6

EXTERNALITIES AND THE ENVIRONMENT

FOCUS QUESTIONS

1. What are externalities?
2. How do private markets respond to externalities? What are the limitations of these private remedies?
3. What are the principal ways by which the public sector attempts to deal with externalities? What are the advantages and disadvantages of these alternative approaches?
4. What currently are the major environmental public policy issues? What policies regarding these issues have succeeded and what policies have failed? What are some of the current controversies in environmental public policy, and what insights does economic analysis provide into these controversies?

The federal government has long had an interest in environmental policy—the earliest federal action appears to have been the Refuse Act of 1899, designed to rid navigable waters of debris. The modern era of federal environmental regulation began with the Water Pollution Control Act of 1948, the first of a series of laws to protect the water we drink and the lakes and rivers in which we swim and fish.

Government activity on behalf of the environment has clearly had some beneficial effect. The quality of air in major industrial cities such as Gary, Indiana and Pittsburgh has improved noticeably since passage of the Clean Air Act of 1963. Lakes such as Lake Erie, which once faced the prospect of becoming so polluted that much marine life would be extinguished, have been saved.

Although it is increasingly agreed that government actions are required to preserve our environment, the extent and form of those actions remain a subject of debate. This chapter describes the economic rationale for government intervention in the environment and reviews the major government programs and policy issues related to environmental intervention.

THE PROBLEM OF EXTERNALITIES

Air and water pollution are two examples of a much broader range of phenomena that economists refer to as **externalities**, one of the market failures discussed in Chapter 4. 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. Markets affected by externalities result in inefficient resource allocations. Levels of production, as well as expenditures directed at controlling the externality, will be incorrect. For instance, consider a firm that could, by expending resources, reduce its level of pollution. Although there would be a large social benefit, there is no private incentive driving the firm to spend the money.

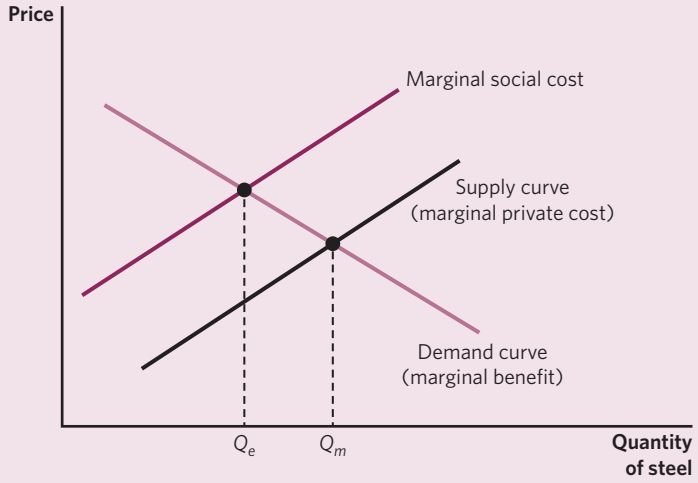
In some cases, the actions of an individual or firm confer (uncompensated) benefits on others; these are called *positive* externalities. A homeowner who maintains his or her property, including planting attractive flowers in front, provides a positive externality. Actions that adversely affect others are called *negative* externalities.

The level of production of negative externality-generating commodities will be excessive. Figure 6.1 shows conventional demand and supply curves. We argued earlier that, in the absence of externalities, the resulting market equilibrium, Q_m, was efficient. The demand curve reflected the individual's marginal benefits from the production of an extra unit of the commodity, and the supply curve reflected the marginal costs of

FIGURE 6.1

EXCESSIVE PRODUCTION OF GOODS YIELDING NEGATIVE EXTERNALITIES

The presence of a negative externality means that marginal social costs exceed marginal private costs, and the market equilibrium will entail an excessive production of the commodity. Q_m is market equilibrium, Q_e is the efficient level of output.



producing an extra unit of the commodity. At the intersection of the two curves, the marginal benefits just equal the marginal costs. Now, with externalities, the industry's supply curve will not reflect marginal *social* costs, only marginal private costs—those borne directly by the producers. If the expansion of steel production increases the level of pollution, there is a real cost to that expansion in addition to the costs of the iron ore, labor, coke, and limestone that go into the production of steel. However, the steel industry fails to take the cost of pollution into account. Thus, Figure 6.1 also shows the **marginal social cost curve**, giving the total extra costs (private and social) of producing an extra unit of steel. This cost curve lies above the industry supply curve. Efficiency requires that marginal social cost equal the marginal benefit of increasing output: production should occur at Q_e, the intersection of the marginal social cost curve and the demand curve. The efficient level of production is lower than the market equilibrium level.

An important class of externalities arises from what is referred to as **common resource problems**. Their central characteristic is that they pertain to a pool of scarce resources to which access is not restricted. Consider a lake in which the total number of fish caught increases with the number of fishing boats, but less than proportionately, so that the number of fish caught per boat decreases as the number of boats increases. Each additional boat reduces the catch of other boats. This is the externality. The marginal social benefit of an additional boat is thus less than the average catch of each boat, as shown in Figure 6.2; some of the fish that the additional boat catches would have been caught by some other boat.

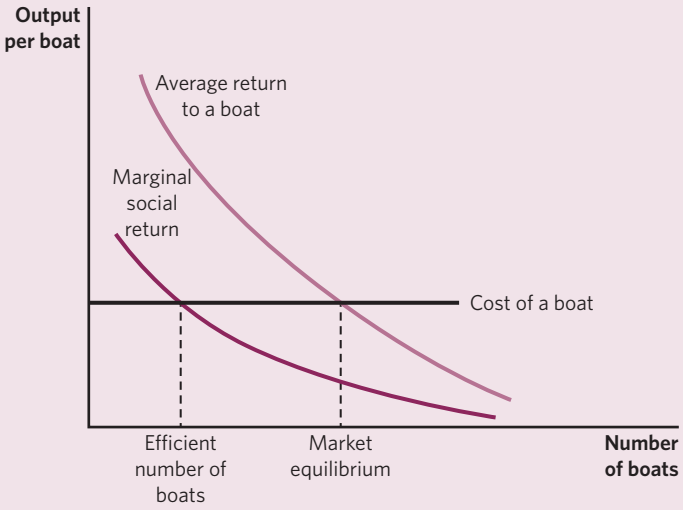


FIGURE 6.2

COMMON RESOURCE PROBLEM LEADS TO EXCESSIVE FISHING

The extra output of an additional boat is less than the average output. There will be an excessive number of boats.

EXTERNALITIES

Externalities arise 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. The consequences are:

1. Overproduction of goods generating negative externalities
2. Undersupply of goods generating positive externalities

The private return to an additional individual deciding whether to purchase a boat is simply the average return (once they are on the lake, all boats catch the same number of fish), which is much more than the marginal social return. Thus, whereas the private market equilibrium entails average returns equal to the cost of a boat (assumed to be constant), social efficiency requires that the marginal social return be equal to the cost of a boat.

In general, when there are externalities, the market equilibrium will not be efficient.

PRIVATE SOLUTIONS TO EXTERNALITIES

Under some circumstances, private markets can deal with externalities without government assistance.

INTERNALIZING EXTERNALITIES

The simplest way this can be done is by **internalizing externalities**—forming economic units of sufficient size so that most of the consequences of any action occur within the unit. Consider, for instance, any community, whether a group of neighboring houses or a set of apartments in the same or neighboring buildings. The quality of life in the neighborhood is affected by how each household maintains its property. If people plant flowers, they confer a positive externality; if they let their houses run down, they confer a negative externality. Even when each family owns its own apartment, the households may *collectively* decide that maintenance of the facilities that affect them all—including the external appearance—should be undertaken collectively. They form a cooperative or a condominium association.

There must be, of course, some way of enforcing the collective agreement that those who purchase a condominium or an apartment in a cooperative sign. A member of the condominium association might prefer to be a free rider, not paying his or her share of the cost of the maintenance of the common facilities; or the member might refuse to maintain his or her apartment in ways that are collectively agreed upon, and that may

adversely affect neighboring apartments. There must be recourse to the legal system, which ensures that the terms of the agreement—by which those living near each other attempt to deal with some of the externalities they impose on each other and to provide what are "public goods" to the group—are adhered to.

THE COASE THEOREM

As we have noted, externalities arise when individuals do not have to pay for the full consequences of their actions. There is excessive fishing in a common pool because individuals do not have to pay for the right to fish. Frequently, externalities can be dealt with by the appropriate assignment of **property rights**. Property rights assign to a particular individual the right to control some assets and to receive fees for the property's use.

Consider the problem of oil pools. Oil is usually found in large pools beneath the ground. To obtain access to a pool, all one needs to do is to buy enough land to drill a well and equipment for the drilling. The more oil that one well takes out of the pool, the less there is for others to take.[1] The total extra oil obtained as a result of drilling an extra well—the marginal social benefit—is thus less than the amount obtained by the additional well. Too many wells will be drilled.

The reason for this is that no one has the property right to the entire pool of oil. When the oil pool is controlled by a single individual, that individual has an incentive to make sure that the correct number of wells is drilled. Because economic efficiency is enhanced by having a single firm control the entire pool, any firm could buy the land over the pool from its present owners (at what they would have received from selling the oil) and wind up with a profit. In this view, no outside intervention would be required to ensure that an efficient pattern of property rights emerged.

Even when property rights for a common resource are not assigned to a single individual, the market may find an efficient way of dealing with the externality. Owners of oil wells frequently get together to **unitize** their production, thus making it less likely that too many wells will be drilled.[2] Fishermen using the same grounds may get together to devise mutually agreed-upon restrictions to prevent excess fishing.

The assertion that whenever there are externalities the parties involved can get together and make some set of arrangements by which

[1] There is another externality: as oil is removed, the costs of pumping out additional oil rise because underground pressure is reduced. Additional wells may actually reduce the total amount that will be extracted.
[2] Under unitization, the development of an oil or gas reservoir is put under a single management, with proceeds distributed according to a formula specified in the unitization agreement. This unitization is not done to reduce competition (it occurs even among small oil companies that take the price of oil as given, unaffected by their actions), but to increase efficiency.

the externality is internalized and efficiency is ensured is referred to as the **Coase theorem**.[3]

For instance, when there are smokers and nonsmokers in the same room, if the loss to the nonsmokers 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. Or, say 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. Then the smokers might 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 off in the regime in which smoking is allowed unless they are paid not to smoke, compared to the regime in which smoking is banned unless they compensate nonsmokers.

USING THE LEGAL SYSTEM

Even when property rights are not perfectly defined, the legal system can provide protections against externalities. Our system of common law does not allow one party to injure another, and "injury" has been interpreted to include a variety of economic costs imposed on others. Implicitly, courts have given individuals some property rights—say, in the waters that they rely on for fishing. Those who have been injured have increasingly turned to courts to enforce those property rights.

When the Exxon tanker *Valdez* spilled oil into Alaska's Prince William Sound in 1989, those damaged by the spill—the fishermen whose catch was diminished, as well as those in the tourist industry who depend on sports fishermen—successfully sued Exxon. Many Americans believed that by spoiling one of the relatively pristine environments in the country, the spill hurt them too. They valued the *existence* of these natural resources, even if they did not immediately enjoy the benefits by visiting Alaska; to that extent, the *Valdez* oil spill had an externality effect upon them too. Courts have recognized these **existence values**—in the *Valdez* case, the state of Alaska, acting as trustee, collected more than a billion dollars in compensation.

Similar issues are now being litigated after the April 2010 explosion and fire on the BP-licensed Transocean drilling rig Deepwater Horizon

[3] R. H. Coase, "The Problem of Social Cost," *Journal of Law and Economics* 3 (1960): 1–44.

in the Gulf of Mexico and the subsequent worst oil spill in U.S. history. Although BP set up an independently administered $20 billion escrow fund while oil was still gushing into the gulf, the U.S. government saw this as a down payment toward compensation for victims of the oil spill. It filed suit in December 2010 against BP and several of its partners

THE EXXON *VALDEZ* OIL SPILL

Oil tankers have long been a major source of ocean pollution. The potential for damage was forcefully brought home with the grounding of the Exxon *Valdez* in Alaska's Prince William Sound in March 1989. Nightly pictures on TV depicted graphically the massive death of wildlife, including sea otters, salmon, birds, and seals. How long the devastation would last—or whether nature would ever fully recover—was not clear.

Exxon was made to pay more than $1 billion, most of which was to be spent on correcting the environmental damage; and the company claimed to have spent more than $2 billion beyond that in the months immediately after the spill, trying to limit the extent of damage. Even so, there was debate over whether the amount paid by Exxon was adequate: How much should Americans be compensated for the damage of the spill?

To answer this question, a study was done in which individuals were asked questions about how much they would be willing to pay to preserve a natural habitat, such as that which was harmed by the *Valdez* spill. Just as opinion polls, by sampling a thousand individuals, can provide an accurate forecast about how the entire population will vote, so, too, a sample of individuals can provide an accurate estimate for the value that would be assigned by the entire population. Some individuals will assign a high value, others a relatively low value, but these differences will be reflected in the sample. By projecting the distribution of values in the sample to the entire population, one can calculate the total value for the nation. In the case of the *Valdez* oil spill, the value estimated in this way was about $3 billion. This methodology for assessing existence values is called *contingent valuation*.

The more fundamental question was how to prevent such disasters or, more accurately, how to make their occurrence less likely and the consequences less severe. As long as oil is transported, there is some risk of a spill, and no one has contemplated a complete ban on shipping oil. Shippers may not have the appropriate incentives to avoid a spill, though, because they do not bear the full consequences. This is a particularly severe problem, as many shipping companies are poorly capitalized, and in the event of an accident they would simply go bankrupt. Only a company as large and strong as Exxon could pay out $3 billion, yet almost any large oil tanker could do comparable damage.

To rectify this problem, Congress passed the Oil Pollution Act of 1990. This combined a system of incentives with regulations. Vessels had to be double-hulled, for example, thus reducing the likelihood of spillage.

One criticism that economists have raised is that the funds paid in compensation for damage, in general, must be used for cleanups. This constraint induces an inefficiency. The amount that the owners of vessels that have spills are required to pay should be designed to provide the corrective incentive to avoid spills. This may be more than the amount that is appropriately spent on cleanup. For instance, suppose that the consequences of a spill would be rectified by nature on its own in a year, and that it would cost an enormous amount to speed up the restoration process. We still would want to penalize firms that spill, but we might not want to spend the money to speed the restoration, as there would be little benefit to doing so.

PRIVATE SOLUTIONS TO EXTERNALITIES

1. Internalize externality.
2. Assign property rights (Coase theorem).
3. Use the legal system.

over violation of safety regulations, seeking unlimited damages to cover the cost of the oil cleanup, long-term environmental damage, and local business losses.

To reduce the uncertainty about these often imperfectly defined property rights, government has tried to clarify them and to specify more precisely the nature and amount of damages that can be collected. Thus, more recent legislation and regulation have recognized the importance of existence values; the government—as "trustee" for the country's natural resources—has the right to sue for damages, although under current legislation the amount recovered must be used for restoration.

FAILURES OF PRIVATE SOLUTIONS

If the arguments asserting that private markets can internalize externalities are correct, is there any need for government intervention, other than to establish clear property rights? Furthermore, if these arguments are correct, why have cooperative agreements failed to take care of so many externalities?

There are several reasons why government intervention is required. The first has to do with the public goods problem discussed in Chapter 5. Many (but far from all) externalities involve the provision of a public good, such as clean air or clean water; in particular, it may be very costly to exclude anyone from enjoying the benefits of these goods. If nonsmokers get together to compensate smokers for not smoking, it pays any individual nonsmoker to claim that he or she is almost indifferent to letting others smoke. This individual 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. Smokers will try to persuade 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 any bargain that might be made.

Problems may arise even when markets are well established. Consider the problem of an oil pool, the land above which is owned by several individuals. Efficiency can be obtained by bringing all the land covering an oil pool under a single unitized management and control—called unitization.

However, if all but one of the landowners unitize, it may not pay for the last owner to join. This landowner knows that production on the unitized portion will be reduced, thus enabling him or her to increase production. The last owner will join only if he or she receives more than a proportionate share of the revenues. Then, all small owners may believe they can gain by holding out to be the last to join the unitization agreement (or selling to a large firm attempting to purchase all the small owners). States have therefore found it necessary to pass legislation requiring unitization.

Another reason for government intervention concerns transactions costs. The costs of getting individuals together to internalize externalities voluntarily are significant. The provision of those organizational services itself is a public good. Indeed, the government may be looked upon as precisely the mechanism that individuals have set up to reduce the welfare losses from externalities.

Transactions costs are a major disadvantage of dealing with externalities through judicial processes. For many externalities, the losses involved may simply be too small to justify undertaking litigation. Because those generating externalities know that litigation is expensive, they may be inclined to generate their externality just up to the point at which it pays the injured party to sue—giving rise to considerable inefficiencies. One way of partially dealing with this is to charge anyone shown to have imposed an externality on another a multiple of the estimated value of the damages. However, this gives rise to a countervailing danger of unwarranted lawsuits, with defendants settling claims simply to avoid the enormous litigation costs.

Uncertainty about the extent of the injury frequently compounds the problem of transactions costs, and there is also some ambiguity about the outcome of most suits. If litigation costs are large, the uncertainty acts as a further deterrent to individuals contemplating using the court system to deal with externalities.

The high litigation costs and uncertain outcome of the litigation process imply that there is, in effect, differential access to legal remedies—poor people may not be able or willing to bear the risks of litigation—a situation that conflicts with our usual notion of justice in a democracy. Because the legal system and the other private methods of addressing externalities so often work so poorly and so inequitably, there has been increasing reliance on public remedies.

FAILURES OF PRIVATE REMEDIES FOR EXTERNALITIES

- Public good (free rider) problems
- Compounded by imperfect information problems
  - How much does the individual need to be compensated for externality?
  - Incentive not to reveal truth
- Transactions costs
- Additional problems with litigation
  - Uncertainty about outcomes
  - Differential access

PUBLIC SECTOR SOLUTIONS TO EXTERNALITIES

Public sector solutions to environmental externalities fall into two broad categories: market-based solutions and direct regulation. Market-based solutions attempt to influence incentives to ensure economically efficient outcomes. For instance, fines for polluting can be used to present firms with the true social costs of their actions, thereby diminishing their incentive to pollute. By contrast, government has used direct regulations to limit externalities, as in the case of mandatory emissions standards for automobiles.

Before comparing the merits of these different approaches, we should first dispel the common fallacy that asserts that an individual or firm should never be allowed 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. In the view of most economists, such absolutist positions make no sense. There is indeed a social cost associated with pollution (or any other negative externality), but the cost is not infinite; it is finite. There is some amount of money that people would be willing to receive in compensation for having to live in a community with dirtier air or dirtier water. Thus, we need to weigh the costs and benefits associated with pollution control, just as we need to weigh the costs and benefits associated with any other economic activity. The problem with the market is *not* that it results in pollution; there is, indeed, a socially efficient level

DOUBLE DIVIDEND

Some have argued that there is a double dividend from imposing taxes (or fines) on pollution. Not only does it discourage pollution, but it also raises revenue, so the government has to rely less on distorting taxes. Those who believe that the tax system is distorting—with taxes on capital discouraging savings and taxes on labor discouraging work—emphasize this double dividend. Not only will national output *as conventionally measured* go up, but *true* output—which takes account of the pollution and degradation of the environment—goes up even more than conventionally measured output, as the tax or fine discourages pollution.

of pollution. The problem rather is that firms fail to take into account the social costs associated with the externalities they impose—in this case, pollution—and as a result, the level of pollution is likely to be excessively high. The task of the government is to help the private sector achieve the 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.

In the ensuing discussion the focus will be on pollution externalities. The arguments, however, extend in a straightforward way to other categories of externalities.

MARKET-BASED SOLUTIONS

Even when markets themselves do not lead to efficient resource allocations—as when there are externalities—market-like mechanisms can often be used to ensure efficient behavior. Market-based solutions to environmental externalities take three forms: fines and taxes, subsidies for pollution abatement, and marketable permits. We now consider each of these solutions in turn.

FINES AND TAXES The simplest form of market-based solution involves levying fees or taxes in proportion to the amount of pollution emitted. In general, whenever there is an externality, there is a difference between the social cost and the private cost, and between the social benefit and private benefit. A properly calculated fine or tax presents the individual or firm with the true social costs and benefits of its actions. Fines of this sort—designed to make marginal private costs equal marginal social costs, and marginal private benefits equal to marginal social benefits—are called **corrective taxes**, or sometimes **Pigouvian taxes**, after A. C. Pigou, a great English economist of the first half of the twentieth century.[4]

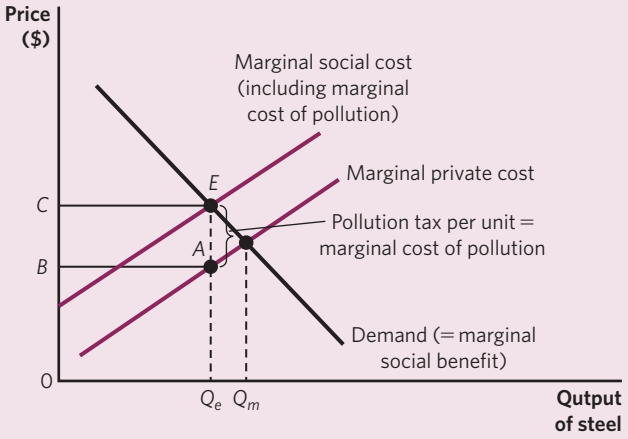
Consider the example, discussed earlier, of steel producers polluting the air. We showed that because firms were concerned only with private marginal costs, not the social marginal costs (the two differing by the marginal costs of pollution), the output of steel would be excessive. By charging each firm an amount equal to the marginal cost of pollution, though, the marginal private costs and marginal social costs are equated.

[4] Pigou argued persuasively for the use of corrective taxes in his book, *The Economics of Welfare* (London: Macmillan, 1918).

FIGURE 6.3

MARKET EQUILIBRIUM WITH AND WITHOUT FINES

In the absence of a tax on pollution, firms will set price equal to marginal private cost. There will be excessive production (Q_m). By setting a tax equal to the marginal pollution cost, efficiency is obtained.



In Figure 6.3 we have assumed that the amount of pollution is proportional to the level of output, and the marginal cost of each unit of pollution is fixed; hence, by imposing a fixed charge per unit of output, equal to the marginal social cost of pollution, each firm will be induced to produce the socially efficient level of output. In the figure, the distance *EA* represents the pollution tax per unit output, and the area *EABC* represents the total pollution taxes paid.

Firms can reduce pollution by producing less, or by changing production methods. Changes in production methods may entail direct expenditures for pollution control devices, or changes in the input mixes and other alterations in the production process. Fines related directly to the amount of pollution ensure that firms will undertake the pollution abatement in the least costly—most efficient—manner possible. Assume that there is a given, known marginal social cost imposed on others by each unit of pollution (measured, say, by the number of particles added to the air per unit of time). It is costly to reduce pollution—and we assume that at any given level of production, it costs more to reduce pollution more. In other words, the *marginal* cost of pollution control is rising. This is depicted in Figure 6.4, in which we measure along the horizontal axis the *reduction* in pollution (from what it would be if the firm spent nothing on pollution abatement). Efficiency requires that the marginal social benefits associated with further pollution abatement expenditures just equal the marginal social costs, point P^* in the diagram. If the firm is charged a fine, f^*, equal to the marginal social cost of pollution, the firm will undertake the efficient level of expenditure on pollution abatement.

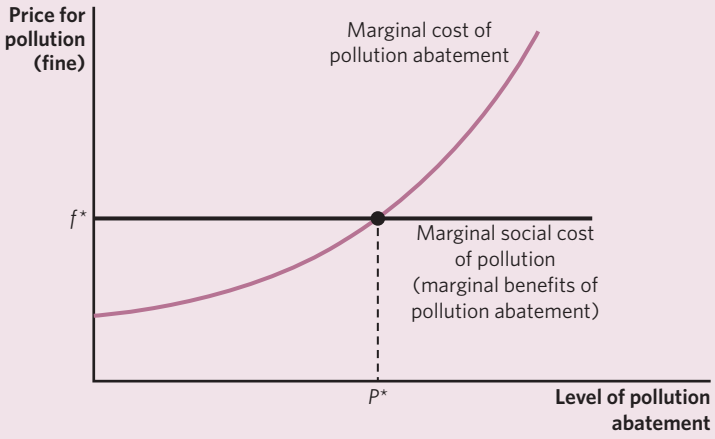


FIGURE 6.4

EFFICIENT CONTROL OF POLLUTION

The efficient level of pollution can be attained either by charging firms a fine of f^* per unit of pollution (say, measured by the number of particles added to the air) or by imposing a regulation that firms have a pollution abatement level P^*.

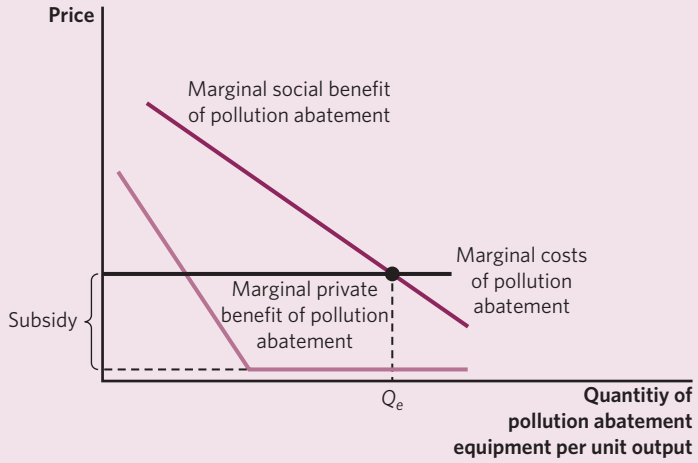
SUBSIDIZING POLLUTION ABATEMENT Because a firm is likely to receive a negligible direct benefit from pollution abatement (most of the benefits accruing to those who live in the vicinity of the plant), absent a fine on pollution, it has little incentive to spend money on pollution abatement. There is, from a social point of view, too little expenditure on pollution abatement. Rather than taxing pollution, the government could subsidize pollution abatement expenditures. By providing a subsidy equal to the difference between the marginal social benefit of pollution abatement and the firm's marginal private benefit, the efficient level of pollution abatement expenditures can be attained. This is illustrated in Figure 6.5. The marginal cost of pollution depicted in Figure 6.4 is directly related to the marginal benefit of pollution abatement depicted in Figure 6.5. Whereas in Figure 6.4 we assumed a fixed marginal social cost of pollution, and hence a fixed marginal social benefit from pollution abatement, in Figure 6.5, as pollution decreases, the marginal social benefit from further pollution abatement decreases. Similarly, in Figure 6.4 we have assumed rising costs of pollution abatement, whereas in Figure 6.5 marginal costs are constant. Either case may hold in a real situation.

This remedy, however, does not attain a socially efficient resource allocation. The reason is simple: the total marginal social costs of producing steel include the costs of the government subsidies for pollution abatement. Firms fail to take this into account in deciding on the level of production. Thus, as before, the marginal social cost of steel production exceeds the marginal private cost. The pollution abatement subsidy reduces the marginal social cost of output (from the dashed line to the solid black line in Figure 6.6). But it also reduces the marginal private costs. There is

FIGURE 6.5

POLLUTION ABATEMENT SUBSIDIES

By subsidizing the purchase of pollution abatement equipment (by the difference between marginal social benefit of pollution abatement and marginal private benefit), an efficient level of expenditure on pollution abatement can be attained.



still an excessive level of production of steel, as illustrated by point Q_s in Figure 6.6.[5] Q_m is the output before subsidy, which is markedly greater than Q_e, the efficient level of output with the subsidy. A well-designed subsidy lowers the total marginal social cost of production—there is less pollution. Although there is a cost of the abatement subsidy, including the distortions arising from the taxes required to raise the revenues to finance it, the benefits from the lower pollution exceed these costs; hence, the optimal level of output with the subsidy is greater than the optimal level of output when firms have no incentives to reduce pollution. Thus, Q_o is greater than Q_e. On the other hand, if the pollution abatement equipment confers some ancillary benefits to the firm, it may simultaneously reduce the firm's marginal private costs of production, as indicated by the light gray line. Thus, the firm's output level also increases from Q_m to Q_s. However, because the main benefit of the pollution abatement equipment is to reduce pollution, presumably, the distortion—the magnitude of the excess production—is reduced.

The reason why polluters prefer subsidies over fines for pollution abatement is clear: profits are higher under the former system than under the latter. The distributional consequences are not limited to the polluting firms and their shareholders. Because output will be smaller under the system of fines, prices will be higher, and consumers of the polluting firm's products will be worse off. On the other hand, those who have to

[5] If the level of pollution of a firm cannot be directly monitored, a desirable policy would entail a subsidy for expenditures on pollution abatement combined with a tax on output. The tax on output, if set at the appropriate rate, reduces the level of output to the socially efficient level.

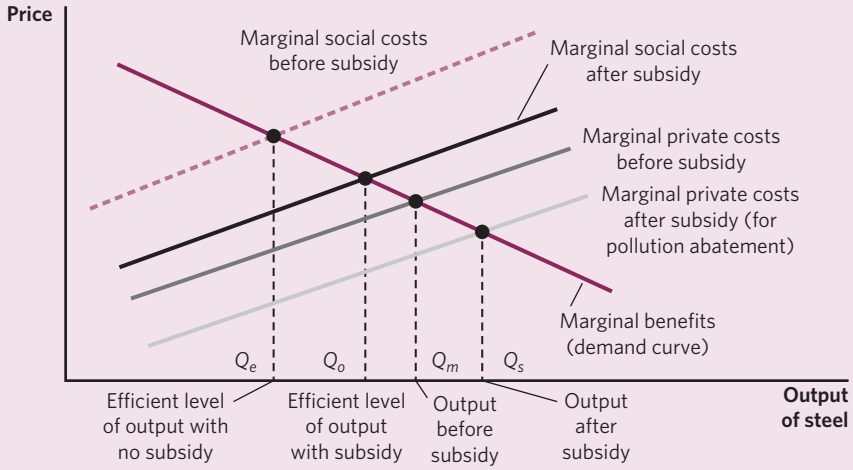


FIGURE 6.6

MARKET EQUILIBRIUM WITH POLLUTION ABATEMENT SUBSIDIES

Even after the pollution abatement subsidy, the equilibrium level of output of steel is still inefficient; the firm fails to take into account the extra costs of public subsidies for pollution abatement associated with increased output of steel as well as the marginal social cost of any remaining pollution.

pay the taxes to finance the subsidies for pollution abatement are clearly better off under the system of fines. It should be emphasized, however, that the choice between subsidies and fines is not just a distribution issue. As we have seen, under the pollution abatement subsidy scheme, producers do not face the true social cost of their production; there is an inefficiency. By contrast, with an appropriately designed system of fines, producers do face the true social costs.

MARKETABLE PERMITS An increasingly popular market-based solution involves **marketable permits**, commonly referred to as tradable permits, which operate under a **cap and trade** system. A limit, or cap, is placed on the total amount of a pollutant that may be emitted, and this limit is either allocated or sold to firms in the form of emissions permits. These limit the amount of pollution that any single firm may emit. For instance, each firm may be allowed to emit 90 percent of the amount it emitted the previous year. Thus, a firm is granted a permit to emit so many units of pollutants. Because what the government cares about is the *total* amount of emission reduction, it allows firms to trade permits. A company that cuts its emissions in half could sell some of its permits to another company that wants to expand production (and hence increase its emission of pollutants).

Under this system, firms will be willing to sell permits as long as the market price of the permit is greater than the marginal cost of reducing pollution, and firms will be willing to buy permits as long as the marginal cost of reducing pollution is greater than the market price of the permit.

Thus, in equilibrium, each firm will reduce pollution to a level such that the marginal cost of pollution reduction is equal to the market price of the permit. Like fines, marketable permits use the market mechanism to ensure economic efficiency in the reduction of pollution: the marginal cost of reducing pollution is the same for every firm.

In the absence of uncertainty, the two systems are essentially equivalent: setting a price (say, for emissions) leads to a particular quantity, and setting a quantity leads to the corresponding price. In the presence of uncertainty, both about the costs of pollution and of pollution abatement, the two may not be fully equivalent. In setting a price, the quantity of pollution that emerges will be variable; in setting a quantity, the price that polluters will have to pay is uncertain.

Consider the problem of global warming, with which we know that there is a high social cost of carbon emissions, but we are uncertain exactly what that cost is. At the same time, we are uncertain about how firms and consumers will respond to any price of emissions imposed. Those who feel confident that we know much more about what we need to do—by how much emissions should be reduced—argue for marketable permits and for forcing firms to bear the risk of the uncertain price for emissions that will emerge. Advocates of a carbon tax (a price system) argue that, in practice, adjustments will have to be made to either prices or quantities over time. What matters is the level of concentration of carbon dioxide in the atmosphere, and we can adjust the flow (the level of emissions) as we see the level of concentration build up and as we observe the consequences, *either* by adjusting the level of marketable permits or by adjusting the price of carbon.

There are three problems with tradable permits. The first is making the initial assignments. Even though the system of assigning firms a fraction of their current levels of pollution might at first glance seem reasonable, it causes a major equity problem: marketable permits are an asset that can be traded, so giving pollution permits is equivalent to giving away money. Why should firms that have been polluters in the past be entitled to receive a bigger gift from the government? There is even a perversity in doing so: "good" firms that have spent large amounts on pollution control are given fewer permits and, if they have already installed state-of-the-art technology, will have a harder time reducing pollution. An alternative system bases permits simply on the level of production. This system is basically the one used when tradable permits were introduced to control acid rain. When Los Angeles introduced tradable permits in 1994, its assignments took into account both the levels of output and pollution and the state of the firm's current technology. There is a third alternative, particularly attractive in an era of budget stringency: auction off the emission permits. Firms that have been polluting will be worse off than before, but

the question is: Why should they receive money for not harming others? (Remember the reason that pollution imposes costs on others.) As we have noted, with such auctions there is little difference between marketable permits and taxes/fines.

This leads to the second problem, which traditionally was viewed as an advantage of tradeable permits: firms could be "bribed" to support the legislation curbing emissions, because they have less (or little) to lose. Indeed, the firms that believe that they can reduce emissions considerably become supporters, because selling their emission permits can be a new source of revenue. In Europe, though, we have seen the downside: governments come under pressure to issue more emission permits (it is like giving away money, without a budget constraint). The result is less reduction in pollution.

The third problem is more subtle. Tradable permits work well only when the location of the pollutant makes no difference. In many situations this is not the case, thus air pollution is much more serious near large cities. Moreover, with prevailing winds blowing from west to east, pollution along the East Coast may not be much of a problem, as most of it gets blown immediately out to sea; but pollution in the Midwest may have adverse effects on all the eastern states. The marketable permits that were introduced to control acid rain did not fully take this problem into account.

REGULATION

Economists have usually argued that market-based solutions provide the most promise for curbing environmental externalities, but government traditionally has relied on direct regulation. It has set emission standards for automobiles; put forth detailed regulations relating to the disposal of toxic chemicals; outlawed smoking on domestic airline flights; imposed laws requiring oil companies with wells in the same oil pool to unitize their production; imposed restrictions on fishing and hunting to reduce the inefficiencies associated with excessive utilization of these common resources. These examples illustrate the myriad forms that regulation may take.

Advocates of regulations argue that they provide greater certainty: if firms are prohibited from emitting more than a given level of pollution into the water, then one knows the maximum level of pollution; with fines, the level of pollution depends on the costs of reducing the pollution level. However, advocates of fines argue that one can easily adjust fines to induce firms to lower pollution to the desired level. Moreover, marketable permits provide a market-based way to attain efficient pollution reduction

and certainty of outcome. Indeed, a major criticism of regulations is that they do not reduce pollution in the most efficient way: different firms may face different marginal costs of further pollution abatement. Furthermore, regulations typically provide little or no incentive for firms to reduce pollution below the standard that has been set, regardless of how low the cost of doing so.

In the case of pollution, we should distinguish between two important classes of regulations. Recall that the market-based mechanisms discussed earlier focus on the *amount* of pollution; to pollute more, a firm must pay more in fines or buy more permits. This is a performance-based system, since the government only cares about the final outcome—how much pollution is produced. There are many **performance-based regulations**, such as regulations on automobile emissions, that also focus on the final outcome. However, much of pollution regulation has focused on standards, practices, and inputs, rather than performance. For instance, the government may prohibit the use of certain grades of coal, or it may require firms to employ scrubbers and other pollution abatement devices, or to construct smokestacks to specific heights. These are called **input regulations**. Market-based mechanisms may also focus on inputs and practices in this way; for example, a tax may be levied on high-sulfur coal, rather than on the pollution emitted.

When feasible, it is preferable to focus on performance, either for regulations or for market-based mechanisms. The one argument for focusing on inputs and practices is that they may be more easily monitored. Thus, it may be difficult to measure the amount of pollution coming out of a smokestack, but it is certain that if scrubbers (devices that reduce the amount of sulfur being emitted by a coal-burning electric power plant) are used, the amount being emitted will be less than if scrubbers are not used.

Although there may be good reasons for these policies, in some cases, politics rather than policy has dominated the decision. In the case of coal, had a performance-based standard been used, eastern coal producers would have been disadvantaged relative to western coal producers, because eastern coal contains more sulfur. To attain the same level of sulfur, firms using eastern coal would have had to use scrubbers, whereas those using western coal would not. Eastern coal producers successfully lobbied for the universal imposition of the requirement to use scrubbers.

INNOVATION

One of the reasons for performance-based regulations (as opposed to input standards) and pollution-based taxes (as opposed, say, to subsidies

for particular forms of abatement equipment) is that they directly address what is of concern—the level of pollution—and they may induce innovations, such as new ways of producing that generate less pollution or new techniques for abating pollution at lower costs. Advances in technology have improved the ability to monitor some kinds of pollution; ongoing innovation should enhance this further.

There has been considerable controversy over the best way to stimulate innovation and about the scope for innovation. Some environmentalists are less convinced than economists of the power of normal economic forces. Many believe that industry must be *forced* to innovate. Thus, by imposing extremely stringent standards—for instance, that cars get at least 40 miles per gallon—they will force industry to develop a product meeting these standards. Implicitly, they believe that the benefits of the innovation would outweigh the costs, but that the incentives that could be provided by the price system—charging car companies taxes in proportion to the amount of pollution—simply do not suffice to warrant their attention on this area.

In practice, the success of this strategy has been mixed. In some cases, rather than inducing innovation, stringent regulations have induced litigation: it may appear cheaper to a firm to try to persuade a court that the regulation is unreasonable than to spend the money to meet the standards imposed by the regulation. In some cases, firms have played a game of chicken, gambling that if they fail to meet the standards, the government will not shut them down, for fear of a political backlash from workers who are put out of a job. In some cases, however, industry unity has been broken by an innovative firm that showed that the standards are indeed attainable, or can even be surpassed. For instance, the great commercial success of the Toyota Prius has spurred its American competitors to develop hybrid cars of their own to compete in a rapidly growing market.

Environmentalists who doubt the effectiveness of market incentives by themselves in inducing innovation often point to the large gap between best practices—which often seem to be the most cost-effective practices—and what actually occurs. They point out, for instance, that there are energy-efficient light bulbs that more than pay for their higher costs in terms of reduced usage costs. Sometimes there is a coordination failure that government action can help remedy: no one wants to install fixtures that use energy-efficient light bulbs if it is going to be difficult to replace the bulbs when they burn out, and stores will not carry such light bulbs if there is no demand; and there won't be a demand if builders do not put them in houses they construct and lamp manufacturers do not put them in the lamps they make. Sometimes there are information barriers and other types of barriers to the adoption of cost-efficient energy-saving

technologies, and government can help promote the diffusion of these technologies by disseminating information.

Behavioral economics has explained how sometimes there can be inertia in changing customs. Government can help change norms, though. There have been large changes, for instance, in norms concerning smoking or the use of plastic bags, induced in part by government regulations. Of course, prices too can help in changing practices. One of the reasons that energy-efficient light bulbs are more prevalent in Japan than in the United States is that the price of electricity is higher there. Between these two camps are those who argue that simply providing information and small price signals will not lead to the large changes in behavior that are needed; changes are likely to be modest and slow. Today, labels on many electric products identify energy usage and costs, helping buyers make more intelligent decisions about lifetime costs of different products.

Thus, there may be win–win regulations with which efficiency is enhanced at the same time that environmental costs, especially those associated with the use of energy, are reduced; slight modifications in construction practices—the color of roof shingles or the planting of trees, for example—can have a noticeable effect on energy consumption.

Critics of approaches focusing on inputs rather than performance argue that such approaches are not only inefficient, but also stifle innovation and push it in the wrong direction. For instance, rather than seeking the most effective way of reducing emissions from coal-burning power plants, research is focused on making cheaper scrubbers. Moreover, research directed at improving the ability to monitor outputs accurately—thus reducing the necessity of relying on input regulations—is not encouraged.

INFORMATION DISCLOSURE

In some areas, governments have been experimenting with another approach, focusing on public pressure rather than the heavy hand of government. Government's role would be limited to requiring firms to disclose, for instance, the potentially cancer-inducing chemicals that they discharge into the water or emit into the air. Government would not even comment on the extent of scientific evidence concerning the impact of the chemicals on humans. Critics of this approach often argue that the costs of such information disclosures can be high, but their real concern is that government would be encouraging a scare campaign. Most people would simply assume that if a chemical is listed as dangerous, it must be dangerous—or, in any case, why risk it? People in the neighborhood would

put enormous pressure on the firm to eliminate the chemical, without any assessment of the costs or benefits of doing so. There could be enormous adverse economic effects. Particularly troubling is the evidence of one study by the Environmental Protection Agency (EPA) that showed the magnitude of popular misconceptions about environmental risks. Scientists and nonscientists were asked to rank a number of different potential environmental health hazards, and there was little correlation between the two. Among the risks rated most highly by the nonscientists were several that were ranked at the bottom by the scientists, and vice versa.

COMPENSATION AND DISTRIBUTION

So far most of our discussion has focused on the *efficiency* of alternative ways of controlling pollution (externalities). But much of the debate is about *distribution*—who bears the costs. Different systems of controlling pollution may have markedly different distributive consequences. Subsidies for pollution abatement equipment may result in a less efficient resource allocation than a system of fines for polluting; but firms will clearly prefer subsidies. Greater efficiency means that, in principle, the overall gains to society from using the more efficient system are such that the gainers could compensate the losers.

Why then do governments so often resort to inefficient systems like abatement subsidies? The reason is that the compensation is typically not paid. Partly this is because it is often difficult to measure the gains and losses to each individual—the information required to implement the desired compensations is simply not available—and partly it is because those who benefit from the inefficient system are more politically organized. The losers from a system of fines are clear—both the owners of the polluting firms,

ASSESSING ALTERNATIVE APPROACHES TO CONTROLLING EXTERNALITIES

Performance-based versus input-based

- Performance-based is more efficient when performance can be measured.
- Costs of monitoring inputs may be lower.

Regulation versus fines

- Fines related to costs of pollution provide appropriate incentives.
- However, there may be greater uncertainty about the actual level of pollution.
- Regulations provide greater certainty, strong incentives to meet the regulatory standards, but no incentive to reduce pollution below the standard, regardless of how low the cost is to do so.

Marketable permits versus fines

- Both can result in efficient reductions in pollution levels.
- Marketable permits provide greater certainty about the level of pollution.
- Marketable permit systems face difficult problems in allocating initial permit rights.
- There are further problems if the costs of pollution depend on *where* the pollution occurs.

Subsidies for pollution reductions versus fines for pollution

- Both can induce reductions in pollution levels and even achieve efficient levels of pollution abatement. The level of production of the pollution-inducing industry will be too high, however, because the firm will not take into account full costs—including costs of pollution abatement. Firms prefer pollution abatement subsidies.

who see their profits decreased, and the consumers of their products, who see their prices increased. The gainers are more dispersed—all the taxpayers who bear the burden of the taxes used to pay the subsidies, and all the consumers of all the other products who might see their prices rise slightly as production shifts slightly toward the subsidized industry. As is so often the case, the losers are much easier to identify than the gainers; thus, it is much easier for the losers to get together and use the political process to argue for a system that, though inefficient, makes them bear less of the cost of reducing pollution.

One of the reasons that governments may resort to regulation rather than the market-based systems described earlier is that the distributive consequences may be less; for instance, individuals and firms may respond only to a limited extent to a small price of emission permits. To induce the large changes in behavior that are required to avoid global warming (say, to avoid an increase in the world's temperature by more than 2 degrees Celsius, a goal of the international environmental community) might require a very large increase in the price of emissions, which would translate into large increases in energy prices, with significant distributive consequences. It may be possible to "force" the adjustments the economy needs with less adverse distributional effects by imposing regulations on electricity producers and car manufacturers.

Recent discussions of environmental policy have also focused on the distributional consequences of environmental hazards. For instance, the poor are more likely to live near toxic waste sites, and exposure to these hazards imposes large costs not only on parents (on their health and life expectancy), but also on their children. There is a greater likelihood that their children will be born with low birth weight, which, in turn, is associated with lifelong consequences, including lower average lifetime incomes.

PROTECTING THE ENVIRONMENT: THE ROLE OF GOVERNMENT IN PRACTICE

We now look more closely at the actual policies that the government undertakes to protect the environment. For convenience, we divide them into three categories: those directed primarily at air, water, and land. There are, of course, important interactions among these pieces of our environment, so several of the policies affect two or more of these categories.

AIR

The air we breathe has been taken for granted since the beginning of time, but by the middle of the twentieth century this was no longer possible in many major cities. London became famous for its pea-soup fog generated by pollution; Los Angeles for its life-threatening smog; Gary and Pittsburgh for their brilliant red overcast skies, a product of the steel mills on which those cities' economy depended. People with weak respiratory systems knew the dangers of living in these cities, but the fact that *all* individuals faced greater health risks was recognized only slowly.

There are several aspects of the nation's attempt to control air pollution. Two have been marked by considerable success; there is heated controversy over a third one; and in the fourth, progress remains slight.

The most marked success is associated with ozone depletion and chlorofluorocarbons.

OZONE DEPLETION The Earth's atmosphere has a thin layer of ozone, which shields us from harmful solar radiation. In the late 1980s it became clear that a hole was appearing in the ozone layer over Antarctica, and that the cause of the hole was chlorofluorocarbons (CFCs) and other ozone-depleting substances (ODSs). The nations of the world responded in 1987 with a treaty signed in Montreal, Canada, called, appropriately, the Montreal Protocol. It initially required the production and consumption levels of CFCs to be cut in half by 1999, but was strengthened in 1990 with a commitment to phase out CFCs and halons entirely by 2000 (by 2010 for less developed countries). Since then, ODS atmospheric concentration has steadily declined, although complete recovery of the Antarctic ozone layer is not expected until 2050 at the earliest.

ACID RAIN The control of sulfur dioxide (SO_2), which gives rise to acid rain and is emitted especially by coal-burning power plants, is another success story. In the 1970s, we became aware that the leaves on the trees in many of our forests were turning yellow and many of our lakes seemed to be devoid of fish. The Acid Precipitation Act of 1980 and the Clean Air Act Amendments of 1990 began a program to control these emissions, and a national program of tradable permits was introduced. These are estimated to have significantly reduced the overall cost of bringing down the level of pollution. Regional cap and trade markets for nitrogen oxide (NOx)—another pollutant—have been established as well.

An especially problematic aspect of acid rain is that SO_2 and NOx emissions cross state lines. In 2011, the U.S. Environmental Protection Agency issued the Cross-State Air Pollution Rule (CSAPR) to strengthen

its court-challenged legal authority to regulate interstate acid rain emissions. The CSAPR focuses on pollution in the eastern United States, with the goal of reducing power plant SO_2 emissions by 73 percent and NOx emissions by 54 percent from 2005 levels by 2014 in affected regions.[6]

PARTICULATE AIR POLLUTION Small particulates in the air can pose serious health problems for certain individuals. The federal government's involvement in addressing the challenges of particulate air pollution has evolved over the past half-century from purely research (Air Pollution Control Act of 1955), to setting of standards (Clean Air Act of 1970), to enhanced authority for pollution control (1990 Clean Air Act Amendments). Although the EPA estimates that the direct benefits from the 1990 Clean Air Act Amendments will reach an annual economic value of almost $2 trillion by 2020, much less that the estimated $65 billion annual cost of public and private efforts to comply with the requirements of this law, there is still considerable debate about the assumptions underlying this cost–benefit analysis.[7] The controversy concerns the cold calculations of the costs of reducing the level of particulates versus the health benefits. As hard as it is to quantify these benefits, there are standard procedures by which this is done; such calculations are made routinely in evaluating how much to spend to make a safer highway, a safer car, or a safer airplane. These changes can result in a slightly smaller probability of an accident from which one can calculate, *on average*, how many lives will be saved. The government must have a systematic way of deciding whether the benefits exceed the costs, by doing so, it places a value on life—in this case, the value of reducing the risk of fine particle-related premature mortality.

GLOBAL WARMING The one area in which little progress has been made is global warming and greenhouse gases. The Swedish chemist Svante Arrhenius explained as early as 1896 that carbon dioxide emissions from the burning of coal would enhance Earth's natural greenhouse effect (retention of solar radiation by Earth's atmosphere) and thus lead to global warming, but it was not until the 1980s that the world's attention turned to the issue. The scientific community was able to show that the current level of carbon dioxide concentration in the atmosphere due to the burning of carbon—from coal, gas, and oil—is, indeed, substantially greater than it was at the beginning of the Industrial Revolution, and

[6] U.S. Environmental Protection Agency, *Cross-State Air Pollution Rule (CSAPR)*, accessed July 20, 2011, http://www.epa.gov/crossstaterule.
[7] For the complete cost–benefit analysis, see U.S. Environmental Protection Agency, Office of Air and Radiation, *The Benefits and Costs of the Clear Air Act from 1990 to 2020* (Washington, DC: U.S. EPA, March 2011).

continues to grow. Scientists have also established that there was overwhelming evidence that these substantial increases were leading to significant increases in Earth's temperature. Since 1990, the Intergovernmental Panel on Climate Change (IPCC) has issued periodic assessments on the state of global warming, and, together with former vice president Al Gore, was awarded the Nobel Peace Prize for contributions to international environmentalism.

To many, the world seems embarked on a risky experiment with our planet as we continue to add carbon dioxide and other greenhouse gases to the atmosphere; it is leading not just to a warming of Earth, but also a rise in the sea level. There will be severe adverse effects from this warming, especially on the tropics, and the increase in sea level will obviously have adverse effects on low-lying islands and countries, such as Bangladesh, Vietnam, and the Netherlands. Other predicted effects include an increase in the variability of weather. Even though there is clear evidence for the increase in greenhouse gases, and there is a general (but not universal) consensus on the long-run effects, there is more controversy over whether the effects are already being felt. There is evidence, for instance, of a marked increase in losses from weather—far greater than the increased losses from nonweather events such as earthquakes. Although there is some disagreement among economists about the magnitude of the overall costs—with some countries in cold climates actually benefiting—the consensus, reflected in an agreement made in Copenhagen, is that the costs will be large.

As the scientific evidence has mounted, the issue has taken on greater urgency over the past two decades. In 1997 collective global concern resulted in adoption of the Kyoto Protocol, under which industrialized countries pledged to reduce their emissions of greenhouse gases. Most countries have ratified the Kyoto Protocol, with the notable exception of the United States. A key U.S. objection is the protocol's exclusion of developing countries such as China and India, who will be the largest future sources of CO_2 emissions.

In response, developing countries have argued that most of the problem has been caused by the profligacy of the advanced countries, their own contributions to the greenhouse gases thus far have been relatively small, their projected future contributions to greenhouse gases will still be much lower than high-income countries on a per capita basis, and they are too poor to devote much of their resources to reducing their emissions below the level that economics dictates.

To reduce overall costs, the countries agreed at Kyoto to explore more market-based mechanisms—tradable permits and a variant called "the clean development mechanism" or **joint implementation**—because

one country would "buy" the greenhouse gas reduction from another; in effect, by paying for it, they could be thought of as "jointly" implementing the greenhouse gas reduction. Joint implementation can be thought of as a limited form of marketable permits. Some critics suggested that the United States was advocating joint implementation not out of a commitment to economic efficiency, but because it could not or would not take measures that would reduce greenhouse gases within its own borders.

Today, there are many active cap and trade systems for greenhouse gases. The European Union Emission Trading Scheme (EU ETS) was established by the EU to help meet its Kyoto Protocol commitments by the time the protocol expired at the end of 2012, and is now the world's largest CO_2 emissions trading system.

Negotiations for a new global agreement on greenhouse gases are continuing, with very slow progress. In Copenhagen, countries agreed to draw up their own action plans to reduce emissions. There was peer pressure to make significant reductions, but no commitments were made. Subsequently, parties to the United Nation's Framework Convention on Climate Change concluded their December 2012 climate conference in Doha, Qatar, with agreement to continue negotiations on a successor to the Kyoto Protocol, which they hope to approve during their 2015 conference in France.

The easiest and most cost-effective way of reducing emissions in the United States would be a carbon or energy tax, but this option has been adamantly opposed by the powerful gas, coal, and oil interests. Currently, gasoline taxes in the United States are markedly lower than in Europe and most other industrialized countries, as shown in Table 6.1.

TABLE 6.1 GASOLINE TAXES AROUND THE WORLD

COUNTRY	TAX PER LITER IN U.S. DOLLARS
United Kingdom	1.32
Germany	1.26
France	1.19
Italy	1.14
Spain	0.90
Japan	0.77
Canada	0.38
United States	0.11

SOURCE: International Energy Agency, *End-Use Petroleum Product Prices and Average Crude Oil Import Costs*, Table 3 (Average end-use prices) and Table 5 (Average end-use taxes), March 2011.

A central problem in any international agreement is *enforcement*. Global warming is a global public good, and there is an incentive for each country to be a free rider; that is, each would like to continue to pollute, but also to enjoy the benefits of a world that is not subject to global warming as a result of the efforts of others. In the Montreal Protocol, discussed earlier, countries that did not comply were threatened with trade sanctions. Some have suggested that similar sanctions might be desirable, or even necessary, to deal with global warming. Indeed, many European countries that were making large efforts to reduce their emissions thought that the failure of the United States to do anything was giving U.S. firms an unfair competitive advantage. European steel producers, for instance, had to pay for their carbon emissions, while U.S. steel producers did not. It was as if the U.S. producers were being subsidized, because they did not bear the full costs of their production. Some have suggested, accordingly, that it is only appropriate that those who do impose a carbon price (either through a carbon tax or tradable permits) impose a tax on imports from the United States or any other country refusing to do similarly.

WATER

The debate over clean air today centers not around whether pollution should be controlled, but rather how and at what levels. Likewise, in the case of water, there is consensus that the controls that have been put in place for drinking water make sense, but controversy remains over the benefits relative to costs of stringent regulations attempting to reduce pollution in streams and rivers. Much of today's water pollution comes not from factories, which can be more easily controlled, but from difficult-to-control sources such as runoff from farms. Controlling such pollution would require controlling the use of fertilizers and pesticides. Although price mechanisms (taxes) might discourage the use of fertilizers and pesticides, it would be virtually impossible to differentiate between usages that contribute to pollution and those that do not. Moreover, there is controversy over some of the benefits. How worried should we be about the pollution of groundwater that will almost surely never be used for drinking and that is unlikely to seep into wells or springs? Some environmentalists believe that we should never spoil a part of our natural heritage; keeping groundwater clean has nothing to do with the use to which groundwater might be put. Others take a very risk-averse stance: How can we be sure that the groundwater will never be used for drinking? Controversy over these issues has prevented reauthorization of the Clean Water Act, although many limited, specifically targeted clean water bills have been enacted in recent years.

LAND

TOXIC WASTES Newspapers have presented graphic stories of rivers, canals, and land that chemical companies have turned into toxic waste sites, subjecting those who come into contact with them on a regular basis to increased risk of cancer. Americans had nightmares about discovering that their homes had been built over toxic waste sites. In response, in 1980 Congress passed the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), commonly known as **Superfund**, after the trust fund it established with a tax on chemical and petroleum companies, to help clean up these sites.

The law was badly designed, however. It was based on the principle that those who contributed to the pollution should pay for its cleanup, but it provided that anyone who had contributed at all to the particular site was liable for the entire cleanup costs. This enabled the government to go after large corporations—those with "deep pockets"—forcing them to pay for the cleanup and letting them sue the other polluters to recover their shares. (This is called the **system of joint and several liability**.) Furthermore, it provided for perpetual liability: even after the site was seemingly cleaned up, it was always possible that on the site another chemical with adverse effects would be discovered, so the guilty party is never completely free from liability. To make matters worse, the polluters' insurance companies argued that their general liability policies did not cover pollution other than that which originated as a result of an accident. In several states, the courts supported the insurance companies, whereas in other states, the courts said that the insurance companies were liable. The upshot was litigation—between the government and the polluters, among the different polluters, and between the polluters and their insurance companies. The lawyers made out like bandits, but the toxic wastes did not get cleaned up. Over 70 percent of insurance company expenditures went to legal fees, and more than a quarter of what the polluters spent went to lawyers. Worse still, property owners had a new nightmare to worry about: that toxic waste would be discovered on their property that might not hurt their health but would definitely hurt their pocketbooks. They would be responsible for cleaning it up, and the EPA often set standards for which the costs simply could not be justified by the benefits. In some places, the result was "gridlock" in the land market: no one would buy potentially polluted sites, which hampered efforts to redevelop inner-city areas. Banks would not make loans, lest they wind up holding the property (and being responsible for the cleanup) in case of a default. America's landscape was scarred with such "brownfields" (as they came to be called), and America's firms had to get out to find green fields to

build their new factories. A law intended to preserve and protect the land had led to opposite results.

Thirteen years after the bill was passed, only one of seven major sites that had been identified had been cleaned up. Four years later, the administration was claiming that two-thirds of the sites had been, or were on the way to being, cleaned up. The situation was similar in 2010, when more than half the work had not yet been completed for the remedial construction phase of cleanup for over 60 percent of the 239 nonfederal National Priorities List (NPL) sites with unacceptable or unknown human exposure.

Despite this modest progress over the thirty years since enactment of the Superfund legislation, the other problems, such as the brownfields and the inequities associated with joint and several liability, persisted. Even though there was universal agreement that reforms were needed, the differing perspectives of environmentalists, insurance companies, and polluters made resolution of these problems difficult. There were conflicts about both the standards of cleanup and about who should pay. Although forcing those who pollute to pay provides strong incentives not to pollute, there was controversy over whether it was right to force people to pay for actions that were not illegal at the time they occurred, and whose consequences might not even have been apparent. Indeed, the worst effects of the powerful chemicals that dry cleaners had used was probably not on the land onto which some of these chemicals spilled but on the owners and workers who spent their lives working in these cleaning plants, unaware of the health effects. They had already paid a high price—and given the competitive nature of the industry, the benefits of their using the chemicals were received by their customers: had they been required to dispose of the chemicals in another way, they would have done so and passed the costs on to their customers. And in any event, in many cases, it was not the polluters that would actually pay but their insurance companies, thus undermining the moral argument that polluters should pay. However, environmentalists point out that firms are in the best position to judge the risks posed by the chemicals they use, and that insurance firms are in a good position to put pressure on those they insure to look carefully at the risks of their products. The debate continues, although the EPA claims, "Over the past 20+ years, we've located and analyzed tens of thousands of hazardous waste sites, protected people and the environment from contamination at the worst sites, and involved others in cleanup."[8]

[8] U.S. Environmental Protection Agency, *Superfund: Basic Information*, accessed July 20, 2011, http://www.epa.gov/superfund/about.htm.

ENDANGERED SPECIES There has been concern not only to protect the environment from pollution, but also to preserve it. As populations expand, they crowd out nature. Throughout the world, a multitude of species are threatened with extinction. At the global level, international treaties have been signed to combat these threats; 1992 was marked not only by a treaty on global warming, but also by a treaty intended to preserve the world's biodiversity—plants as well as animals. Particularly powerful in this debate was the recognition that within this diverse biological heritage, there might live cures for a myriad of diseases. Other international treaties are directed at preventing the extinction of whales and eliminating trade in ivory (which might encourage the extinction of elephants) and rhinoceros horn (highly valued in certain parts of the world for its alleged powers in enhancing sexual potency).

In 1973, the United States passed the Endangered Species Act. The legislation has been highly controversial because of its potentially strong economic impact. For instance, logging in large parts of Washington and Oregon was halted because of a concern over the destruction of the habitat of the spotted owl, an endangered species; and in Texas, development of areas near Austin was halted over fear of destroying the habitat of some endangered species of spiders.

Critics argue that the preservation of these species is a public good, but a public good that owners of these particular parcels of land are made to pay for. If the public wants these species to be preserved, it should buy the land. Prohibiting owners from developing the land is almost tantamount to seizing it. Indeed, many argue that any restrictions on usage represent a "taking" of property; just as the government cannot simply take away your property without compensation, it should not be allowed to take away the uses to which you can put your property without compensation. There is a fundamental difference between laws that stop a person from imposing an externality on others, and laws that require a person to provide a public good (the protection of an endangered species) to others.

Supporters of endangered species legislation, even when they recognize these arguments, say that there simply is not enough money available to provide compensation to property owners; the choice is a pragmatic one—allow the species to become extinct, or impose these mandates on property owners. Besides, the longer the law is on the books, the less these arguments on "takings" become relevant: those who buy property know that their use may be encumbered by the Endangered Species Act, and this is reflected in the purchase price they pay. The cost was effectively borne by the owners of the land at the time the law was enacted; if anyone should be compensated, it is the former owners, not the current ones.

Protecting endangered species is only one of several pieces of legislation designed to protect our natural environment. There is also, for

instance, important legislation protecting the wetlands and coastal land. President Theodore Roosevelt protected 230 million acres of some of the country's most treasured areas while serving from 1901 to 1909 by establishing 5 national parks, 150 national forests, 4 national game preserves, and 51 federal bird reservations.

CONCLUDING REMARKS

Although the specifics of environmental legislation—how best to improve the environment and how high to set the standards—are likely to remain contentious, there is a growing awareness that the government has at its disposal a wide range of instruments and a growing consensus on a set of general principles: the environment is of critical importance; markets alone will not provide efficient outcomes because of important externalities; some form of government action is required; when possible, interventions should be performance based and market oriented; the government must be sensitive to the distributional consequences both of environmental degradation and the policies that are implemented to ensure the protections of the environment; and the environment is so important that we cannot make the perfect the enemy of the good.

REVIEW AND PRACTICE

SUMMARY

1. Externalities are actions of an individual or firm that have an effect on another individual or firm for which the latter does not pay or is not paid.
2. Sometimes economic efficiency can be attained without resorting to government intervention
   a. By establishing sufficiently large economic organizations, the externalities can be internalized.
   b. By establishing clear property rights, private parties can bargain toward an efficient solution, as suggested by Coase.
   c. By using the legal system, imposers of externalities can be forced to compensate victims.
3. There are important limitations to each of these private remedies. For instance, public goods problems and transactions costs impede efficient bargaining solutions in the manner suggested by Coase. These failures necessitate a greater role for government in remedying the problems of externalities.
4. There are four methods by which the government has attempted to induce individuals and firms to act in a socially efficient manner: fines and taxes, subsidies, tradable permits, and regulation.
5. When there is good information about the marginal social cost of the externality (as with pollution), and the fines can be adjusted to reflect those

costs, then a fine system can attain a Pareto efficient outcome. Subsidies to pollution abatement, while enabling the efficient level of pollution abatement to be attained, will result in excessive production of the pollution-generating commodity. In principle, the gainers under the fine system could more than compensate the losers, but in practice these compensations are seldom made. Thus, the choice of the system for controlling externalities has important distributional consequences.

6. Tradable permits (cap and trade systems) can also result in efficient pollution abatement.
7. Regulations focusing on inputs or standards are likely to result in inefficiency.
8. The Clean Air Act has greatly reduced the level of pollution in the air. There is increasing concern about greenhouse gas emissions, which may lead to global warming.
9. The Clean Water Act has greatly reduced water pollution. Controversy remains over whether standards are excessively stringent, so that at the margin, costs exceed benefits.
10. The Superfund program, which is intended to clean up toxic waste sites, faces several problems, including excessive litigation costs and slow cleanups. Remedies include reforms in the legal system and the cleanup standards, and must address the problem of who should bear the costs of cleanup.
11. There has been increasing interest in preserving biodiversity and protecting endangered species. There is concern, however, that restrictions on land usage required to protect endangered species constitute an unfair "taking" of property.
12. There are several global environmental problems, the most important of which is global warming. There is broad consensus among the scientific community that increases in the concentration of greenhouse gases in the atmosphere will lead to higher temperatures, an increase in sea level, and increased weather variability, with significant economic consequences. The international community has so far not been able to reach an agreement to curb emissions of carbon dioxide and other greenhouse gases.

KEY CONCEPTS

Cap and trade
Coase theorem
Common resource problems
Corrective taxes (Pigouvian taxes)
Existence values
Externalities
Input regulations
Internalizing externalities
Joint implementation
Marginal social cost curve
Marketable permits
Performance-based regulations
Property rights
Superfund
System of joint and several liability
Unitize

QUESTIONS AND PROBLEMS

1. Make a list of the positive and negative externalities that you generate or that affect you. For each, discuss the advantages and disadvantages of each of the remedies discussed in the text.
2. An important class of externalities to which attention has recently been directed is called *information externalities*. The information produced by one individual or firm generates benefits for others. The success of an oil well on one tract of land increases the likelihood of oil's being found on an adjacent tract, and hence increases the value of that tract. Can you think of other examples of information externalities? What are the likely consequences of information externalities for the efficiency of resource allocations? Discuss the possibilities of private market solutions to these problems.
3. Explain why subsidies for pollution abatement equipment, even if they result in an efficient level of pollution abatement, will not result in an efficient resource allocation.
4. Assume that there is uncertainty about the value of pollution control as a result of, for instance,

uncertainty about the costs of pollution. Draw two different "demand curves" (or benefit curves) for pollution, showing the marginal benefit of reducing pollution by one more unit decreasing as the level of pollution reduction increases. Assume that the marginal cost of pollution abatement increases as the level of pollution abatement increases.

a. Assume the government can regulate the amount of pollution control *after* it knows what the benefits are. Show what the level of pollution control will be in each situation.

b. Assume the government can impose a tax on pollution *after* it knows what the benefits are. Show what the level of tax (or fine) will be in each situation. Is there any difference between regulations and fines in these circumstances?

c. Now assume that the government must set the level of allowable pollution before it knows what the benefits are. How will it set the level of allowable pollution? (Hint: there is a cost to society due to allocative inefficiency: from allowing too much pollution, if it turns out the benefits of pollution reduction are high; from being too restrictive, if it turns out the benefits are low.) How do you minimize the sum of these two social welfare losses?

d. Now assume the government must set the level of fine before it knows what the benefits are. How will it set the fine? Is there a difference between fines and regulations here?

e. Now assume that marginal benefits of pollution abatement are unknown. Assume also that when marginal benefits are high, the marginal costs are also high, and similarly, costs are low when benefits are low. Contrast a system of fines and regulations under these circumstances, where the level of fine or regulation must be set before costs are known.

5. Assume there are two types of communities in the United States, those in which there is a high benefit of pollution control and a high cost of pollution control, and those in which there is a low benefit of pollution control and a low cost of pollution control. Assume that the government must set either uniform regulations (a uniform level of pollution control) or a uniform fine for pollution. Show diagrammatically that a regulatory scheme may be preferable to a system of fines. How does your answer change if communities in which there is a high marginal cost of pollution control happen to be communities in which there is a low marginal benefit; and communities with a low marginal cost of pollution control happen to be communities in which there is a high marginal benefit?

6. The impact of some externalities is very local, such as noise from airplanes landing and taking off at an airport. Such externalities depress the value of the immediately surrounding real estate. We say that the cost of the externality is *capitalized* in the value of the property. Assume that poor individuals are more willing to accept the high level of noise pollution, in return for the much lower rents they have to pay for housing. Describe the *incidence* of a regulation lowering the noise level surrounding the airport; that is, who benefits? (Hint: What will happen to land values? To rents?)

7. Zoning laws, which restrict how individuals can use their land, are sometimes justified as a means of controlling externalities. Explain. Discuss alternative solutions to these externalities.

8. What is the externality associated with an additional individual's driving on a congested road? How do tolls help alleviate this externality? How should the toll be set?

9. Explain why a system of joint implementation for reducing greenhouse gases is more efficient than a system whereby each country must reduce its pollution by a fixed amount.

10. Many economists are worried that unless all countries are required to reduce their levels of greenhouse gas emissions, reductions in emissions in one country may be partially offset by increases in another. Explain how this might occur.

11. Global warming is related to the concentration of greenhouse gases in the atmosphere. Once in the atmosphere, gases remain there for long periods of time (centuries). Greenhouse gases include carbon dioxide and methane.
    a. Assume the effect on global warming of a given amount of carbon dioxide is four times that of methane. What should be the relative fine (tax) on emissions of the two gases?
    b. How should the tax vary over time?
    c. A carbon tax is a tax related to the amount of carbon dioxide that burning gas, oil, or coal adds to the atmosphere. With a carbon tax, coal is taxed very heavily (relative to the amount of energy put out) and natural gas relatively lightly. A BTU (British thermal unit) tax is a tax related to the amount of energy produced, for instance, by burning gas, oil, or coal. If one is concerned about greenhouse gas warming, why is a carbon tax preferable to a BTU tax?
12. Two different strategies are debated for reducing greenhouse gas emissions. One is that all the countries in the world should adopt common measures, such as a carbon tax. The other is that all countries in the world should adopt common goals, such as reducing the level of emissions to the levels of 1990. Explain the distribution and efficiency aspects of these two strategies.
13. Corporate Average Fuel Economy (CAFE) standards stipulate the average fuel efficiency (miles per gallon) of cars produced by each manufacturer. That is, the average fuel efficiency of cars sold by GM, Ford, Chrysler, Toyota, and so forth must be at least equal to the standard set by the government. Explain why such a system introduces both inefficiencies and inequities among different automobile manufacturers. (Hint: Consider a company that specializes in small cars versus one that specializes in large cars.)
14. Discuss some of the problems with CAFE standards. How might a system of "tradable CAFE standards" be designed, and why might such a system improve efficiency?
15. To resolve the controversy over insurance coverage of Superfund sites, it has been proposed that the insurance industry be taxed to create a fund out of which claims would be paid. What difference does it make if the tax is levied on the basis of:
    a. Insurance premiums as of 1980?
    b. Current insurance premiums?

    Which insurance companies might be expected to prefer each way of levying the tax? (You can use a supply and demand diagram to illustrate the answers.) How does each form of tax affect the supply curve of insurance?
16. One proposal to reduce automobile emissions involves "pay at the pump insurance," under which individuals would pay, say, 25 cents per gallon of gasoline, with the proceeds going toward an insurance fund. What might be the environmental effects of such a proposal? Can you think of other grounds on which such a proposal might be attractive?