Cost," Journal of Law and Economics, 3 (1960) : 1-44.

smokers can get together and compensate the nonsmokers in order to allow themselves to smoke.

Of course, the determination of who compensates whom makes a great deal of difference to the distributive implications of the externality. Smokers are clearly better of in the regime in which smoking is allowed unless the smokers are paid not to smoke, compared to the regime in which smoking is banned unless they compensate nonsmokers.

Another private mechanism for the control of externality is social sanctions and the inculcation of social values. The golden rule can be thought of as an attempt to deal with externalities: "Do unto others as you would have them do unto you." And also "Do not do unto others as you would not have them do unto you." This golden rule can be roughly translated into our language as "Do cause positive externalities" and "Do not cause negative externalities." As children, we are all made aware of the fact that some of our actions, such as talking loudly at the dinner table, have effects on others for which we do not have to pay at least directly in the form of monetary compensation. There are however other sanctions that may be applied. Parents try to induce their children to behave in "socially acceptable ways" (including not generating negative externalities and conferring positive externalities). Although this socialization process does succeed in avoiding many negative externalities at the level of family, it is less successful in dealing with many of the kinds of externalities that arise in modern society: even the threat of a $50 fine for littering may be insufficient to induce some individuals to clean up after themselves in a public park. It is not possible to rely solely on social mechanisms for limiting externalities.

### Failure of Private Solutions

There are basically three reasons why the private sector has failed to take care of so many externalities. The first has to do with the **public goods problem.**[3] Many externalities entail the provision of a public good, such as clean air or clean

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[3] For the discussion of public goods see David N. Hyman (1987 : Ch.4)

water. And it may be very costly to exclude anyone from enjoying the benefits of these goods. Where nonsmokers get together to compensate smokers for not smoking, it pays any individual nonsmoker to claim that he is almost indifferent to letting others smoke. He will attempt to be a free-rider on the efforts of other nonsmokers to induce the smokers not to smoke.

The problems of arriving voluntarily at an efficient solution are exacerbated by the presence of imperfect information. The smokers will try to persuade the nonsmokers that they require a lot of compensation to induce them not to smoke. In any such bargaining situation, one party may risk the possibility of not arriving at a mutually advantageous agreement, in order to get more out of those bargains that are made.

The second reason why the private markets may not be able to deal with the externalities concerns **transaction cost**. The cost of getting individuals together to internalize these externalities voluntarily is significant. The provision of those organizational services itself is a public good. Some individuals involved may simply attempt to be free riders.

The third reason that currently markets may not deal adequately with externalities is that the set of **property rights** that have been established often give rise to inefficiencies. Many of the existing property rights have been established not by legislative laws but through what is called the common law. When one individual imposed an externality on another the injured individual brought suit against the first individual. Sometimes these suits were successful, sometimes they were not. Over the years, a set of implicit property rights and rules has been established that defines in a fairly clear way those situations in which an individual suffering an externality can bring suit with some hope of success, and where he cannot. For instance, if a nonsmoker develops a cough as a result of some smokers smoking in the same compartment of a train in which he sits, he cannot sue the smokers with much hope of success. If an individual throws garbage on his neighbor's lawn, the neighbor has a reasonable chance of success in a suit. If an individual burns leaves on the corner of the lot so that the wind blows smoke into his neighbor's house, causing smoke damage to the house, the neighbor has some chance of a successful suit.

Therefore, it is important that there are well-defined assignments of property rights. In the examples given above with well-defined property rights, the party that would have suffered from the externality could have bribed the other party if it was worth it to him, assuming that one of the other problems, such as transaction costs, to which we have already referred, did not occur.

From this failure of the private sector to take care of externality problems, there is a need for government intervention when we have an externality problem. The advantages of using the government as a vehicle through which externalities are dealt with are that it saves on transaction cost (an additional organization to deal with each type of externality does not have to be created) and it avoids the free rider problems typically associated with public goods.

## Public Remedies for Externalities

There are four broad categories of public-sector remedies for externalities:

A. The government can impose corrective **taxes or subsidies** as a means to internalize externalities.

B. The government can impose **regulations** (or direct control) to restrict the negative externalities imposed by one group or another.

C. The government can **subsidize** expenditures to reduce negative externalities.

D. The government can **assign property rights** to discourage negative externalities.

Before comparing the merits of these alternative remedies we should first dispel the common fallacy, which asserts that we should never allow an individual or firm to impose a negative externality on others. For example, it is sometimes asserted that a firm should never be allowed to pollute the air and water. This absolutist position in reality makes no sense. There is no way that we can eliminate all pollution. There are also costs associated with pollution control. We need to weigh the costs and benefits of pollution control just as we need to weigh the costs and benefits of other government activity.

## Corrective Taxes: A Method of Internalizing Negative Externalities.

The problem with the market is not simply that it creates negative externalities (e.g. pollution). The problem instead is that firms fail to take into account the social cost associated with externalities they impose, and as a result, there is likely to be an excessively high level of pollution. Since the government cannot eliminate pollution entirely, its task is to help the private section achieve a socially efficient level of pollution, to make individuals and firms act in such a way that they are induced to take into account the effects of their actions on others. This is usually called an **internalization of externalities** (Baumol, 1972: 62).

Internalization of an externality occurs when the marginal private benefits or costs of goods and services are adjusted so that the users consider the actual marginal social benefit or cost of their decisions. In effect, this means that the marginal value of the externality is priced. In the case of a negative externality, the marginal external cost is added to marginal private cost for internalization. For a positive externality, the marginal external benefit is added to marginal private benefit to internalize the externality. **Internalizing an externality** results in changes in prices to reflect full marginal social cost or benefit of a good.

However, it should be noted that internalization of externalities requires identification of the individuals involved and measurement of the monetary value of the marginal external benefit or cost. The data required for such identification and measurement are often difficult to obtain. Policy toward externality is sometimes controversial because of strong differences of opinion concerning the actual value of the external cost or external benefit. For example, how can all the sources of air pollution be identified? How is the damage done to property and personal wellbeing evaluated? This is a formidable scientific, engineering, and economic detective problem. Since there is strong disagreement among scientists as to the costs of pollution, the necessary information required for internalizing the externality can be elusive (Seneca and Taussing, 1984: 41).

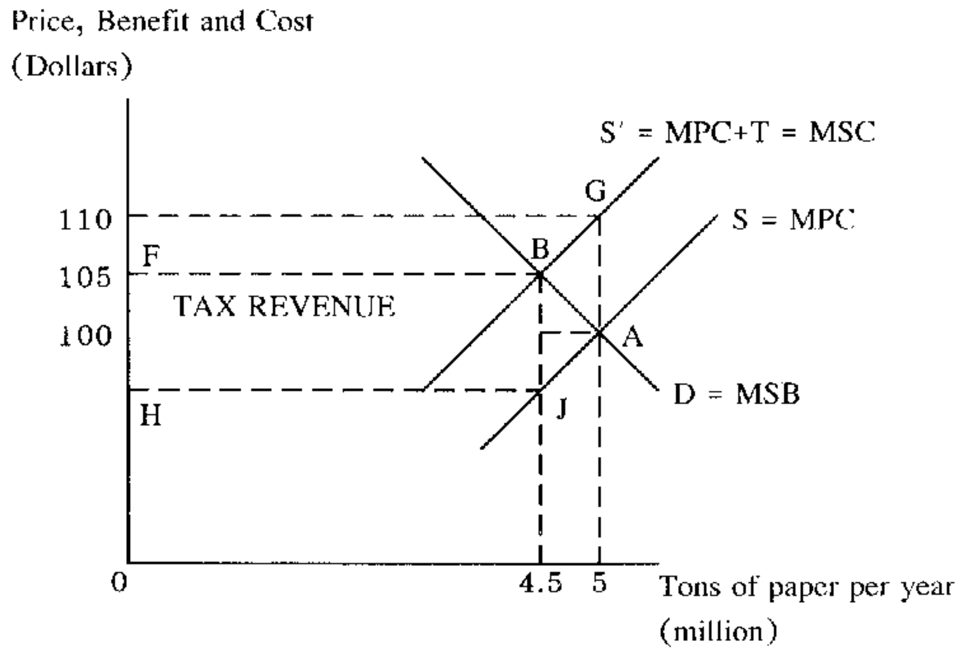
In the case of a negative externality, **corrective taxes** can be used as a method of internalizing negative externalities. Corrective taxes are designed to adjust the marginal private cost of a good or service in such a way as to internalize the externality. A corrective tax can be imposed so that the marginal private cost of producing a good whose sale results in a negative externality is raised to equal the marginal social cost. The tax must equal the marginal external cost per unit of output to achieve this objective.

Suppose a corrective tax was levied on producers of paper to internalize the negative externality resulting from their output. Figure 5 shows the impact of such a tax. The marginal external cost per unit of output is assumed to be MEC = $10. The corrective tax is therefore:

$$T = MEC$$

In this case, the tax would be set at $10 per ton of paper, the marginal external cost of paper per year. This tax is levied on each unit produced and will be treated by producers as an increase in the marginal private cost of production. Consequently the supply curve shifts up from S to S', where S' reflects the full marginal social cost of producing paper. The increase in cost caused by the tax changes the point corresponding to the market equilibrium from A to B. The market price of paper increases to $105 per ton and the equilibrium quantity of paper consumed declines from 5 million tons to 4.5 million tons per year. This is exactly equal to the efficient annual output.

**Figure 5:** A Corrective Tax




The tax of $10 per ton will collect $45 million of revenue per year at the equilibrium output of 4.5 million tons. This is represented by the area FBJH in Figure 5. After the tax is imposed, the annual value of pollution costs to alternative users of the stream declines. Initially, these costs were $50 million per year, equal to the $10 per ton cost of pollution multiplied by the annual output of 5 million tons. Because the annual output declines to 4.5 million tons, the annual value of pollution costs to alternative users of the stream declines to $45 million.

Note that the corrective tax does not reduce the pollutants in the stream to zero. It merely raises the cost of using the stream to reflect the marginal damage done to alternative users of the stream. Paper producers that use the stream now compare this extra cost ($10 per unit output) with other alternatives of waste disposal and then decide how much of the stream's service to use at that cost. It is unlikely, though possible, that all producers will stop dumping in the stream.

But given the costs of alternatives, including the recycling of any wastes, purifying the wastes before disposal, reducing output, or going out of business, there will most certainly be a reduction in waste emitted. The actual amount of that reduction will depend on the availability and cost of alternative disposal methods relative to the corrective tax and on the impact of the tax on the profitability of producing paper. The tax is designed to force the producers to compare the marginal benefit of dumping wastes in the stream with the marginal external cost of the emission of untreated water. It does so by adding the marginal external cost to producers marginal private cost.

The tax revenue collected can be used for a variety of purposes. If the competing users of the stream are easily identifiable, the tax revenue collected ($45 million) could be used to compensate other users of the stream for $45 million in damages that remain after the externality is internalized by the corrective tax. Alternatively, the revenue collected could go toward a reduction in other taxes or an increment in government services.

**In summary, the corrective tax causes the following results:**

1. An increase in the price of paper and a reduction in the quantity demanded to the efficient level.
2. A consequent transfer of income away from paper producers and consumers in favor of individuals who use the recreational services of streams and of others who may have their taxes reduced or enjoy the benefit of increased government services if the revenue collected is used for those purposes.
3. A reduction in, but not the elimination of, the use of the stream for disposal purposes and a consequent reduction in damage to alternative users of the stream.

## Corrective Taxes in Practice

Corrective taxes can actually be effective in reducing the external costs associated with pollution. For example, the government authority in the Ruhr River basin in Germany has imposed charges on the industrial wastes dumped in the river by industrial firms. These charges are called **"effluent fees,"** which vary with the kinds and amounts of wastes disposed of in the river. Assuming that the effluent fees vary with the marginal external damage done by the chemicals to other users of the river, the fees are equivalent to corrective taxes on the polluting firms. The fees, under these circumstances, would act to internalize the negative externality associated with pollution, thereby reducing the amount of damage from the pollution. The effluent fees serve to increase the marginal private cost of production up to the level of the marginal social cost.

Evidence indicates that these charges have been quite effective in reducing the level of industrial pollutants in the Ruhr River over the period they have been in effect. The level of pollution in that area is now lower than that in similar areas where no effluent fees are charged for the right to pollute (Baumol and Oates, 1978 : 112) In some areas of the United States, similar charges are levied on firms that dump industrial wastes in municipal water treatment facilities.

Corrective taxes are often feasible when pollution stems from stationary sources. For example, it would be relatively easy and inexpensive to meter the pollutants emitted from power-generating plants and large factories. Effluent fees could be charged to their firms according to the marginal external cost of their emissions.

Currently effluent charges are also used to control pollution in France, Italy, the Netherlands, and Japan. However, the charges are more commonly used to control water pollution (Anderson, 1977). In both France and the Netherlands the charges are designed to raise revenue for the purpose of funding activities specifically designed to improve water quality (Bressers, 1988).

The Italian effluent charge system is mainly designed to encourage polluters to achieve provisional effluent standards as soon as possible. The charge is nine times higher for firms that do not meet the prescribed standards than for firms that do meet them. This charge system is designed only to facilitate the transition to the prescribed standards so it is scheduled to expire once full compliance has been achieved (Vos, 1989).

Air-pollution emission charges have been implemented by France and Japan. The French air-pollution charge was designed to encourage the early adoption of pollution-control equipment with the revenues returned to those paying the charges as a subsidy for installing the equipment. In Japan the emission charge is designed to raise revenue to compensate victims of air pollution. The charge rate is determined primarily by the cost of the compensation program in the previous year and the amount of remaining emissions over which this cost can be applied (Vos, 1989).

Charges have also been used in Sweden to increase the rate at which consumers would purchase cars equipped with a catalytic converter. Cars not equipped with a catalytic converter were taxed, while new cars equipped with a catalytic converter were subsidized. This Swedish tax on heavily polluting vehicles and subsidy for new low-polluting vehicles was very successful in introducing low-polluting vehicles into the population at a much faster than normal rate. However, owing to the objective of altering vehicle choices, the policy is not revenue-neutral, the subsidy payments greatly exceed the tax revenue (Vos, 1989).

**Direct Regulation or Control as a Means to Restrict Negative Externalities**

Another measure that can be used by the government to restrict negative externalities is the use of direct control or regulation. This is probably the most simple way to control pollution. That is the government can limit polluting activities or agents by simply setting an emission standard on pollution discharges.

In the United States, for example, government agencies such as the Environmental Protection Agency (EPA) commonly use direct controls to reduce many kinds of polluting activities. The agency sets and attempts to enforce emission standards for such polluters as automobiles, power plans and steel mills.

It should be noted here that in the U.S.A. effluent fees and corrective taxes are rarely used by the government as a means of internalizing externalities. The typical method used to control the external costs of pollution is the establishment of standards that limit the amount of pollutants that can be emitted into the air or water. For example, the U.S. Clean Air Act establishes stringent limits on automobile emissions per vehicle. Maximum levels of emission of hydrocarbons, nitrogen oxides, and carbon monoxide per vehicle are specified. These limits led to the adoption of catalytic converters on vehicles, serving to increase the price of automobiles in the U.S. The emission standards specify the maximum number of grams per mile that can be emitted while driving.

Emission standards differ from corrective taxes in that they do not charge for emission damage if the amounts emitted are less than legally established standards. In effect, those who emit pollutants in amounts less than the standards can do so for free. Emission levels that exceed the standards are strictly outlawed.

The use of emission standards therefore has some disadvantages. The first disadvantage of using standards, as compared to corrective taxes, is that standards do not generate any revenue. Secondly, the use of standards faces the problem of efficiency when the cost and benefit of pollution control varies among different firms or locations. For example, it may be very much more costly for a steel mill to eliminate a unit of sulfur dioxide from its emission than it is for a power plant. In the interests of economic efficiency, it is best to eliminate pollution where it is least costly to do so. Thus, the power plant should be required to reduce its sulfur dioxide emission to a lower level than the steel mill is required to do. Since the marginal social benefits and cost of emission vary among firms or locations, rigid emission standards do not achieve an efficient outcome. This problem can be seen in Figures 6 and 7.

Figure 6 shows the marginal social benefit and marginal social cost of emission of a certain pollutant into the air by two firms, A and B. The marginal social benefit of the emission reflects the maximum amount that a firm will pay for the right to emit these wastes. If there are currently no emission charges at all, firms will emit wastes up to the point at which the marginal social benefit is zero. Thus, firm A emits $Q_{A1}$ tons of waste per year, while firm B emits $Q_{B1}$ tons of waste per year. This would be efficient only if the marginal external cost associated with emission were zero.

In Figure 6, it is assumed that the marginal external cost associated with each ton of emission per year is $10 for each firm. This is also the marginal social cost of emission. The efficient level of annual emission is therefore $Q_A$ for firm A and $Q_B$ for firm B. This is the amount of emission that would be observed per year if each firm were charged a fee of \$10 per ton of emission for the right to emit waste. Note that $Q_A > Q_B$ because the marginal social benefit of emission is greater for any given quantity for firm A than it is for firm B. The marginal social benefit of emission can vary from firm to firm because of differences in the cost of reducing emission or differences in the prices of output produced with inputs that pollute.

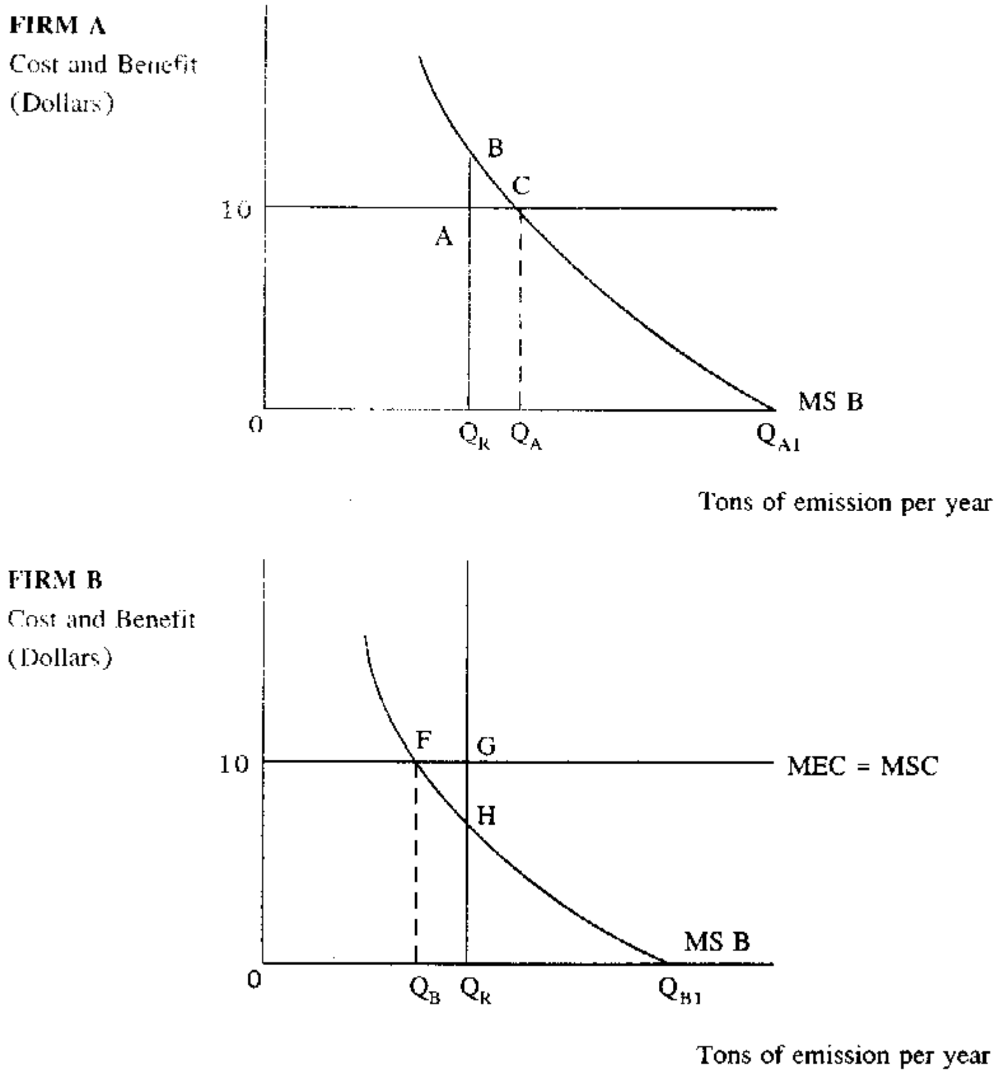
Now suppose that government emission standards allow each firm to emit up to $Q_R$ tons per year at no charge. Emission of more than $Q_R$ tons per year is then strictly prohibited. Accordingly firm A is forced to cut back waste from $Q_{A1}$ to $Q_R$ tons per year. Similarly, the regulations force firm B to cut back emission from $Q_{B1}$ tons to $Q_R$ ton per year.

It is easy to show that the standards do not achieve efficiency. They result in less than the efficient level of annual emission for firm A. At $Q_R$, the marginal social benefit of emission exceeds the marginal social cost for A. If instead this firm were charged \$10, the marginal social cost of the damage per ton of emission, it would choose to emit $Q_A$ tons of waste per year. The extra net gain in well-being made possible by using an emission charge is represented by the triangular area ABC in figure 6.

Standards set at $Q_R$ result in more than the efficient amount of emission from firm B. The efficient amount of emission corresponds to $Q_B < Q_R$. This is the amount that firm B would choose to emit per year if it were charged according to the marginal external cost of \$10. The extra net gain possible by using the \$10 emission charge is represented by the area FGH.

Or from another perspective, it can be shown that uniform standards result in a greater reduction in emission than is efficient for firm A. Pollution abatement is the reduction in pollution that results from reduced emission. As shown in the graph, under uniform standards of emission, firm A reduces emission from $Q_{A1}$ to $Q_R$ tons per year. This results in more than the efficient amount of pollution abatement. Similarly, reduction in emission from $Q_{B1}$ to $Q_R$ by firm B is less than the efficient amount of abatement by this firm.

**Figure 6** Regulating Emission: Losses in Efficiency from Differences in Marginal Social Benefit of Emission

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Standards set at $Q_R$ result in more than the efficient amount of emission from firm B. The efficient amount of emission corresponds to $Q_B < Q_R$. This is the amount that firm B would choose to emit per year if it were charged according to the marginal external cost of $10. The extra net gain possible by using the $10 emission charge is represented by the area FGH.

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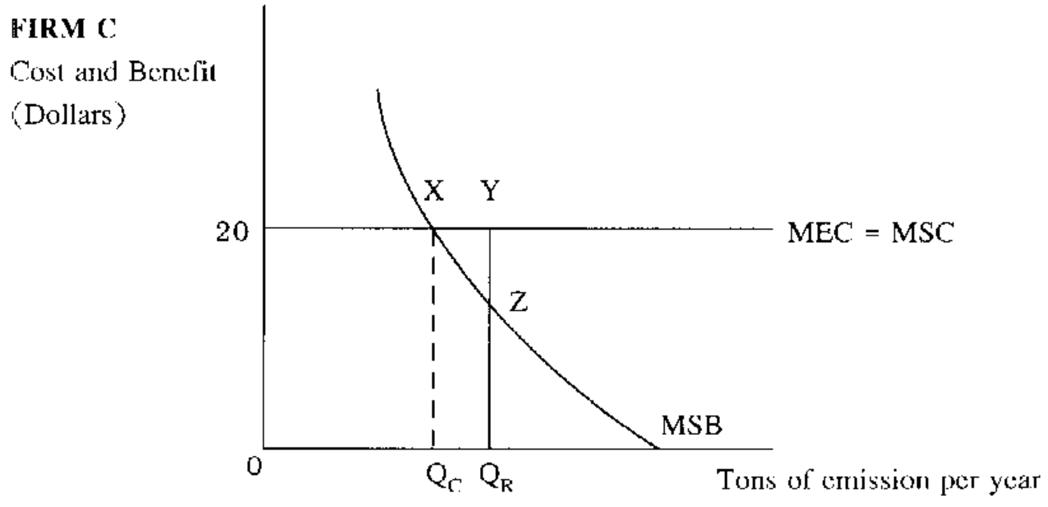
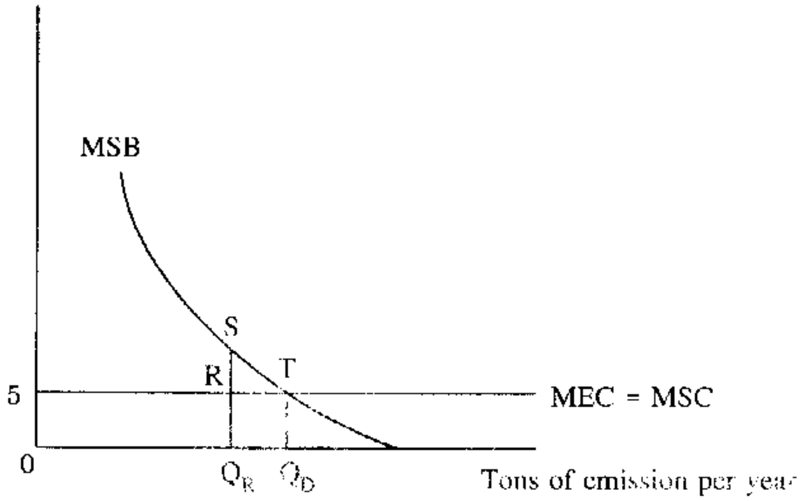
Similarly, uniform regulations would not achieve efficiency if the marginal external cost of emission varied by region in a nation. Suppose the marginal external cost per ton of emission were $20 in urban areas but only $5 in rural areas. These represent the marginal social costs of emitted waste in the two regions. Figure 7 shows that the efficient amount of emission for firm C, located in an urban area, is $Q_C$. This is the amount for which MSB of emission = $20. The efficient amount of emission for firm D, located in a rural area, is $Q_D$. This is the level at which MSB of emission = $5. If all firms, irrespective of their location, are subject to the same emission standard of $Q_R$ tons, the efficient level of emission will not be achieved. The standard would allow all firms to emit $Q_R$ tons of emission per year at zero cost and prohibit more than this amount. This results in more than the efficient amount of emission by the firm in the urban area because $Q_R > Q_C$. On the other hand, less than the efficient amount of emission is allowed in the rural area because $Q_R < Q_D$.

Figure 7 Losses in Efficiency from Emission Standards when MEC Differs among Regions.



**FIRM D**
Cost and Benefit
(Dollars)




The efficient amount of emission could be attained by an emission charge of $20 per ton in the urban area and $5 per ton in the rural area. The loss in net benefit when uniform emission standards, and not charges, are used is the sum of the areas XYZ for firm C and RST for firm D.

In sum therefore, uniform standards for controlling emission that results in negative externalities are unlikely to achieve efficiency. Use of a standards approach to control negative externalities such as pollution will have to be flexible to achieve an efficient outcome. This can be accomplished by adjusting for differences in the marginal social benefit and marginal external cost of pollution among firms and regions. However, a disadvantage of using standards, as compared to corrective taxes, is that standards do not generate any revenue.[4]

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[4] Although effluent fees and corrective taxes are rarely used in the U.S., one recent study has concluded that if the U.S. government used a corrective tax on sulfur dioxide and other emissions from stationary sources, it would have raised as much as $8.7 billion in 1992 (see David Terkla, 1995: 107-123).

## Direct Control versus Corrective Taxes in Practice

As we all know, in the case of the United States, corrective taxes are rarely used as a means to internalizing externalities. The typical method used to control the external costs of pollution is the establishment of standards that limit the amount of pollutants that can be emitted into the air and water. Ever since the U.S. Environmental Protection Agency (EPA) was created, it has relied primarily on a direct control strategy. The EPA has tried a few market mechanisms: tax credits for energy conservation, a small tax on gas guzzlers. But the EPA has primarily set standards and dragged businesses or local governments to court for violating them. Moreover today the EPA has even dictated the technology the business must use to comply with its standards.

This strategy has yielded some positive results. Air quality in most metropolitan areas has improved. The Great Lakes are much cleaner than they were in 1970, and many rivers have been cleaned up. Bans on toxic substances like DDT have limited the problem sharply (Callahan, 199: 90).

But the direct control strategy has hardly been an unqualified success. Cities such as New York, Los Angeles, Boston, and Houston routinely exceed EPA standards for air quality - Los Angeles by 140 days a year. Half of all Americans still live in counties whose air is rated unhealthy by the American Lung Association. The EPA has tried to regulate several toxic air or water pollutants. And these entire efforts have been extremely expensive. In 1990, it has been estimated that American corporations, local governments, and individuals spent $115 billion a year to comply with the environmental regulations. Several studies suggest that other methods could have achieved the same results at 25 percent of the cost (Callahan, 1990: 90-91).

The direct control strategy has a number of drawbacks (Osborne and Gaebler, 1993: 299-305).

1) Direct control does not change the underlying economic incentives driving firms or individuals. Rigid or uniform controls have made it very difficult for business firms or individuals to comply with the EPA's standards. This is because of the differences in the marginal social benefit and marginal external

costs of emission among firms and individuals. Because the EPA's standards have been very difficult to comply with, businesses and firms often do their best to find some way around them, legal or illegal. A great deal of time and money goes into fighting and circumventing regulations, and illegal dumping increases.

2) Direct control strategy is a very slow process. It requires the EPA to establish unsafe levels of exposure to thousands of substances, with enough accuracy to stand up in court. EPA regulations tend to be an all-or-nothing matter. Since the consequences are so severe - requiring industry to scale back or eliminate its use of the substance in question - the stakes are very high. Hence industry often fights these decisions in court, and often fights in Congress as well. Not only does this take forever, it makes regulators extremely cautious about reaching their decisions, because they know they will be fiercely contested.

3) Direct regulations that specify the exact technology industry must use to control pollution discourage technological innovation. Most government regulations require that industry adopt the "best available technology" when they install new plants and equipment. The EPA defines that technology, and businesses must use it. If they develop a better technology, they have to convince the EPA bureaucracy to redefine its standards - a costly and uncertain process. So, EPA regulations discourage businesses from developing new technologies to solve their problems. They also discourage businesses from closing down their old dirty plants and opening cleaner ones, because the best available technology is required primarily in new facilities and industries. In this, several studies conclude that a direct regulatory system discourages the development of innovative pollution-control technology.

4) Because the direct control or regulation approach imposes the same requirements on industries all over the country, it is extremely expensive. No matter what the cost, it requires everyone to use the same technology and meet the same standards. This one size fits all approach is tremendously wasteful, because it requires clean businesses to make the same investments as dirty businesses, rural businesses to make the same investments as urban businesses.

From these problems of the direct control approach, many scholars today believe that the most efficient way to reduce pollution is to assess an effluent charge on polluters. The idea of using an effluent charge is to make sure that both the producers and the consumers face up to the full cost and consequences of their decisions. This is done by building the cost imposed on society by the polluters into the cost of the product. When this is done, people have an incentive not to pollute. And businesses that do not spend money or time to reduce their pollution put themselves at a competitive disadvantage.

Effluent fees or corrective taxes have many advantages over direct control. They create powerful economic incentives for everyone – businesses and individuals – to change their behavior, because they drive up the cost of activities that pollute. Consumers need no sophistication about which product is more environmentally damaging than another. They simply have to look at the price. If driving a heavily polluting car creates high levels of air pollution, it becomes expensive. If electricity from coal-fired plants creates acid rain, it becomes expensive.

Not only does this approach give everyone clear price signals about the cost of pollution, it lets them decide how best to respond. For example if they want to keep driving the dirty, gas-guzzling car, they can. But if they want to drive an energy-efficient, clean car, they will save more. If they want to stick with expensive electricity, they can. But if they want to put solar panels on their roof, they will save money.

If pollution became a significant expense, industries would do what they could to avoid it, developing cleaner technologies, changing the fuels they burned, recycling materials, and conserving energy. The profit motive is a powerful incentive for innovation. A system of "green taxes," as Osborne and Gaebler (1993: 303) call it, would turn loose the creativity of private corporations to find cleaner ways to live, work, and produce.

Green taxes might also avoid some of the drawn-out legal battles that come with direct regulation, because the stakes would be lower. They would give governments more flexibility. By raising or lowering the fee, they could vary the pressure. This would be far cheaper, because it would achieve their goals more efficiently. And they would also generate public revenue, which could be used both to clean up pollution and to invest in activities that prevent it, such as mass transit.

These market incentives appear to be the wave of the future. Not only has Western Europe endorsed the idea, but many states and cities in the United States have also begun to experiment. Iowa, Minnesota and Oregon have taxed agricultural pesticides and fertilizers, then used the tax revenues in groundwater protection. Florida has passed a tax on nonrecycled paper and a law requiring disposal fees on certain containers if 50 percent of them were not recycled within a specified time period. Oregon and New Jersey have created investment tax credits for the purchase of recycling equipment (Osborne and Gaebler, 1993: 304).

In Washington, the Clean Air Act stimulated the development of an emissions trading program to control acid rain. Emissions trading is a mechanism that acts like a green tax: polluters can pay to pollute or innovate to save money. That is it gives credits to firms that reduce air pollution below the level set by law, and allows them to trade the credits between different sources of pollution within the firm or sell them to firms in the same general location. The idea is to encourage businesses to meet EPA's goals, but to let them figure out the most innovative and economical way to do so. If they can reduce one source of pollution economically, they can use the credits generated to offset others that are more expensive (Osborne and Gaebler, 1993: 304).

In 1982, the EPA extended the emission trading program to lead in gasoline. If refiners produced gasoline with lead content below EPA standards, they earned credits, which they could sell to other refiners that were still above required levels. This produced a lively market in credits, partly because buyers and sellers had greater access to one another in a relatively homogeneous refining industry (Osborne and Gaebler, 1993: 304).

And also in 1990, acid rain was the most important environmental issue facing the U.S. government. The government therefore recommended an emissions trading system in which coal-burning electric power plants essentially receive credits for the amount of sulfur dioxide emission they are allowed. They can use any means to reduce their emission, and if they emit less than they are allowed, they can sell their credits to other plants. By using this system, it has been estimated that this will reduce the cost of compliance from $8 billion a year to $4 billion (Osborne and Gaebler, 1993: 304).

Emission charges and taxes are possible today because the information age has radically increased our ability to measure pollution and quantify its impact. Only in the past decade, for example, have we developed continuous emission monitors that are capable of measuring the sulfur emission from a power plant, or electronic systems that can record which car is passing and at what time, without a toll-booth. Businesses today are even developing systems that can measure the exhaust pollution from cars as they pass. Technology like this makes it possible to use emission charges in ways we could barely dream of just a decade ago.

Recently, Joseph E. Stiglitz (1988) has also tried to compare the advantages of the different systems of externality control. He found that corrective taxes and direct regulation have differences in their monitoring costs, information requirements, and in the costs and benefits of pollution control.

Direct regulation and corrective taxes require different kinds of monitoring on the part of the government. Under both schemes it is not in the interests of a polluting firm to announce how much pollution it is creating. Nor is it in the interests of any of the users, since any taxes imposed as a result of excessive pollution or any expenditures on pollution-control devices mandated by regulations are simply passed along to the user. And while it may be in the interests of consumers collectively to monitor, if monitoring is costly, none will be willing to do it. We have a classic public good problem. The burden of monitoring must fall on the government. Direct regulation systems require only that the government ascertain whether a firm has exceeded a certain level of pollution. This may be much less costly than determining with any precision the exact level of pollution, as a system of corrective taxes requires (Stiglitz, 1988: 229).

Equally important, different externality control systems require different information for their implementation. It is perhaps reasonable to assume that the government has a fair estimate of the marginal social costs associated with pollution. But it is likely that the government is not well informed about the technology of pollution abatement and control, at least not as well informed as are private firms. This is particularly true in those cases where the pollution control devices have not yet been developed. Neither side has very good information: both are simply making guesses, but since producers know more about the technology of their industries than does the government, their guesses are likely to be more accurate. The private producers have no incentive to reveal their information to the government; rather they have every reason to try to persuade the government that the technology for pollution abatement will be extremely hard to develop, so that it will be impossible to satisfy stringent regulations.

The information required to achieve an efficient level of pollution by using direct regulation is even greater when firms have different costs associated with pollution abatement. In this case, the efficient level of pollution abatement will differ from firm to firm. To set efficient levels of pollution control, then, the government must know the cost functions of each firm in the economy. Since the government's knowledge of firms' cost functions is heavily dependent on information provided by the firms, firms clearly have an incentive to "fudge" the data.

Note, moreover, that if in the direct regulation system the government errs in its judgment concerning the costs of pollution control, the resulting level of pollution will be inefficient. If the government underestimates the cost of pollution control and sets stringent regulations, firms may spend a considerable amount of resources to comply with the regulations. At the margin, the cost of compliance will exceed the marginal social benefit. And these costs will be passed on to the users of the products.

The corrective taxes system does not suffer from the same information requirement. The government needs ascertain only the marginal social costs of pollution. Then the firms decide whether the costs of the pollution control devices exceed the benefits of pollution control as measured by the penalties imposed for failing to control pollution. There is no longer any gaming between the industry and the government. Of course, if the government incorrectly estimates the marginal social costs of pollution, then inefficiencies will arise, under either a system of taxes or a regulatory system (Stiglitz, 1988: 230).

The costs of pollution control (and the benefits) may vary from place to place, from time to time, and from firm to firm. The marginal social benefit of pollution control may be quite different in Los Angeles (which is faced with a severe smog problem) from what it is in Montana. The cost of pollution control may be markedly different for one kind of coal than for another. In principle, either direct regulations or corrective taxes should recognize these differences. There should thus be a different set of regulations for each different set of circumstances, or a different level of taxes for each community, firm, and date. The information requirements to implement such a detailed system are clearly enormous. In practice, this has resulted in broad sets of regulations that are not adapted well to varying conditions. In localities where there is a belief that the marginal social cost locally is greater, these general regulations are supplemented by local regulations. Thus California, for example, has far more stringent regulations on automobile pollution than does the rest of the U.S., because of the tendency of air pollution to combine with moist air off the ocean to produce smog.

By the same token, if the marginal social costs of pollution vary from situation to situation, then the appropriate tax should vary. Governments seldom have the requisite information to adapt the corrective tax schedule to all of the varying situations. As a result, sometimes the tax may be too high, sometimes it may be too low.

The nature of the variability in costs and benefits plays an important role in he choice between direct regulation and corrective taxes. If costs of pollution control vary but benefits are certain, corrective taxes are preferable to regulation. Firms that are subject to taxes will adjust the level of pollution control to the efficient level; regulations will not allow this adjustment. If benefits vary but costs do not, the two systems are equivalent. The tax system will result in a fixed level of pollution, sometimes too high, sometimes too low, just as with a regulatory system. The consequences of a tax are no different from those of a regulatory system in which the government fixes the level of permissible pollution (Stiglitz 1988: 231).

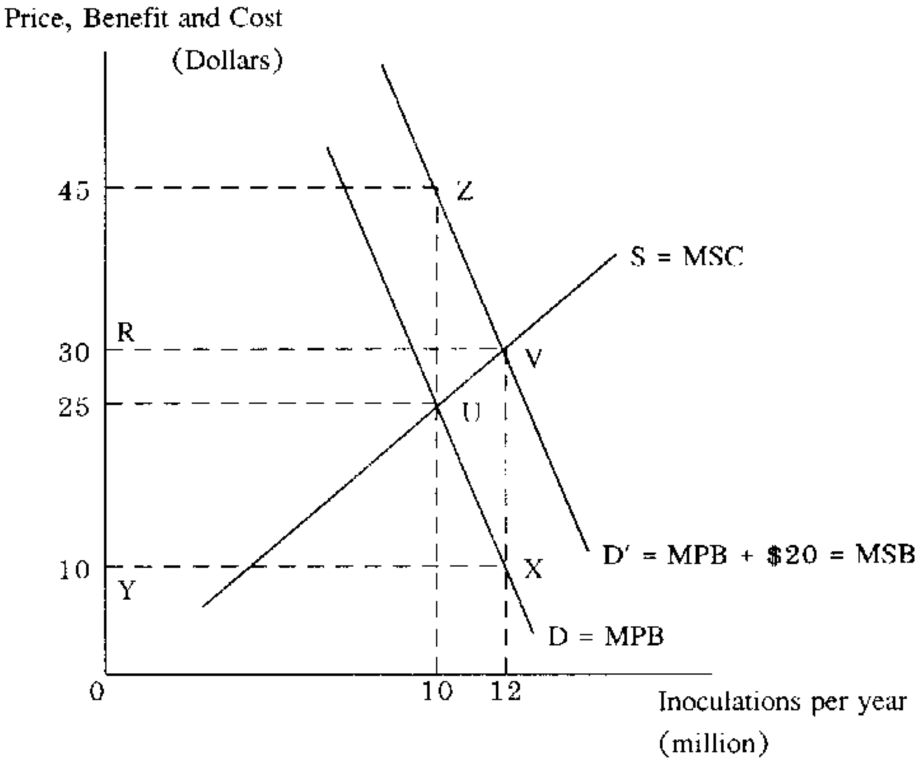
## Corrective Subsidies: A Means of Internalizing Positive Externalities

A corrective subsidy is similar in conception to a corrective tax. Figure 8 shows how a corrective subsidy for inoculations results in the efficient output of this good. The market equilibrium output would be 10 million inoculations per year at the market price of $25 per inoculation. This is inefficient because the marginal social benefit (MPB+MEB) at that level of consumption exceeds the marginal social cost.

A corrective subsidy is a payment made by government either to buyers or sellers of a good so that the price paid by consumers is reduced. The payment must equal the marginal external benefit of the good or service. In this case, $20 is the marginal external benefit associated with each person inoculated. Suppose the government announces that it will pay each person inoculated a subsidy of $20. This subsidy adds $20 to the marginal private benefit of each inoculation. The demand curve for inoculations shifts upward from D to D'. As the demand for inoculations increases in this way, the market equilibrium moves from point U to point V in Figure 8. At that point, the market price of an inoculation increases to $30 to cover increased marginal costs of production. However, the net price after receiving the subsidy declines for consumers. The net price is now $30-$20 = $10 per inoculation. This reduction in the net price to consumers increases the quantity demanded to 12 million per year, the efficient output.

The effect of the subsidy is to increase the benefit of inoculation accruing to those other than the buyers or the sellers of inoculations from $200 million per year to $240 million per year ($20 per person inoculated multiplied by 12 million inoculations per year). The government accomplishes this by making a total of $240 million in subsidy payments to the 12 million persons inoculated each year. This is represented by the area RVXY in Figure 8. The subsidy is paid from tax revenues.

**Figure 8**: A Corrective Subsidy




Examples of corrective subsidies include the provision of certain government services at levels below the marginal cost of such services. For example, many municipal governments make special pickups of trash and large waste items at prices below marginal cost. The difference between the actual price and the marginal cost of the pickup can be regarded as a corrective subsidy designed to avoid accumulation of trash and unauthorized dumping. Some city governments also subsidize property owners who plant trees by the curbs on their property. They might, for example, pay half the price of those trees. This is designed to internalize the positive externality associated with property beautification and air purification. Another example is mass transit. Many European governments give subsidies to their mass transit systems. This subsidy is granted to internalize the positive externality of the mass transit system in reducing traffic congestion and pollution costs as compared to private cars (Buracom, 1995: 6-9).

However, it must be noted that not all subsidies are designed to internalize positive externalities. Many subsidies are based on other goals, such as alleviating poverty.

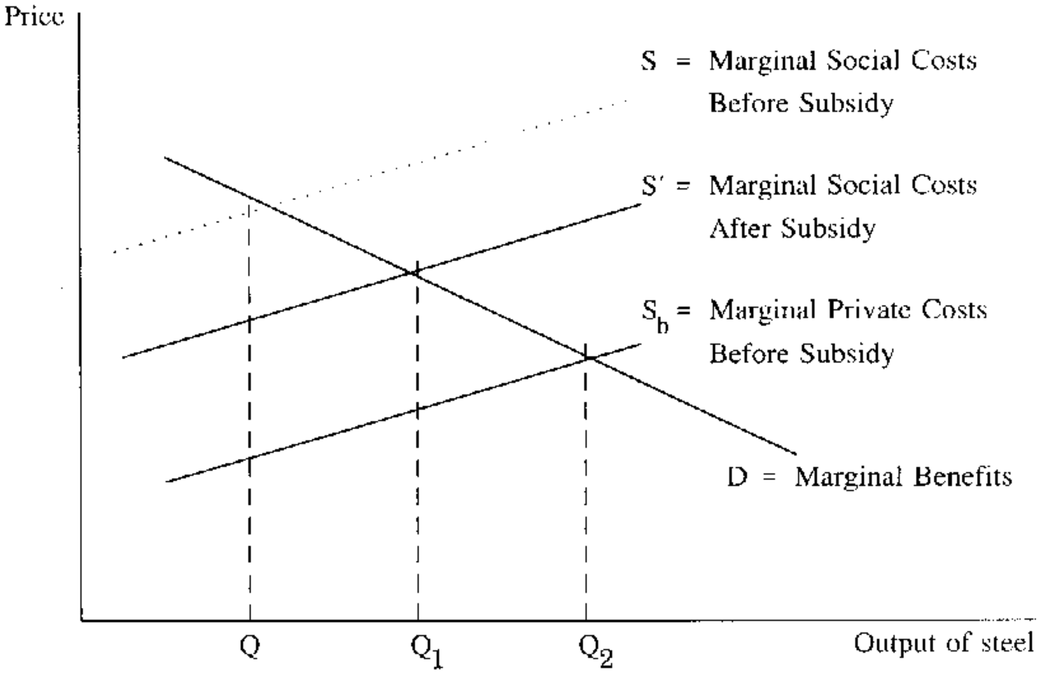
**Pollution abatement equipment subsidies: A method of reducing negative externalities.**

We have noted earlier, in the discussion of negative externalities, that since the firm in question was likely to receive a negligible direct benefit from pollution abatement (most of the benefits accruing to those who live in the vicinity of the plant), it had little incentive to spend money on pollution abatement. There was, from a social point of view, too little expenditure on pollution abatement. Rather than taxing pollution, the government could alternatively subsidize pollution abatement expenditures. By providing a subsidy so that the firm can buy pollution abatement equipment at lower cost.

This remedy does not, however, attain a socially efficient resource allocation. The reason is simple: the total marginal social cost of producing, for example, steel includes the costs of the government subsidies for pollution abatement. Firms fail to take this into account in deciding on the level of production. The pollution abatement subsidy reduces the marginal social cost of output from the dashed line S to line S' in Figure 9. There is still an excessive level of production of steel.

The reason that polluters prefer subsidies for pollution abatement to corrective taxes is clear. Profits under the former system are higher than under the latter. Because output will be smaller under the corrective tax system, prices will be higher, and the consumers of the products of the polluting firms will be worse off. On the other hand, those who have to pay the taxes to finance the subsidies for pollution abatement are clearly better off under the corrective tax system. However, it should be stressed here that the choice between subsidies and corrective taxes is not just a distribution issue. The main idea is that the corrective tax system results in a socially efficient resource allocation, while the system of subsidies for pollution abatement does not (Stiglitz, 1988: 223-226).

**Figure 9**: Pollution Abatement Subsidies




Q = Efficient level of output with no subsidy

$Q_1$ = Efficient level of output with subsidy

$Q_2$ = Output before subsidy

## Government assignment of property rights to internalize negative externalities: The Coase theorem.

The Coase theorem states that governments, by merely establishing the rights to use resources, can internalize externalities when transaction costs of bargaining are zero (Coase, 1960: 1-44). Once these property rights to resource use are established, the Coase theorem holds that free exchange of the established rights for cash payments among the affected parties will achieve efficiency. This result holds irrespective of which of the involved parties is granted the right.

For example, suppose that there are only two competing uses for a stream: a convenient place to dump waste in paper production or a site for recreation. Suppose that the transaction costs of trading established rights to use the stream between the paper factory and the recreation users of the stream are zero. Under these circumstances, the Coase theorem maintains that it makes no difference whether the factory is granted the right to pollute the stream or the recreational users are given the right to a pollution-free stream. In either case, an efficient mix of industrial and recreational uses of the stream will emerge from private bargaining between the factory and the recreational users. There is no need for corrective taxes or any other charges because competition for the use of the stream by the interested parties will internalize the externalities.

If the factory is granted the right, it will be in its interest to reduce pollution if the recreational users will offer a payment that more than offsets the reduction in profits resulting from reduced pollution. If, instead, the recreational users have the right to a pollution-free stream, they would give up part of this right if the factory can offer them a payment in excess of the losses they incur from increased pollution. By creating the right, the government gives the user who receives it a valuable asset that can be exchanged for a cash payment from the other user. The exchange of those rights will lead to efficient use, provided that there are no third parties affected by the exchange of the government-created rights.

The transaction costs of bargaining to exchange rights include the costs of locating a trading partner and agreeing on the value of the traded right. In general, these transaction costs tend to be close to zero when the parties involved in trading the right are few in number. Under such circumstances, those who are granted a right are likely to know who is willing to purchase it, and a price can easily be agreed upon to internalize any externalities. Those who purchase the rights of others to pollute, for example, know that there are no other polluters who will continue to cause damage after the deal is complete. The kinds of externalities for which the Coase theorem is relevant therefore are called small number externalities (Stiglitz, 1988: 233-34).

Consider another example, suppose that a cattle rancher and a wheat farmer operate on two adjoining plots of land. Currently, the border between the two plots is unfenced. The cattle occasionally stray into the wheat fields, thus damaging the crop. As the size of the cattle producer's herd increases, it is inevitable that more steers will stray into the wheat fields and more wheat will be damaged.

Assume that the governing authorities grant the wheat producer the right to cattle-free land, requiring that the cattle producer pay the wheat farmer for damages incurred by his cattle. This forces the cattle producer to take into account the external cost, measured in wheat damage, caused by the herd. Faced with the charge, the rancher's options would include paying the charges, reducing the size of the herd, purchasing the wheat farmer's land, or building a fence to eliminate the straying. The rancher will choose the alternative that allows the greatest profit.

On the other hand, suppose that the cattle rancher is not liable for damages. This means that the right to use unfenced land for grazing is granted to the rancher. This means that the wheat farmer will have to pay for the rancher's right of unlimited grazing. As was the case when the rancher was liable for damages incurred by his cattle, the wheat farmer can be expected to choose the option that will give maximum possible benefits. The farmer will compare the alternative of annual payments to the rancher to reduce the size of the herd or to build a fence with that of buying the rancher's land outright. He will choose the option that maximizes profits.

## Significance of the Coase Theorem: The Case of Aircraft Noise.

Aircraft noise in a nuisance for citizens who live or work near airports. It can damage hearing, interfere with sleep, and impair human health. As such, it is an example of negative externality.

Since there are relatively few airports, it is fairly easy to identify the source of the problem. It would not be very difficult to establish the right of adjacent property owners to an environment free of aircraft noise. The airport authorities could be made liable for noise damage. If it were possible for local property owners to form an organization to bargain directly with the airport owners, trade of established rights for cash payments could be worked out. Under those circumstance the government could even award the right to produce noise to the airport owners. The property owners organization then would have to purchase the airport's right to use the environment.

Aircraft noise is measurable. The units of measurement are effective perceived noise in decibels (EPNdB), and a noise exposure forecast (NEF) which is a measure of average noise in the vicinity of an airport during a 24-hour period. Noise occurring between 10 p.m. and 7 a.m. is weighted by a factor of 12 times the same noise during the day (Schelling, 1983: 40).

At the same time, aircraft noise can reduce property values in the vicinity of the airport. The reduction in property value, due to the noise, is an indication of the willingness of property owners to pay for its reduction. Estimates of the noise-induced property value reduction represent the discounted present value of noise damage. One study concluded that the average property value discount due to aircraft noise was 0.62 percent for each NEF unit (Nelson, 1979). This implies that each one-unit increase in NEF would decrease the value of a $100,000 house by approximately $62. If the noise level in the area were 40 NEF, then the value of the house would be $20,480 less than it would otherwise be. The researcher concluded that, assuming a 10 percent interest rate, a noise charge of $62 per NEF per household, assuming an average property value of $100,000, could internalize the externality. This charge could be levied on the airport owners (Nelson, 1979).

Faced with the charge, the airport owners would decide the best way to deal with the problem. Their alternatives would include paying the charges, reducing flights, and requiring modified takeoff and landing procedures. Alternatively, they could relocate the airport or assist surrounding residents in soundproofing their homes. Finally, they could buy up property in the area to reduce the number of households bearing the costs of the noise.

It should be noted as well that insofar as the noise damage is reflected in decreased property values, persons who buy property in the area after the airport is constructed are compensated for its costs by lower land prices.[5] The persons who suffer losses in wealth as a result of the airport being located near their land are those who owned the land at the time the airport was built. Of course, other factors associated with the desirability of locating near an airport could serve to increase property values. The estimates of property value reduction presented above include only the adverse effect of noise on property values.

Direct regulations or controls, not charges, are currently used in the United States to internalize externalities associated with aircraft noise. These regulations include noise-reducing takeoff and landing procedures, requirements for low-noise engines, and land use controls in the vicinity of the airport, including those requiring soundproofing in new buildings. The U.S. Federal Aviation Authority also establishes standards for maximum noise of newly designed aircraft.

Noise charges, on the other hand, can vary from airport to airport, with the time of day, and weights can be assigned to noise measures according to the number of persons and types of activity bearing the cost. The charges can be levied on each EPNdB weighted by households or property affected. The cost of reducing noise varies with the types of aircraft. A noise charge would allow those who pay it to determine the least costly means of reducing the noise. This is likely to be a less costly way of solving the problem compared to the alternative of direct government regulation.

## Conclusion

Externalities are costs or benefits of market transactions not reflected in prices. When externalities are present, market prices fail to equal the marginal social cost or benefits of goods. Exchange of goods and services in the market fails to achieve efficiency when externalities prevail. When the marginal external

[5] Only unanticipated noise will cause losses to property owners.

cost or benefit is priced so that buyers and sellers consider it in their decisions, an externality is internalized.

Externalities may be negative or positive. Negative externalities result in costs, while positive externalities result in benefits to third parties to market exchanges. To internalize an externality, the parties involved must be identified and marginal external cost or benefit must be measured.

In some cases, particularly when there are few individual emitters and receptors, informal bargaining can be expected to internalize the externality without recourse to collective action through government institutions. The Coase theorem shows that, in such cases, government assignments of rights to resource use, along with facilitation of free exchange of those rights, achieves efficiency independent of which party is granted the right. In cases where larger numbers of individuals are involved, a solution will require collective action to internalize the externality. Among the techniques used for this are corrective taxes, subsidies, and direct regulation. In many cases, corrective taxes can attain more efficiency in internalizing negative externalities.

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